

STANFORD LAPTOP ORCHESTRA (SLORK)

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ABSTRACT

In the paper, we chronicle the instantiation and adventures of the Stanford Laptop Orchestra (SLOrk), an ensemble of laptops, humans, hemispherical speaker arrays, interfaces, and, more recently, mobile smart phones. Motivated to deeply explore computer-mediated live performance, SLOrk provides a platform for research, instrument design, sound design, new paradigms for composition, and performance. It also offers a unique classroom combining music, technology, and live performance. Founded in 2008, SLOrk was built from the ground-up by faculty and students at Stanford University's Center for Computer Research in Music and Acoustics (CCRMA). This document describes 1) how the founding members built the Stanford Laptop Orchestra from laptops, IKEA salad bowls, amplifier kits, car speakers, meditation mats and pillows, commodity input devices, and custom software, 2) the initial performances of SLOrk, including a large-scale outdoor concert, as well as a networked concert between Stanford and Beijing, and 3) the Stanford Laptop Orchestra as a classroom. In doing so, we hope to present a history of the laptop orchestra, and look to its future.

1. INTRODUCTION

The Stanford Laptop Orchestra (SLOrk) is a large-scale, computer-mediated ensemble that explores cutting-edge technology in combination with conventional musical contexts - while radically transforming both. Founded in 2008 by director Ge Wang and students, faculty, and staff at Stanford University's Center for Computer Research in Music and Acoustics (CCRMA), this unique ensemble comprises more than 20 laptops, human performers, controllers, and custom multi-channel speaker arrays designed to provide each computer meta-instrument with its own identity and presence. The orchestra fuses a powerful sea of sound with the immediacy of human music-making, capturing the irreplaceable energy of a live ensemble performance as well as its sonic intimacy and grandeur. At the same time, it leverages the computer's precision, possibilities for new sounds, and potential for fantastical automation to provide a boundary-less sonic canvas on which to experiment with, create, and perform music.



Figure 1. The SLOrk classroom in action.

Offstage, the ensemble serves as a one-of-a-kind learning environment that explores music, computer science, composition, and live performance in a naturally interdisciplinary way. It also provides a unique research platform for exploring new performance paradigms, new instruments, as well as novel expressive uses of technology.



Figure 2. SLOrk's multi-channel speaker arrays.

In this document, we chronicle the adventures of the Stanford Laptop Orchestra from its instantiation to its current form. In Section 2, we describe the SLOrk aesthetic and examine related works. In Section 3, we describe the process in which over 30 faculty, students, and staff worked together to build the ensemble, starting with

designing the SLOrk hemispherical speaker arrays out of wooden salad bowls, car speakers, amplifier kits, and many other spare parts, resulting in 20 speaker arrays presenting 120 independently addressable channels of audio. We also describe the ingredients of SLOrk, from laptops, to breakfast tables, meditation mats and pillows, joysticks, MIDI controllers, and much more. In Section 4, we describe some of the major performances and the ideas behind them, including a large-scale outdoor concert, a live networked concert with musicians in Beijing, as well as an “electronic chamber music” performance featuring pieces by the members of the ensemble. We then discuss the SLOrk classroom, and conclude with a look to the future, including integration with MoPhO, the Stanford Mobile Phone Orchestra.

2. AESTHETIC AND RELATED WORK

The Stanford Laptop Orchestra embodies an aesthetic that is also central to the Princeton Laptop Orchestra [9, 11, 12, 14], or PLOrk - the first ensemble of this kind, while fully leveraging CCRMA's natural intersection of disciplines (Music, Electrical Engineering, Cognition, Physical Interaction Design, Performance, and Computer Science, etc.) to explore new possibilities in research, musical performance, and education.



Figure 3. Stanford Laptop Orchestra performs.

The SLOrk aesthetic is comprised of several ideas, one of which is that of “meta-instruments” coupled with speaker arrays that mapproximates how traditional acoustic instruments radiate sound during performance, offering more intimate and localize sound sources, comparing to PA-style amplification systems. Another component of the aesthetic is that the ensemble is as much a “computer orchestra” as it is a “human-computer orchestra”. Perhaps ironically, the sheer critical mass of technology in the laptop orchestra context accentuates, not diminishes, the symbiotic and fundamental need for humans. Ensembles like PLOrk and SLOrk seek not to replace humans with computer, but rather find “sweet spots” that maximize the

strengths of each – computers and their precision, possibility for new sounds, and tireless nature, combined with the intentions, expressiveness, and social engagement of humans. In this sense, the laptop might be thought of as an entirely different race of beings that can achieve great synergy with its human counterpart. Furthermore, SLOrk believes in the laptop orchestra as a potential new classroom for interdisciplinary, experiential learning – naturally combining music, sound synthesis, computer science, and live performance.



Figure 4. PLOrkists in Princeton Laptop Orchestra.

Recently, more laptop-mediated ensembles have emerged, including CMLO: Carnegie Mellon's Laptop Orchestra [3], MiLO: the Milwaukee Laptop Orchestra [1], the Worldscape Orchestra [7], with recent and upcoming ensembles in Tokyo, Moscow, Oslo, and Bangkok. Each of these ensembles offers a vision on what a laptop orchestra can be. While these may be quite different from that of SLOrk (and PLOrk), it is consistent with the idea that a laptop orchestra is meant to be open-ended, much like the computer itself, and awaits human creativity to shape it for expressive use. In this sense, each laptop orchestra is a “meta-orchestra” - a gplatform for crafting potentially many different laptop orchestras.

It is with a holistic combination of these notions that the founding members of SLOrk set out to create the ensemble. The follow sections chronicle the process and the results.

3. BUILDING AN ENSEMBLE

3.1. Pre-Laptop Orchestra

In the beginning of 2008, a one-time course was offered at CCRMA, titled “Pre-Laptop Orchestra”, with the ultimate goal of making SLOrk a fully functioning ensemble and platform, and in time for the full course in Spring 2009, titled “Composing, Coding, and Performance with Laptop Orchestra”. Over 30 individuals participated, including Masters students in CCRMA's Music, Science, and

Technology program, CCRMA PhD students, and undergrads from Music, Computer Science, and Symbolic Systems, as well as faculty and staff members.

The Pre-Laptop Orchestra operated on several concurrent tracks. The availability of compact, efficient, low-cost amplifiers and the desire to maximize mobility for the ensemble motivated a campaign design the SLOrk speaker array from scratch, combining speaker drivers and amplifier. Another track focused on drafting and finalizing the hardware specification for the ensemble, addressing the practical aspects of how each SLOrk station works, as well as how the ensemble as a whole is set up. Decisions needed to be made at every level, from choosing the laptops, audio interfaces, external input devices, to all wiring/cabling, power, networking, spatial arrangement of each station, transportation and storage. Another track addressed the software architecture and data storage for the ensemble. These are addressed in details in the next two subsections.

3.2. Speaker Array Design

SLOrk makes use of twenty multi-channel speaker arrays. Each speaker array consists of six discrete car audio speakers, six onboard amplifiers, a hemispherical wooden enclosure, six $\frac{1}{4}$ " mono TS audio jacks, a single ON/OFF switch, and requires a single 12V DC power supply. The overall design goal was to provide an acoustical "point source" immediately adjacent to a performer in a lightweight and mobile fashion. This strongly couples each laptop performer with his or her own localizable sound and more closely emulate typical acoustical instruments in traditional ensembles [10].



Figure 5. Making speaker arrays out of salad bowls.

The main design and building process can be separated into three categories: enclosure, amplifier, and external interface. The enclosure consists of a commercially available wooden hemisphere (e.g., IKEA salad bowl) and wooden base plate, structurally holding five speakers on a 360-degree periphery with a single speaker pointing up.

The speaker amplifier is housed within the enclosure and consists of six discrete amplifiers in the form of three modified stereo Sonic Impact 5065 Generation 2 T-Amps. The speakers, amplifier, and external audio inputs are then fully connected via the external interface (or faceplate) that provides six discrete audio inputs and the necessary power connections.



Figure 6. Building hardware and software of SLOrk.

To effectively approximate such an acoustic point source, numerous speaker enclosure shapes were explored including spherical, tetrahedral, and hemispherical. While the spherical and tetrahedral designs were interesting in their own regards, practical issues limited the feasibility of such enclosures, ensuing the hemispherical design. Additionally, commodity hemispherical enclosures (salad bowls) were found to greatly reduce enclosure cost and construction and arguably improve the sound quality and aesthetic.



Figure 7. A finished speaker array with faceplate.

When considering the speaker amplifier, minimal additional hardware was necessary to greatly increase the mobility and ease of setup requirement of the ensemble. First designs included external audio amplifiers (pre-built and home assembly kits) housed within considerably small

external enclosures, but after much deliberation even small external amplifiers were considered undesirable. Because of this, compact commercially available audio amplifiers were used with slight modification to additionally reduce the physical footprint of the amplifier. The faceplate was then straightforwardly designed to connect the modified amplifiers to the six speakers and audio inputs. For a more thorough description and step-by-step guide to the building process, please visit: <http://slork.stanford.edu/speakers/>

3.3. Integration

In addition to the twenty speaker arrays, Pre-SLOrk decided on the following specifications for the initial ensemble:

Each of the twenty laptop stations is to contain the following: 13" black MacBook MOTU Ultralite audio firewire interface, custom SLOrk speaker array, IKEA breakfast tray (for holding the laptop), meditation mats and pillows (where the player sits), custom 6-channel audio snakes, and powerstrip. A finished station can be seen in Figure 10.



Figure 8. Members of SLOrk build the ensemble.

Shared among the ensemble are the following: 802.11 wireless switch, 802.5 wired gigabit ethernet switch, 4 power conditioners, 10 TriggerFinger USB MIDI interfaces, 8 USB MIDI keyboards, 20 USB joysticks, Microphones (Shure SM-57 and Shure KSM-237), storage bins.

In terms of software, the ensemble uses ChucK [13, 16] as its primary vehicle for instrument mapping, sound generation, and teaching, while always remaining open to using any other software. SLOrk makes extensive use of the Small Musically Expressive Laptop Toolkit (or SMELT) for quickly prototyping instrument from laptop's native input devices [4]. Subversion (SVN) is used for version control, synchronizing a central repository of instruments and pieces across the ensembles.



Figure 9. Routing the bottom plates of speaker arrays.

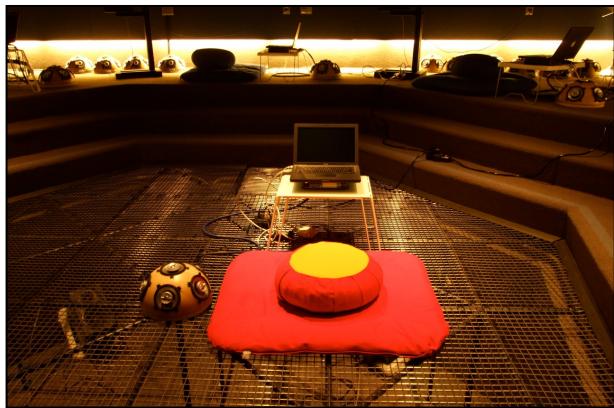


Figure 10. A finished SLOrk station.

4. PERFORMANCES

The Stanford Laptop Orchestra commenced its inaugural term in Spring 2008, offering a number of performances, taking place as part of the "Composing, Coding, and Performance for Laptop Orchestra" course. This section describes some of the performances and the ideas associated with each.

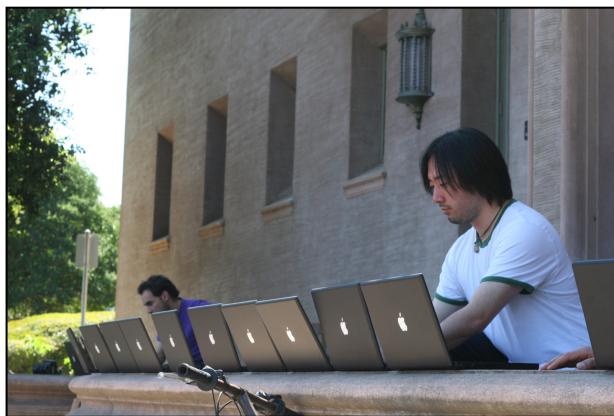


Figure 11. Preparing laptops outside of CCRMA.

4.1. Sonic SLOrk Sculptures

The first official concert for SLOrk took place at the New Guinea Sculpture Garden, Stanford University. This performance was the first full-scale outdoors laptop orchestra performance, involving twenty laptop stations. Because of its unique outdoors setting, the group had to figure out solutions to uncommon problems such as acquiring power, sending wireless signals (the switch had to be placed on a high tree branch to gain line of sight to the distributed stations), and working with ambient noise. The audience was encouraged to sit close to a station to observe the performers, and even to walk around during the performance to hear the soundscapes generated by the ensemble (Figure 12).



Figure 12. SLOrk set up throughout the sculpture garden.



Figure 13. *Onstage:* Stanford Laptop Orchestra and Stanford New Ensemble; *Onscreen:* Musicians at the Central Conservatory of China.

4.2. Pacific Rim of Wire

Another major concert performed by SLOrk was the Pacific Rim of Wire, at Dinkelpiel Auditorium, Stanford University. This was an online concert with China, as part of the 2008 Pan-Asian Music Festival. In this first laptop orchestra telematic concert, musicians from SLOrk and the

Stanford New Ensemble connected with musicians of Central Conservatory of China in Beijing to perform - in real time via a webcast - a program that celebrates music, technology, and international collaboration [2]. (Figure 13)

4.3. SLOrktaastic Chamber Music

In contrast to the Sonic SLOrk Sculptures and the Pacific Rim of Wire concert with China, which were performances that incorporated all twenty laptop stations, the SLOrktaastic Chamber Music concert featured student-composed works in an intimate chamber music setting. All eighteen pieces showcased in the concert were product of a classroom assignment, and each piece reflected the creativity of the student composer. While the original homework assignment called for either (1) an instrument for a single hemi using ChucK that takes advantage of the multi-channel aspect, or (2) a piece for five laptops that is unamplified except for onboard laptop speakers, many students took the liberty to further develop their pieces to their fullest artistic potential. The following is a brief highlight of some of the pieces presented:

Clair De Lupe, by Baek Chang, is a granular synthesis interpretation of Clair De Lune by Claude Debussy. It uses a multigrained granular synthesis patch programmed in ChucK. Two grains come out of each hemispherical channel simultaneously, for a total of twelve at a time (per laptop station). The piece offers a precise keyboard control over various parameters including the grain size, amount of randomness, and position along the buffer. This flexible control allows the performer to beautifully craft the original tune of Clair De Lune. The granular synthesis ChucK patch designed for this piece has now been adapted by other SLOrk works.



Figure 14. q3osc in action, each lizard entity is controlled by a SLOrkist. Here the ensemble constructs a musical lizard pyramid.

nous sommes tous des Fernando...., by Robert Hamilton, is an improvisatory work written for the SLOrk using

q3osc [6] as a user-interface for sound synthesis and spatialization in ChucK. A screen projected in front of the hall displays a virtual environment, in which four performers control avatars: firing sound-projectiles which bounce or home-in on individual performers, creating sound events with every bounce/collision. This piece is both visually and sonically stimulating, and has also been performed by full-scaled SLOrk outdoors (Figure 14).



Figure 15. A conductor leads during SLOrktastic Chamber Music.

PopcorN, by Jieun Oh, is a multi-sensory piece that simulates popcorn being popped inside a microwave. Over a period of about three minutes, six laptop stations creates a 'pop' noise, reaching maximum popping frequency and intensity about 20 seconds prior to the end. Once the time is up, the microwave beeps three times to signal the end of the piece-- at which point real, edible popcorns with their buttery scent is brought into the concert hall for the audience to taste.



Figure 16. Adnan and Kyle negotiates twenty laptops.

20, by Kyle Swenson Spratt and Adnan Marquez-Borbon, is “an experiment in emergence” that plays with the concept of “the independence of sound and its liberated behavior from human control.” The work involves two performers working through a pile of laptops: for each laptop, they (1) initiate a ChucK program that delays and

pitchshifts the input sound and plays it out of the laptop's onboard speakers, (2) place the laptop carefully by other already-playing laptops, and (3) close its screen about two-thirds of the way to act as crude physical filters. The end result is a giant sound-emitting physical sculpture of twenty laptops (Figure 16). When the end of the piece is reached, the performers close the computer screens all the way, which results in the laptops' falling asleep.

As suggested by the sample of pieces above, the SLOrktastic Chamber Music concert served as an opportunity for the students to express their musical creativity, resulting in a new variety of laptop orchestra pieces that take advantage of the nature of laptop as a meta-instrument.

4.4. Additional Performances

In addition to the above performances, the Stanford Laptop Orchestra has performed at various venues, including Maker Faire, MacWorld, and for the Bay Area Music Technology Group.



Figure 17. Electronic chamber music at CCRMA Stage.

5. THE SLORK CLASSROOM

A typical SLOrk classroom naturally integrates aspects of composing, coding, and performance. The beginning of quarter is usually spent exploring existing repertoire to offer new students a sense of what it is like to perform in a laptop orchestra. These sessions spark a lively conversation on the students' initial reactions, which often include sharing ideas for improvement.

As part of the coursework, students also bring to the classroom new compositions for the laptop orchestra. These composition assignments give students opportunities to create new pieces, which are then presented and tried out during class in a chamber setting. Though coding is a natural element of composing, students become experienced with programming also through live-coding practice sessions. During such sessions, students experiment with sculpting sound on the spot by manipulating the code at a variety of levels.

Finally, performance is an integral part of the SLOrk classroom. During rehearsals, students learn about the interface controls to a given piece, become familiar with the conductor's gestures, and come to understand the artistic aims of a piece. Through rehearsals students learn to become a sensitive performer, focusing on the quality of the sound generated and striving for high musicality.



Figure 18. SLOrk classroom in action.



Figure 19. The SLOrk classroom takes place onstage and in more traditional lecture-style settings.

6. ONGOING AND FUTURE WORK

More recently, the Stanford Laptop Orchestra has been exploring mobile composition and performance paradigms with the Stanford Mobile Phone Orchestra (MoPhO) [15]. In many ways, the localized sound sources of mobile devices resemble that of the laptop orchestra, while mobile phone offers a fundamentally different type of computational device that can be more personal, mobile, and can take advantage of wide area location (via GPS).

The laptop orchestra's annual cycle includes two terms of workshop to build new compositions, instruments, and technology as a way to continually innovate the ensemble. As always, new classroom explorations are constantly being explored.

In addition, SLOrk, in collaboration with PLOrk, is exploring using music information retrieval (MIR) techniques in the service of real-time performance, looking towards a new class of instruments that can learn and adapt on-the-fly [5].

In conclusion, the Stanford Laptop Orchestra presents a large-scale, robust, and long-term platform and meta-orchestra. The challenge is find ways to leverage both the computational power of machines and the expressiveness of humans. The Stanford Laptop Orchestra homepage can be found at:

<http://slork.stanford.edu/>



Figure 20. SLOrkists look happily to the future!

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