Connecting Web Audio to Cyber-Hacked Instruments in Performance

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ABSTRACT

Artists and composers of distributed and networked music tend towards mobile devices that contain web browsers (smartphones, tablets, and laptops) as their primary mechanism for creating interactive sonic works. This integrates well with technologies explored at this conference such as web audio, web sockets, web midi, device sensors and click/touch interactions in conjunction with the computational devices themselves. As audiences are increasingly exposed to distributed & networked musical performances (D/NMP) presented through their personal, do-it-all devices, the opportunity arises to move beyond this novelty and expand the palette of networked devices while retaining musical comprehensibility.

To expand the pool of possible hardware devices capable of controlling, reacting to, generating sound and processing sound in collaboration with web audio-based applications, we present artistic endeavors in creating and composing with the recent frameworks Bendit_I/O[1] and NexusHUB[2]. Together they allow nearly any commercially-available electronic device to be cyber-hacked and performed collaboratively along with web audio applications in typical D/NMP settings. Interrogation of select historical precedents and an explanation of the Bendit_I/O and NexusHUB frameworks, precede discussion of the *gravity|density* performance showcasing the potential for expanding the pool of web audio art into the realm of re-purposed technology and the Orchestra of Things (OOT/IoMusT).

1. INTRODUCTION

The proliferation of compact, powerful, and accessible mobile devices across the planet provide artists of distributed and networked music with a hardware-based outlet for disseminating web-based graphics and audio in performance. A 2019 study by the Pew Research Center found that an estimated 5 billion people globally own mobile devices, with half of those devices being smart phones and the strongest concentration of those phones located in nations with advanced economies[17]. With their near global ubiquity, plethora of on-board sensors, and integration of multi-point click/touch interactions through high-quality touchscreens, it is not surprising to see these devices become fully integrated into the world of web audio.

Figure 1: gravity|density spinning discs

1.1 Incorporating Cyber-Hacked Devices

While smartphones and other mobile devices will no doubt continue to play a prominent role in the performance of interactive Web Art, new research in the realm of the Internet of Musical Things (IoMusT)[18] and the Orchestra of Things[4] demonstrates a creative potential in utilizing custom-made web-enabled instruments that, in conjunction with mobile devices, can be seamlessly merged with web audio systems in D/NMP performance settings. At the same time, the proliferation of IOT and smart home devices (ranging from automated security systems to remote-controlled cookware) in the worldwide consumer market may allow for audience members to become more familiar with the activity of remotely interacting with and influencing the actions of hardware through their mobile devices.

As the traditional web audio toolsets become more popular and advanced, the time is right to expand the pool of possible hardware devices capable of controlling, reacting to, generating sound and processing sound in collaboration with web audio-based applications. Our interest was peaked when we considered the possibilities of merging the artistic practice of circuit bending/hardware hacking (which centers on the act of creating avant-garde instruments out of existing consumer toys and hardware through modification of the device's internal circuity[15][6]) with the same approach to networked performance topologies practiced by web audio

[1]https://www.benditio.com/
[2]https://github.com/nexus-js/nexusHub

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artists. Performing with hacked hardware draws connections to the Upcycling movement and highlights a nostalgic connection between the audience, performer, and the device. It is our hope that interacting with repurposed technology through the use of mobile devices will serve as a natural extension of web interactivity with online media. For example, the same touch and drag interactions across a graphical, web page UI often used for modifying playback of a sound sample could now extend to the skipping and seeking functions of a hardware CD player or tape machine.

This research led to the creation of two new frameworks: Bendit_I/O[9] by the first author and NexusHUB[3] by the second author. Together, these hybrid hardware/software frameworks allow almost any commercially-available electronic device to be cyber-hacked and performed collaboratively along with web audio applications in typical D/NMP settings.

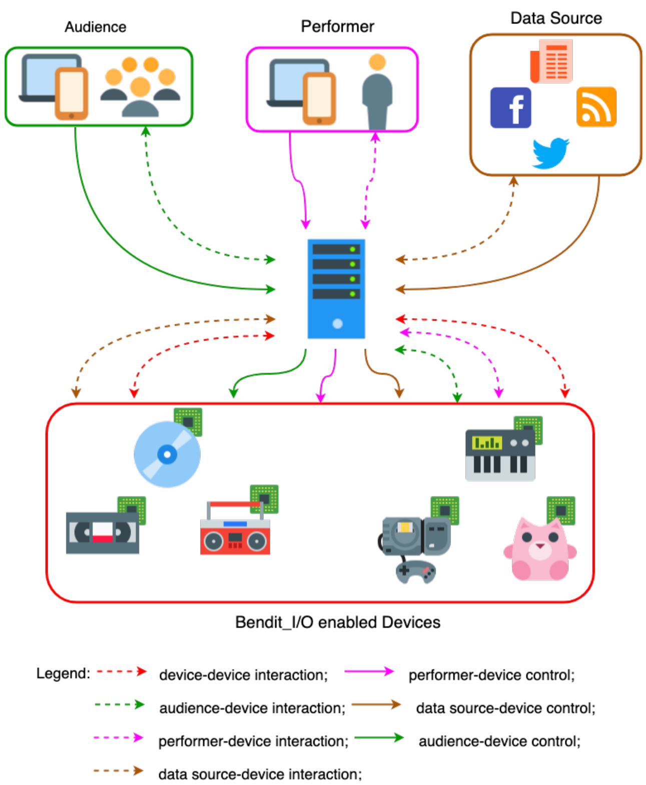

Figure 2: Possibilities for interaction and control between connected users and hacked devices using the Bendit_I/O and NexusHUB frameworks.

2. HISTORICAL PRECEDENT

Performance using interconnected electronic devices has been explored since the advent of electronic devices. The development of modular synthesizers, explorations by David Tudor[5], explorations at the San Francisco Tape Music Center, and such groups as the HUB all provided prescient work at connecting computer and electrical devices for making music. Our exploration is specifically rooted in manipulating the internet, the standardized global computational communication platform, to connect with electronics that were not designed to be able to communicate over this network. To reach this state, these prior explorations happened:

1) Traversal[7], a series of pieces from 2007 to 2012 by John Fillwalk and Jesse Allison using a web server to connect audience cell phones; touch screen interfaces; virtual objects, structures and avatars in Second Life; and musically performable physical objects such as a bell tower, carillon, and midi-controlled organ together for live performance.

2) control of networked musical robotic devices exemplified by the work of Eric Singer and the League of Electronic Musical Urban Robots[14] [10] [13], the work of Ajay Kapur and collaborators [19] [8], and the robotic musical works of Trimpin[8].

3) hacking of electronics to make musical and artistic sonic art such as the CD skipping artwork of Nicolas Collins[16] the techniques of which were codified and disseminated in the original Hardware Hacking book and the subsequent book Handmade Electronic Music[6]

4) Web Audio and distributed performance systems enabling interconnected, browser-based music making such as NexusHUB, Sebastian Piquemal's Rhizome project [12], and the Soundworks framework from IRCAM [11]. These helped bridge the gap between musical distributed performance and performance over an Orchestra of Things or Internet of Things.

Each of these developments coalesced into a number of prior artworks by the artists including Anthony Marasco's *The Spinning Earth will Spread Before You* (2019) for two web-controlled circuit-bent CD players and the works *Causeway* and *Diamonds in Dystopia* by Jesse Allison, Derick Ostrenko, and Vincent Cellucci for poet and audience mobile devices[2] [1].

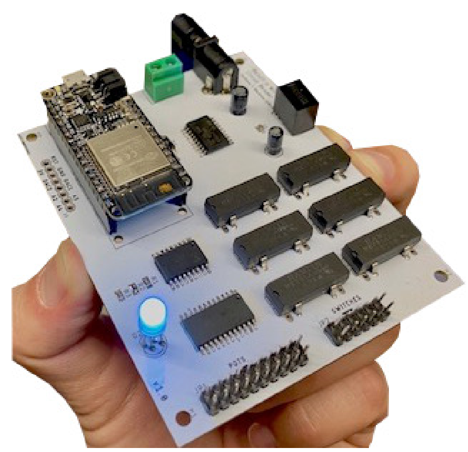

Figure 3: The Bendit_I/O board.

3. OVERVIEW OF HARDWARE & SOFTWARE DESIGN

The Bendit_I/O system consists of two components: a Wi-Fi-enabled I/O board (which users connect to a hacked device) and an accompanying software. The Bendit_I/O board contains an ESP32 microcontroller, an eight-channel digital potentiometer IC, eight reed relay switches, and a dual-H bridge motor driver. Output signals from the board terminate in multi-pin headers or screw terminal connectors, allowing users to replace physical switches or dials typically used for connecting bend points on a hacked device with the cabling attached to a Bendit board[9].

Connecting the Bendit-hacked devices is a NexusHUB server, allowing them to communicate both amongst themselves and with any other web-enabled devices (mobile devices, laptops, etc.).

The NexusHUB framework is a tool for managing distributed performance across browsers and OOT/IoMusT arrangements utilizing web-sockets. It offers a relatively standard setup of various pages for audience members, performers/controller pages, web-socket connections to external audio or media applications, and a page for projection/display. In conjunction with Bendit_I/O it provides a centralized server that can sample recordings of sounds live at the server, can serve client web pages to audience members which can sample and upload recordings from their device, and can distribute the live recordings to any client browser for playback and/or manipulation. As the recordings are also on the server, they can be controlled and played back directly on the central server over house sound system, or into further processing devices.

4. COMPOSING WITH THE SYSTEM

Working within this combined system, we have composed *gravity|density*, an interactive work for cyber-hacked devices and web audio applications.

In *gravity|density*, we begin by manipulating fixed-audio sources through the performance of hacked CD players. The sonic results of this mangled audio is sampled by audience members and can be played back alternately by the audience, and then shifting into passive mode and performed dynamically across the field of audience mobile devices. This passive distribution of recordings allow us to create intricately-spatialized rhythmic interplay between the glitching CD players and the blanket of overlapping samples dispersed throughout the networked audience. Active distributions allow the audience to join in our performance; by choosing small portions of the audio sampled and sending these selected samples back to us, we string this audio together and feed it into a cyber-controlled distortion pedal before feeding it back to the audience for more samping and manipulation. This results in overlapping cycles of control and audio generation between performer, audience, network, and machine.

The work received its world premiere in Trondheim, Norway at the fifth Web Audio Conference in December of 2019. Figures 3-4 demonstrate performance elements of *gravity|density* including the cyber-hacked CD players and distortion pedal, and the audience-participation web interface.

5. FUTURE DIRECTIONS

The Bendit_I/O and NexusHUB systems are almost infinitely expandable. As new electronic objects are hacked and able to be controlled, it expands not only the sound palette that is available, but also folds in the social meanings inherent in the physical interactions with each object. This meaning can then be used to make connections between the audience and the disturbed technology. Looking forward, electronics such as coffee grinders, flashlights, alarm clocks, toothbrushes, and other day-in-the-life type objects can be incorporated for pieces that abstract, or toy with the sounds

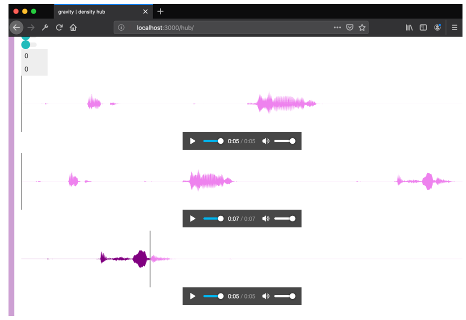

Figure 4: gravity|density hub containing samples captured by the audience

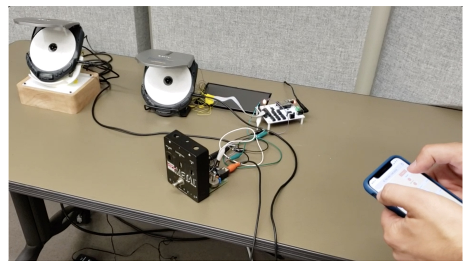

Figure 5: gravity|density performed with Bendit_I/O cyber hacking

of our 21st century lives. Drones are also a natural hacking target as they are becoming increasingly inexpensive, noisy, and have a developing identity in unregulated intrusiveness via surveillance and warfare that offers substantial areas for artistic exploration and societal critique.

On the systemic side, further development of the control structures for interacting with hacked electronics are being explored. Many of these are moving away from direct control of the device and into mapped or process based control that may have more meaning, or at the very least allow for performers to incorporate more devices in sophisticated arrangements. These include using data sources to sequence and trigger events, procedural control that can create musical textures, aggregated audience input, and events generated by devices which are mapped to other devices creating a cyber-rube-goldberg machine.

6. DOCUMENTATION

Further information about our work composing with these frameworks can be found at https://gravity.emdm.io/.

7. REFERENCES

[1] J. Allison, V. Cellucci, and D. Ostrenko. Creative data mining diamonds in dystopia. *Media-N*, 13(1), 2017.

[2] J. Allison, D. Ostrenko, and V. A. Cellucci. Causeway. Georgia Institute of Technology, 2016.

[3] J. T. Allison, Y. Oh, and B. Taylor. Nexus: Collaborative performance for the masses, handling instrument interface distribution through the web. In *NIME*, pages 1–6, 2013.

[4] S. D. Beck and C. Branton. The orchestra of things: a new approach to managing, controlling, and composing for laptop and mobile device ensembles.

Presented at the 30th Annual SEAMUS conference, Virginia Tech, Blacksburg, VA, 2015.

[5] N. Collins. Composers inside electronics: Music after david tudor. *Leonardo Music Journal*, 14(1):iv–1, 2004.

[6] N. Collins. *Handmade electronic music: the art of hardware hacking*. Routledge, 2014.

[7] J. Fillwalk and J. Allison. Between two worlds: Virtuality in arts and teaching. *MG 2009 Proceedings*, page 6, 2009.

[8] A. Kapur, M. Darling, J. Murphy, J. Hochenbaum, D. Diakopoulos, and T. Trimpin. The karmetik notomoton : A new breed of musical robot for teaching and performance. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 228–231, Oslo, Norway, 2011.

[9] A. T. Marasco, E. Berdahl, and J. Allison. Bendit_I/O: A system for networked performance of circuit-bent devices. In M. Queiroz and A. X. Sedó, editors, *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 331–334, Porto Alegre, Brazil, June 2019. UFRGS.

[10] B. Neill and E. Singer. Ben neill and lemur. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 331–331, Pittsburgh, PA, United States, 2009.

[11] S. G. B. M. Norbert Schnell, Jean-Philippe Lambert. Soundworks, 2015.

[12] S. Piquemal. Rhizome, 2014.

[13] E. Singer, J. Feddersen, and B. Bowen. A large-scale networked robotic musical instrument installation. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 50–55, Vancouver, BC, Canada, 2005.

[14] E. Singer, J. Feddersen, C. Redmon, and B. Bowen. Lemur's musical robots. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 181–184, Hamamatsu, Japan, 2004.

[15] J. Skjulstad. Circuit bending as an aesthetic phenomenon. Master's thesis, University of Oslo, 2016.

[16] C. Stuart. Damaged sound: Glitching and skipping compact discs in the audio of yasunao tone, nicolas collins and oval. *Leonardo Music Journal*, pages 47–52, 2003.

[17] K. Taylor, L. Silver, K. Taylor, and L. Silver. Smartphone ownership is growing rapidly around the world, but not always equally. *Pew Research Center's Global Attitudes Project*, Feb 2019.

[18] L. Turchet, C. Fischione, G. Essl, D. Keller, and M. Barthet. Internet of Musical Things: Vision and Challenges. *IEEE Access*, 6:61994–62017, 2018.

[19] N. D. VillicaÃśa-Shaw, S. Salazar, and A. Kapur. Mechatronic performance in computer music compositions. In T. M. Luke Dahl, Douglas Bowman, editor, *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 413–418, Blacksburg, Virginia, USA, June 2018. Virginia Tech.