Developing a Performance Practice for Mobile Music Technology

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Figure 1: *A sonic ritual for Auraglyph* **and 46 iPads, performed at Hack Music LA in Los Angeles, CA. MECA, an ensemble for performing mobile music, is arrayed in the foreground and maintains a sonic backdrop as members of the audience explore and play with iPads equipped with custom music software.**

ABSTRACT

This paper documents an extensive and varied series of performances by the authors over the past year using mobile technology, primarily iPad tablets running the Auraglyph musical sketchpad software. These include both solo and group performances, the latter under the auspices of the Mobile Ensemble of CalArts (MECA), an ensemble created to perform music with mobile technology devices. As a whole, this diverse mobile technology-based performance practice leverages Auraglyph's versatility to explore a number of topical issues in electronic music performance, including the use of physical and acoustical space, audience participation, and interaction design of musical instruments.

Author Keywords

mobile music, digital ensembles, iPad, spatialization

CCS Concepts

•**Human-centered computing** → **Mobile devices;** •**Applied** **computing** → **Sound and music computing;** •**Software** **and its engineering** → **Visual languages;**

1. INTRODUCTION

Mobile technology has found notable use in music performance and creation in the past decade, as devices capable of flexibly processing sample-level audio in real-time have become available. The advent of touchscreens and programmable mobile devices have opened up an abundance of opportunities for developers of music software and the musicians that perform with them.

In this paper, we document a series of solo and ensemble performances led by the authors over the past year. These performances have largely used the Auraglyph [19] iPad-based music programming system, which was developed to explore embodiment, gesture, and interaction in electronic music. Leveraging these characteristics, the performances we document consider ideas related to embodiment, space, and presence in electronic music. Ensemble works have been developed under the aegis of MECA, a new ensemble for performing music with mobile technology. As a whole, the performance practice we have developed aims to extend mobile music performance in new directions, utilizing new aesthetic approaches and technological methods.

2. BACKGROUND

Early concert-oriented performances using consumer mobile technology devices includes Levin et al.'s *Dialtones (A Telesymphony)* [11] and Ligna and Jens Röhm's *Wählt die Signale* [3]. The Stanford Mobile Phone Orchestra (MoPhO) updated these ideas to phones capable of running custom sound synthesis software, with extensive documentation of performance practice [29, 15]. MoPhO was extended from aesthetic ideas developed by the Stanford Laptop Orchestra

(SLOrk) [28]. Snyder and Sarwate's Mobile Device Marching Band, something of an offshoot from the Princeton Laptop Orchestra (PLOrk) [24], augmented mobile technology with custom-made sensors and performance interfaces [22]. Similar efforts include the University of Michigan's Mobile Phone Ensemble [7], the Google Mobile Orchestra [10], and the Smartphone Ensemble [1]. Shaw et al.'s *Fields* used Web-based technology to diffuse sound across the audience's phones [21]. Essl and Rohs have further discussed the design of mobile musical instruments, with attention to their use in musical performance [8].

A plethora of tablet applications exist for musical composition and performance, including a tablet version of the reacTable,[1] the BladeAxe [14], Pyxis Minor [2], Gliss [26], Orphion [25], TC-11 [20], an application for "random access remixing" [9], Borderlands Granular [4], and Magic Fiddle [30], as well as many, many more digital audio workstations, synthesizers, sequencers, and other instruments not documented in the research literature. Of the instruments noted above that do refer to a performance practice, most do not discuss it in detail, with evaluations focusing instead on user studies or distribution metrics such as number of downloads or user reviews. Polashek and Meyer's *Engravings for Prepared Snare Drum, iPad, and Computer* is a work for a single percussionist playing a snare drum and a customized iPad interface controlling laptop-based audio synthesis [16]. D'Alessandro and Dutoit have discussed the development of performance techniques for a digitizer (screen-less) tablet-based sketching instrument over a two year period [5].

3. MOTIVATION AND CONCEPTS

Auraglyph was developed to explore ideas related to embodiment, gesture, and interaction in electronic music performance and composition, specifically related to musical programming[2] [18, 17]. To validate the extent to which it achieves these goals and to better understand the possibilities for using Auraglyph in live performance, we held a number of performances utilizing the software in a diverse set of performance contexts: solo and ensemble performances, trans-disciplinary performances, and performances involving pieces by multiple composers. Our belief is that to understand the capabilities of a new musical interface, it is necessary to explore its utility and expressivity in such a variety of musical settings.

Overall, our goals for developing a new mobile performance practice rest along the following axes:

- **Solo vs. ensemble performance**
  Solo and ensemble performance in electronic music can offer vastly different aesthetic and interactive possibilities. A solo performance requires a single individual to be responsible for the entirety of the musical result, placing a distinct set of constraints on them and thus on the musical interface they are using. In an ensemble performance, no single performer needs to carry the entire piece, and individuals may drop in or out as needed; a conductor can also be used to synchronize the ensemble in various ways. The demands placed on the performers and their instruments in this setting can be quite different than in solo performance. (Much of the ensemble work described here is inspired by the work of PLOrk, SLOrk, and other laptop-based performance ensembles.)

- **Embodiment**
  The distinctive characteristics of mobile technology equip it to naturally introduce gesturality and embodiment in musical performance. The physical form of these devices allows them to be easily picked up, moved around, and gestured with, and such devices also have sensors to detect these activities. Furthermore, modern smartphones and tablets devote nearly half of their physical surface area to a large screen; choosing appropriate graphics to display on this screen can greatly augment any physical metaphor implied in the underlying software. To paraphrase Wang in designing Ocarina, the effect is "not 'this simulates an [instrument],' but rather 'this is an [instrument]'" [27]. The ability to touch and directly interact with these on-screen graphics completes this sense of embodiment and the performer's connection to the software. These concerns may not have a direct impact on the sounds that are heard, but they do inform the relationship between the performer and their instrument. A sense of embodiment also provides audiences with something interesting to watch during a performance, which is evidently still valuable in electronic music.

- **Presence and Space** Earlier research efforts and practices by various laptop orchestras have emphasized space, both physical, acoustic, and virtual [6]. Wang, Essl, and Penttinen extend this out of the concert hall and into a larger regional or even global space using mobile devices, under the notion of "locative media" [29], an idea further explored by the concept of mobile devices performing on a so-called "world stage" [31]. The mobile music practice we have developed embraces these ideas, with the goal of exploring how space affects both the acoustic presence, visual impact, and conceptual identity of the musical works. Space as we use the term includes physical arrangements of performers and loudspeakers and the resulting spatialization of sound, the movement of performers or sound sources in space, and the relative distributions of performers and audience members in space.

4. PERFORMANCE PRACTICE
4.1 Solo Performance

Throughout the past year the first author has performed solo using Auraglyph in a number of contexts and venues (Figure 2). The first of these took place at California Institute of the Arts (CalArts), and included two pieces, called *DRONE* and *PULSE*. The former was essentially a technology demonstration in which a few basic oscillators and filters were combined to create a sonically intricate but musically threadbare piece.

PULSE was designed with a greater degree of musical intention. The piece begins with a slowly repeating bass note that echoes hypnotically; a zoomed-out version of the patch is visible in the center of the screen. Using Auraglyph's free drawing mode, the performer writes the name of the piece, their own name, and possibly other information such as the location or date. The performer then zooms in so that the musical patch fully occupies the screen and the written text is no longer visible; this three-dimensionalization of the patch hints at a sense of virtual space within the tablet itself. The performer begins to add short swells of noise layered above the bass. After some time, the single bass note abruptly switches into a full bass line at a higher tempo; the swirls of noise persist as the performer plays a melody by writing in individual MIDI note numbers. After the melody completes, the original bass pulse returns. The

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[1] `https://reactable.com/mobile/` (accessed 2018-04-10)
[2] As such, the authors consider Auraglyph's model of creating and patching audio and control processors to be a form of programming.

Figure 2: From a solo Auraglyph set.

noise swirls are further processed by modulating delay lines at high rates, gradually rendering the entire soundscape a wash of static. At last, the performer zooms back out to indicate the end of the piece, leaving the patch barely visible amidst the massive waveforms of the noise bursts, and showing the handwritten text from before (Figure 3).

Figure 3: The ending of *PULSE*. Waveforms that have been processed and blown completely out of proportion can be seen.

The first author continued to perform solo using Auraglyph in a number of venues, developing several new works in the process: *Midnight Signs* repeats a fairly conventional arpeggiated chord progression while the performer modulates the arpeggio register and timbre; in *Teeth*, the performer draws in real-time the waveforms and control signals that are sonified (Figure 4), similar to Iannis Xenakis' UPIC system [13] or Daphne Oram's Oramics Machine [12].

In most of these performances, a camera was positioned above the tablet and routed to a projector, displaying to the audience all of the performer's actions as well as Auraglyph's built-in visualizations of all processed waveforms and control signals (Figure 5). This setup ensured that the audience were aware of the exact activities of the performer; additionally Auraglyph's distinctive graphics provided a compelling visual dimension to the performance experience. The overall goal of this camera arrangement was to increase the transparency between performer, the music, and the audience, an issue of ongoing interest in the electronic music community.
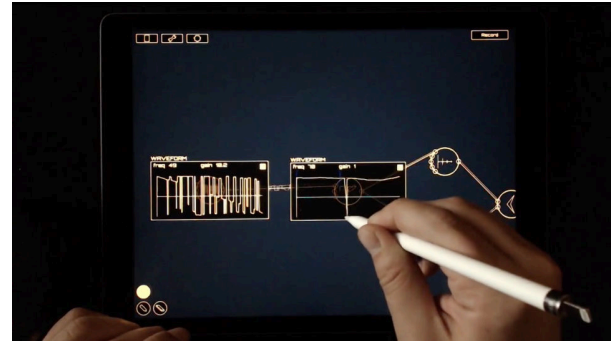
4.2 An Ensemble for Mobile Music

Figure 4: Drawing waveforms and control signals in real-time in *Teeth*.
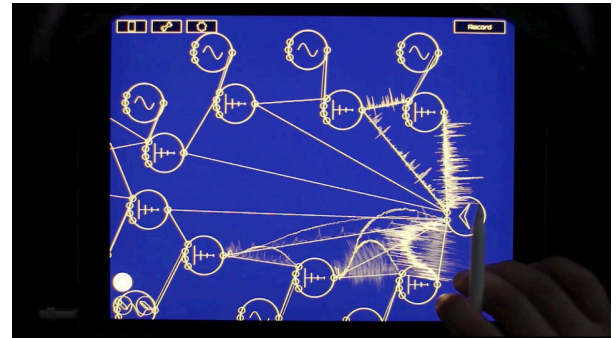

Figure 5: Waveforms in Auraglyph are displayed at every discrete step of audio processing.

The Mobile Ensemble of CalArts (MECA) was formed in 2016 to explore performance practice of mobile technology in an ensemble setting. The original ensemble was formed by the first author for his Composing for Robots course. A second edition formed among students of his Mobile Music Computing course, performing at the CalArts Digital Arts Expo. A third version of the ensemble formed from the Composing for Mobile Technology and Robots class, incorporating hardware updates in the form of individual hemispherical speakers and subwoofers for each member of the ensemble. The design of these speakers were derived from those used by the Stanford Laptop Orchestra. The use of separate amplifiers and loudspeaker for each performer ties in to Trueman's notion of "sonic presence" [23], as each performer's sonic contribution is separately framed, locational, spatialized by default, and individuated. In general, MECA's performances emphasize this notion of sonic presence and the physical space of music performance. A fourth version of MECA arose within a workshop called Immersive Media and Movement, in which various intermedia explorations were conducted.

4.2.1 Composing for Robots

The initial version of MECA came about when the first author introduced Auraglyph to his Composing for Robots course, consisting of a dozen undergraduate and masters-level music students. The class included a final concert. Here, the ensemble was made up of three sets of iPads and hemispherical speakers arrayed in a triangle across the performance space. Notably, this arrangement tethered the iPads to the hemispherical speakers, reducing their effective mobility. This was deemed an acceptable compromise given the limited need for mobility in this particular concert and given the improvement in loudness and sound quality provided by the speakers.

One of the concert pieces developed was *HedonismBot*, by Nathan Shaw, Kyle McCarthy, Ivy Liu, and Jake Turpin, in which iPad performers are combined with robotic instrumentation (Figure 6). The human performers begin by playing an Auraglyph patch in which their tablet's orientation is used to control an acoustic feedback loop with their corresponding speaker; this instrument is played by moving the tablet about the speaker, adjust its rotation and proximity to the speaker. After specific intervals, each performer brings their tablet to HedonismBot, a robotic instrument constructed for the piece, and offers the device to it in a ritualistic fashion. HedonismBot responds to this offering by playing an increasingly aggressive series of resonant mechanical clacks; after a number of these interactions it finally takes over the entire piece. The use of movement, both in the performance of the instrument and the theater of presenting the iPads to HedonismBot, illustrates an inventive use of mobile technology for electronic music performance.
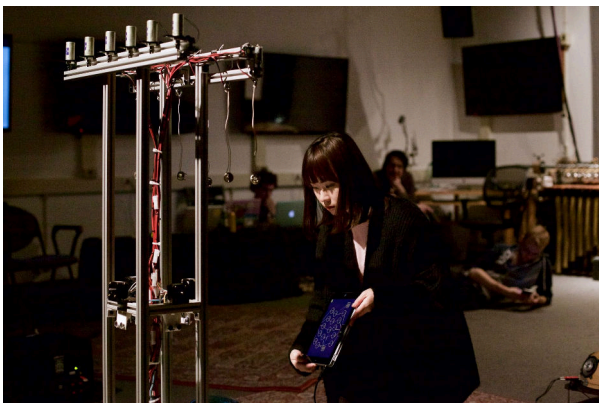

Figure 6: In *HedonismBot*, performers present their instruments to the eponymous robot.

4.2.2   Digital Arts Expo

MECA's next performance occurred at the CalArts Digital Arts Expo. In this arrangement, MECA performed using both mobile phones and iPad tablets, configured to project sound from their built-in speakers rather than plugged into separate loudspeakers. As such, every performers device was able to freely move about, untethered to any loudspeaker setup. Additional amplification was provided by positioning overhead microphones above the ensemble and projecting these microphone feeds over the house sound system. The concert's initial piece, *Smartphones*, began with the ensemble members calling one another on their phones and manipulating the phone-to-phone feedback loops that resulted from placing them in close proximity. The piece progressed using only sounds that would come about during normal phone use, such as dialtones, ringtones, voicemails, navigation directions, and interactions with the Siri personal digital assistant.

In another piece during this performance, *Eleven Rituals* for iPad, each performer was instructed to develop, in advance of the performance, three sonic textures: rhythmic, tonal drone, and noise. These performers were then conducted through a sequence of eleven distinct "rituals" of varying length. Each ritual interposed and combined the three textures in a musically significant fashion. While the specific sounds assembled in the piece were outside the control of the composer and, to a degree, unpredictable, musical form was created by the arrangement, repetition, and contrast of these sounds over the course of the performance.

4.2.3   Hack Music LA

MECA next reformed in anticipation of a commissioned performance at the Los Angeles Philharmonic's Hack Music LA event at Walt Disney Concert Hall in Los Angeles, California. For this performance, a set of eight hemispherical speakers were repaired and upgraded to work better with iPads, and eight subwoofers were purchased to supplement the hemis (Figure 7). Again, this arrangement tied the performers' devices to their individual speaker locations. The performance itself took place in a concrete amphitheater outside the hall, near the facility's garden and a few steps away from the city streets of downtown Los Angeles.
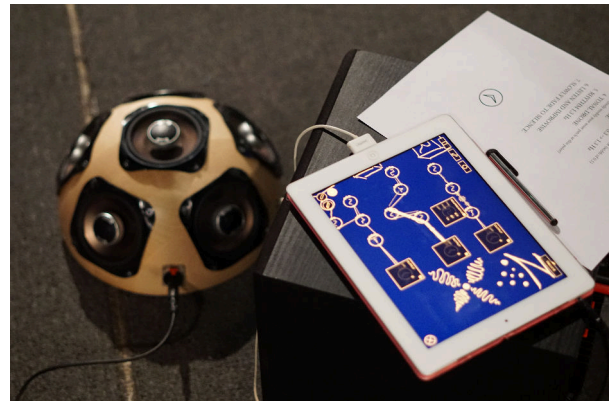

Figure 7:   Setup for an individual MECA performer: hemispherical speaker, subwoofer, iPad, stylus, score.

The ensemble developed a piece for the performance called *A sonic ritual for Auraglyph* (Figure 1). Reviving the concept of *Eleven Rituals*, three distinct sonic textures (rhythmic, tonal, and noise), were individually developed by each performer. A shorter, simpler score was produced for the piece, to fit the reduced time window required of the performance. 38 additional iPads were also rented and outfitted with the Auraglyph software, to be played by audience members during the performance.

The piece begins with each performer bringing in their rhythmic texture, eventually increasing its tempo to introduce a sense of tension. This tension resolves to a wash of noise, before settling to a serene drone. The ensemble then returns to the rhythmic texture; as they lower their volume, the audience is encouraged to join in with the unamplified iPads provided to them.

To prepare the audience for their participation in the performance, iPads were placed strategically around the amphitheater, with short instruction cards indicating generally what to do:

> *A sonic ritual*
> *for Auraglyph*
>
> When the conductor of the ensemble before you rises, you are invited to participate in the musical experience.
>
> Opening Auraglyph on the nearest iPad will activate your instrument. Your instrument's sound will change based on your movements, and can be retuned or reprogrammed on-screen. Explore; be curious; let your feet become ears.
>
> When the conductor returns to their seat, close Auraglyph and find stillness.

The audience assumedly had no previous experience with Auraglyph, as the software is not publicly available. When

audience members opened the iPads, a patch was preconfigured for them to play with, designed after the sound of a mouth harp. This patch included progressive levels of engagement an individual could partake in during the musical experience. At the very basic level, the iPads' orientation sensors were mapped to different parameters of the sound, such that simply moving the device around could effect sonic change. Utilizing Auraglyph's freehand drawing mode, the audience's patch also included diagrams indicating interesting on-screen controls to change, like frequency and modulation parameters. For the truly curious, indications were given of how to dynamically re-patch the program to more drastically affect its sound. Some members of the ensemble were planted in the audience to lead the experience and demonstrate how to use the instrument to individuals who needed additional direction. No explicit verbal indication of how or when to play was given during the performance.

The result was a dense sonic field, with moments of variety and change, pervading and reverberating through the concrete amphitheater. Amid the larger sonic texture created by the entirety of the audience, individuals could hear the sounds of their own device and those around them, imbuing the sonic experience with a sense of physicality and presence. No single listener heard the same sound. In a recording of the piece, audience members can be heard saying both "I don't get it" and "this is amazing;" most seemed enthusiastic to play and explore over the 5 minutes allotted before the conductor cued the end of the piece. After the cue, audience members realized the performance was concluding and dropped out one by one; the synthetic sounds of the iPads gradually gave way to the faint din of the urban cityscape. Following the performance, many came to the stage area to chat with the ensemble, learn more about what had just happened, and further explore the software instruments.

A sonic ritual for Auraglyph provides a study in the use of mobile devices for ensemble music performance, the use of space in electronic music, and the incorporation of the audience into a performance. Part performance and part technology demonstration, the event aimed to leave audience members with another perspective on how music can be created and experienced. The use of rental devices preloaded with MECA's custom software made the audience participation component completely seamless, avoiding the often shaky device setup stage of many audience participation concerts, though renting so many devices is a potentially costly option when most concert goers are likely to have their own mobile phone. The use of plants in the audience helped with this as well. The piece has since been performed a number of times at the authors' host institution, albeit without the audience participation component.

4.2.4 Immersive Media and Movement

The most recent formation of MECA was for a two week workshop titled Immersive Media and Movement. The workshop sought to integrate multiple artistic disciplines and media, including dance, electronic music performance, and 360 degree video capture. Over the course of the workshop, the workshop's two instructors, teaching assistants, and students developed a single mixed-media performance (Figure 8). 360 degree video footage, captured over the course of the workshop, was projected onto the walls of a square room and onto a white parachute hung from the room's ceiling. The videos captured a kind of totality of various external spaces, and then distorted these in the process of projecting them within the performance space. MECA provided a musical and sonic dimension to this distorted space. Five Auraglyph musicians, distributed to each side of the room,

progressed through an extended improvisation, in which the only explicit instructions were to listen, to "be bold," and to change their patch entirely every 5-10 minutes. Dancers, dressed in white, moved about the space, interacting with the video, manipulating their projections, and responding to the music.

Figure 8: Final performance of the Immersive Media and Movement workshop.

The performance comprised an hour and half of continuous video, music, and dance. It achieved its goal of constructing an immersive space, with performers describing the sensation of being "underwater." Interestingly, the musicians rarely looked up from their tablets throughout the entire event; while immersed in the musical space they had created, they did not seem responsive to the coexisting physical and visual space. Future collaborations of this sort might better support mutual engagement between the combined media and performances.

5. CONCLUSIONS

Overall, the performances documented demonstrate a breadth of settings, aesthetics, and integration with other media. As such, they show Auraglyph to be a versatile tool for performing music with mobile technology. To varying degrees, these performances have explored dimensions of solo and ensemble-based mobile music, issues of embodiment in digital music creation, and concerns related to space and presence in a music performance.

While the solo work as discussed only hints at any creation of a sense of space, we believe it has captured a sense of embodiment and a physical presence apparent to the performer and audience. This presence derives from the nature of interacting with Auraglyph and from the use of a projected overhead camera feed of the performer's tablet, making transparent the performer's actions and their relationship to sound and image.

The ensemble works for MECA presented introduce considerations of space into this performance practice. They achieve this through means common in the laptop orchestra model, such as the use of individual speakers and the physical distribution of performers, and through other means, such as audience participation. However, tethering the performers' devices to hard-wired speakers, as was done in most of the MECA concerts, reduces their mobility, diminishing their use of space in the sense of Wang's "locative media" [29]. As a whole, the works described put forward new ideas and considerations in the musical practice of mobile technology.

6. ADDITIONAL INFORMATION

A video abstract of this paper with performance excerpts is available here:

`https://www.youtube.com/watch?v=4xFNuLD9Amw`

7. ACKNOWLEDGMENTS

8. REFERENCES

[1] J. J. Arango and D. M. Giraldo. The smartphone ensemble. exploring mobile computer mediation in collaborative musical performance. In *Proceedings of the New Interfaces for Musical Expression Conference*, pages 61–64, 2016.

[2] T. J. Barraclough, D. A. Carnegie, and A. Kapur. Musical instrument design process for mobile technology. In *Proceedings of the New Interfaces for Musical Expression Conference*, pages 289–292, 2015.

[3] F. Behrendt. *Handymusik: Klangkunst und "mobile devices"*. epOs-Music, Osnabrück, Germany, 2005.

[4] C. Carlson and G. Wang. Borderlands-an audiovisual interface for granular synthesis. In *Proceedings of the New Interfaces for Musical Expression Conference*, 2012.

[5] N. d'Alessandro and T. Dutoit. Advanced techniques for vertical tablet playing a overview of two years of practicing the handsketch 1.x. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 173–174, 2009.

[6] R. Dannenberg. Laptop orchestra communication using publish-subscribe and peer-to-peer strategies. In *Proceedings of the 1st Symposium on Laptop Ensembles Orchestras*, pages 88–93, 2012.

[7] G. Essl. The mobile phone ensemble as classroom. In *Proceedings of the International Computer Music Conference*, 2010.

[8] G. Essl and M. Rohs. Interactivity for mobile music-making. *Organised Sound*, 14(2):197–207, 2009.

[9] J. Forsyth, A. P. Glennon, and J. P. Bello. Random access remixing on the ipad. In *Proceedings of the New Interfaces for Musical Expression Conference*, pages 487–490, 2011.

[10] D. Iglesia. The mobility is the message: The development and uses of MobMuPlat. In *Proceedings of the 5th International Pure Data Convention*, 2016.

[11] G. Levin, G. Shakar, S. Gibbons, Y. Sohrawardy, J. Gruber, E. Semlak, G. Schmidl, J. Lehner, and J. Feinberg. Dialtones (a telesymphony). `http://www.flong.com/projects/telesymphony/`, 2001. (Online, accessed 2018-04-10).

[12] P. Manning. The oramics machine: From vision to reality. *Organised Sound*, 17(2):137–147, 2012.

[13] G. Marino, M.-H. Serra, and J.-M. Raczinski. The UPIC system: Origins and innovations. *Perspectives of New Music*, 31(1):258–269, 1993.

[14] R. Michon, J. O. Smith, M. Wright, and C. Chafe. Augmenting the ipad: the bladeaxe. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 247–252, Brisbane, Australia, 2016.

[15] J. Oh, J. Herrera, N. J. Bryan, L. Dahl, and G. Wang. Evolving the mobile phone orchestra. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 82–87, 2010.

[16] T. Polashek and B. Meyer. Engravings for prepared snare drum, ipad, and computer. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 82–83, London, United Kingdom, 2014.

[17] S. Salazar. Searching for gesture and embodiment in live coding. In *Proceedings of the International Conference on Live Coding*, 2017.

[18] S. Salazar. *Sketching Sound: Gestural Interaction in Expressive Music Programming*. PhD thesis, Stanford University, Stanford, CA, USA, 2017.

[19] S. Salazar and G. Wang. Auraglyph: Handwritten computer music composition and design. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 106–109, 2014.

[20] K. Schlei. Tc-11: A programmable multi-touch synthesizer for the ipad. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2012.

[21] T. Shaw, S. Piquemal, and J. Bowers. Fields: an exploration into the use of mobile devices as a medium for sound diffusion. In *Proceedings of the New Interfaces for Musical Expression Conference*, pages 281–284, 2015.

[22] J. Snyder and A. Sarwate. The mobile device marching band. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2014.

[23] D. Trueman. Why a laptop orchestra? *Organised Sound*, 12(2):171–179, 2007.

[24] D. Trueman, P. Cook, S. Smallwood, and G. Wang. PLOrk: the Princeton Laptop Orchestra, year 1. In *Proceedings of the International Computer Music Conference*, pages 443–450, 2006.

[25] S. Trump and J. Bullock. Orphion: A gestural multi-touch instrument for the ipad. In *Proceedings of the New Interfaces for Musical Expression Conference*, pages 159–162, 2014.

[26] J. von Falkenstein. Gliss: An intuitive sequencer for the iphone and ipad. In *Proceedings of the New Interfaces for Musical Expression Conference*, pages 527–528, 2011.

[27] G. Wang. Ocarina: Designing the iPhone's magic flute. *Computer Music Journal*, 38(2), 2014.

[28] G. Wang, N. Bryan, J. Oh, and R. Hamilton. Stanford Laptop Orchestra (SLOrk). In *Proceedings of the International Computer Music Conference*, 2009.

[29] G. Wang, G. Essl, and H. Penttinen. The mobile phone orchestra. *Oxford Handbook of Mobile Music Studies*, 2:453–469, 2014.

[30] G. Wang, J. Oh, and T. Lieber. Designing for the iPad: Magic Fiddle. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 197–202, 2011.

[31] G. Wang, S. Salazar, J. Oh, and R. Hamilton. World Stage: Crowdsourcing paradigm for expressive social mobile music. *Journal of New Music Research*, 44(2):112–128, 2015.