Introducing L²Ork: Linux Laptop Orchestra

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ABSTRACT

Virginia Tech Department of Music's *Digital Interactive Sound & Intermedia Studio* in collaboration with the College of Engineering and School of Visual Arts presents the latest addition to the *Ork family, the Linux Laptop Orchestra. Apart from maintaining compatibility with its precursors and sources of inspiration, Princeton's PLOrk, and Stanford's SLOrk, L2Ork's particular focus is on delivering unprecedented affordability without sacrificing quality, as well as flexibility necessary to encourage a more widespread adoption and standardization of the laptop orchestra ensemble. The newfound strengths of L2Ork's design have resulted in opportunities in K-12 education with a particular focus on cross-pollinating STEM and Arts, as well as research of an innovative content delivery system that can seamlessly engage students regardless of their educational background. In this document we discuss key components of the L2Ork initiative, their benefits, and offer resources necessary for the creation of other Linux-based *Orks.

Keywords

laptop orchestra, L2Ork, Linux

1. BACKGROUND

Although computer-based experimental ensembles are nothing new, arguably the first ensemble that has consistently exhibited properties of a traditional orchestra in terms of its spatial potential, lack of dependence upon the house PA, persistence, and scope is Princeton's laptop orchestra or PLOrk [10]. Founded in the fall 2005, PLOrk builds upon research in the use of spherical and hemispherical speakers that has freed its infrastructure from audio systems incapable of portraying spatial nuances found in a traditional orchestra. PLOrk was soon followed by Stanford's SLOrk, founded by Ge Wang, Princeton graduate [12]. Both *Orks have received unprecedented media attention and continue to thrive.

Since, a number of institutions across the world have started similar initiatives with a goal of producing a laptop-based orchestra as a more standardized ensemble. Reasons for starting such an ensemble are both compelling and numerous and have been described in great detail in Dan Trueman's "Why a Laptop

Orchestra?" [9].

2. INTRODUCING L2Ork

Virginia Tech DISIS [11] serves as the hub for the international *Linuxaudio.org* consortium [4]. In part inspired by the successes of PLOrk and SLOrk and in part encouraged by the rapidly developing Linux hardware and software support, in the fall 2008 DISIS partnered with Virginia Tech's College of Engineering to explore the ensuing synergy and form the first *Ork based on Linux. Consequently, we sought a way to cut costs without sacrificing sound quality and in turn utilize newfound design to promote growth, encourage development of additional orchestras that would maintain compatibility with the existing *Ork base, and perhaps most importantly facilitate adoption in the K-12 education sector.

Figure 1. L2Ork ensemble (fall 2009).

Over the past years, Linux has matured into a formidable general purpose operating system. Yet arguing its out-of-box readiness for a specialized use such as a laptop orchestra would be deceiving at best. Therefore, very early on we came to the conclusion that to ensure optimal experience we needed to provide ensemble members not only with the necessary supporting hardware (speakers, sound card, etc.), but also the laptop itself, running an optimized version of Linux that streamlines much of the operations necessary for its integration into the L2Ork ecosystem. This way we also circumvent situations where preinstalled software on a student's laptop could cause unwanted deterioration in performance.

It was becoming obvious that for L2Ork to become a reality we needed a large network of on- and off-campus Stakeholders as well as corporate support. Our project, however, coincided with what may be remembered as the onset of one of the greatest recessions in recent US history, thus putting a considerable strain on our funding options.

2.1 SUPPORT NETWORK

Perhaps the most useful aspect of L2Ork's brief history to those seeking to start a similar ensemble is the development of a support network. This step took place throughout the spring 2009 semester during which we managed to bring on board s

number of on-campus initiatives. Apart from our partnership with the Linuxaudio.org consortium, the project also secured three corporate sponsors: Mobile division of the MSI Computer, Roland Corporation, and Sweetwater Inc. who have provided us with supporting hardware. By the end of the spring, we secured the necessary funding and have also brought Prof. Eric Standley on board to assist us in crafting speaker enclosures.

2.2 UNDERGRADUATE RESEARCH

During summer of 2009 our team was complemented by nine undergraduate students, including two volunteers, five full-time, and two part-time. Two Virginia Tech students and one incoming student from Rochester University were sponsored through the National Science Foundation's *Research Experience for Undergraduates* (REU) program. Michael Matthews, a double-major in music and computer science, was one of the REU students and has continued to work on L2Ork since. The summer research team's main focus was on the design, development, and testing of optimal hardware for a 15-member ensemble, as well as software and OS optimization. As a result, we built 16 speakers, configured 17 notebooks, and developed necessary software to allow Pure-Data to seamlessly interface with our input device of choice—the Nintendo Wiimote.

2.3 SUB-$800/SEAT SETUP

The result of a 45-day summer research project is the current setup whose total cost per seat is below $800. The setup includes MSI Wind U-100 notebook, hemispherical speaker, subwoofer (shared with up to 5 other musicians) external USB soundcard, Nintendo Wiimote and Nunchuk, cables and accessories, and all supporting software. Speaker design has taken by far the largest amount of time allocated for this project, in part due to lack of adequate soldering experience among student researchers. Once students attained a level of familiarity, we were able to produce up to four speakers per day. For a detailed overview of hardware and software setup, please consult the L2Ork website (http://l2ork.music.vt.edu).

2.3.1 INPUT DEVICES

One notable aspect of L2Ork that differentiates it from the existing laptop orchestras is standardization of robust and affordable input device, namely the Nintendo Wiimote and Nunchuk [11]. Initially, this choice was to ensure compatibility with existing *Orks whose Mac-based hardware offers built-in accelerometers. Since, we've grown to prefer this choice over other alternatives due to its affordability, versatility, rugged design, and consequent ability to explore a full range of gesture and motion in performance. This choice has in part also driven the development of L2Ork's performance aesthetics that emphasizes physical presence, gesture, choreography, and even theatre. While an argument can be made for both minimal on-stage laptop music performance practice (e.g. a laptop performer on stage facing audience with key strokes on the laptop keyboard being the only indication of their involvement in the music-making process and therefore shifting the drama entirely into the aural domain) [8] and physical performance devised through a tight integration between technology (e.g. input devices) and performers (e.g. dancers) [1], the L2Ork aesthetic has undoubtedly leaned in the direction of the latter, in part because the laptop orchestra borrows so much from the traditional orchestra in which physical drama and coordination between various performers has become an inseparable component of the overall musical experience. Another

advantage of Wiimotes is ability to use them with either hand. As a result every L2Ork composition written for Wiimotes offers a simple way to alternate hand dominance.

2.3.1.1 HAPTIC FEEDBACK

Another compelling reason for using Wiimotes is their ability to convey haptic feedback during performance. We found this form of communication to be instrumental in providing efficient cues while producing no observable distraction artifacts from the audience's perspective.

2.4 *Ork COMPATIBILITY

As we look forward to exchanging repertoire with PLOrk and SLOrk, we cannot fail to notice inconsistencies that have found way into our design despite our best efforts at maintaining backwards compatibility with our precursors. Perhaps, due to sheer nature of a laptop, as well as preexisting inconsistencies (e.g. speaker channel mapping), it appears that absolute compatibility between different *Orks may be impossible. Indeed, even for those who may wish to adopt our Linux-based approach, chances are that the notebooks and supporting hardware our setup relies upon will very soon become obsolete. Yet it is because of this modularity and the free open-source (FOSS) nature of the supporting software that the developing laptop orchestra repertoire will be capable of surviving such historical transitions as well as cross-pollination among the growing international network of *Orks.

One of L2Orks's most noticeable deviations from the existing *Ork designs is its use of Linux. Yet, as dramatic as this change may appear, given that most of the existing *Ork infrastructure is FOSS-based (e.g. ChucK [13] and Supercollider [5], both of which run on multiple platforms including Linux) this choice has resulted in far fewer problems than anticipated. One notable exception is Max/MSP [7] which has been supplanted by Pure-Data [6].

L2Ork's approach to the role of a conductor is perhaps more open-ended than that of PLOrk and SLOrk. As part of L2Ork's debut, all pieces included on the program explored amalgamation of a performer and conductor. Undoubtedly, whatever little nuances may have remained in the physical domain (e.g. ensemble-wide cues), have retained their importance as well as visibility through gesture and eye contact, and yet have done so without significantly adding to the overhead nor detracting from the visual presentation. Consequently, we envision heavier reliance upon networked communication among performers to convey necessary information in as efficient format possible, thus exploring a wide range of possibilities, from a conductor-less ensemble to an environment where every performer also partakes in a role of a conductor. Naturally, should a need arise based on a work's architecture and/or composer's instructions, L2Ork should be more than capable of exploring a more traditional approach to a dedicated ensemble conductor.

2.5 STAGE SETUP

The current L2Ork setup consists of a semi-circle with the open side facing the audience with soloist(s) in the center (Figure 2). Soloists are amplified through hemispherical speakers as needed (e.g. a narrator). As L2Ork continues to grow, we anticipate having to revisit this arrangement to make better use of the available space. As is the case with other aspects of the ensemble, we fully expect that this arrangement may end up being piece-specific and that we may have to carefully consider

striking a balance between composition-driven needs and setup overhead.

Figure 2. L2Ork debut configuration.

3. L2Ork CURRICULUM

L2Ork pilot curriculum was introduced in the fall of 2009 in a form of two complementing courses: a 3-credit-hour lecture and a 1-credit-hour music ensemble. The ensemble was open to all Virginia Tech students regardless of their musical background and major, while the lecture class was available only to those who completed the prerequisite Computer Music Composition & Multimedia Design 2-semester course that deals mainly with learning Max/MSP/Jitter. The latter is also available to all Virginia Tech students, with preference given to music technology majors. All lecture participants were also required to be a part of the performing ensemble.

L2Ork, as other *Orks offers a uniquely level playing field when it comes to specific prerequisites therefore encouraging engagement that defies traditional academic boundaries between different disciplines. While students with a solid computer background generally fare better simply due to their level of comfort with computers, we found this advantage to be small enough not the play a major role in the overall ecosystem. This potentially tremendous advantage also introduces a considerable overhead. Namely, students with such diverse backgrounds and potentially having little or no prior music training require unconventional and often unique means of delivering score information. So far, we found numerical displays coupled with timers, visual cues, and concise textual instructions to work best, reaffirming the RTMix-like approach to coordinating interactive performances [2]. *Pd* has proven an ideal platform for delivering such visual content

4. DEBUT

Despite the growing body of *Ork documentation, the fall semester turned out to be a truly experimental undertaking. Perhaps it is because of the ensuing communal discovery that the ensemble instilled a strong sense of a stakeholder among students. Throughout the semester we experimented with various instrument and input device designs, a process that required lecture participants to take on often concurrently many different professional roles, including that of an engineer, computer scientist, interface builder, composer, and performer. Our December 4, 2009 "Sneak Preview" debut featured approximately 30 minutes of music originally written for the ensemble, including two works by Bukvic and one by music technology major David Mudre. The debut was preceded by a lunchtime technology demonstration showcase.

Despite its relatively short duration, the event literally packed the venue with audience members who were eager to get their hands on the instruments following the performance. The debut has also elicited unexpected amounts of attention from regional and national media and has been featured in a number of international online news outlets. In its end-of-year review, *Create Digital Music* has cited L2Ork as part of "CDM's Biggest Music Tech Stories of 2009." [5] In the following section we will briefly discuss specific approaches utilized by the compositions written for L2Ork.

4.1 "CITADEL"

On the surface, *Citadel* may appear as the most conservative piece on the program, using a traditional soprano line in conjunction with the L2Ork ensemble. Vocal accompaniment relies upon an array of identical monaural and primarily pitch-driven instruments to produce lush string-like accompaniment. The underlying system reveals a number of challenges which were specifically addressed in this first piece written for L2Ork: exploring appropriate performance aesthetics, communicating the score to the ensemble, ensemble coordination, and reliance upon the aforesaid hybrid role of a conductor/performer. Originally referred to as "Exercise 4," this piece has in many ways driven the development of basic tools and intercommunication protocols. As a result, the final version calls for the use of a Wiimote as an "infinite bow," mimicking motion of a traditional bow in a more free-form gesture. Considering that the motion is not constrained by the physical contact to a sound-making device (e.g. string), performers are capable of utilizing a wide array of motions to ensure seamless continuity of the sound. Nonetheless, it became quickly apparent that a common gesture aesthetic was necessary to generate a compelling visual experience. In this piece, the Nunchuk was used to modulate sound properties, including pitch, low-pass filtering, vocoder, and to control delays.

4.2 "HALF-LIFE"

The other Wiimote-based work approaches the use of a controller as a multidirectional mallet, triggering events of various lengths and envelopes. This role is complemented by the "glitching" algorithm typical of the contemporary beat-based electronic music scene. The work, for narrator and L2Ork, draws inspiration from the famous 2004 blog by Elena Filatova depicting a haunting journey through Chernobyl. Most sound sources are based on concrete sounds whose collage and juxtaposition with improvisatory "glitching" patterns is perhaps reminiscent of a jazz ensemble setup, affording each of the L2Ork members a solo section. Unlike "Citadel", where the conductor controlled the pace of the work, in this case at the beginning of the piece every notebook was synced to the master timer after which they delivered time-sensitive cues in a form of visual stimuli and concise textual descriptions.

4.3 "DUSK"

The first L2Ork composition written by a student drops Wiimote use in favor of a conventional laptop keyboard. In order to avoid potential aesthetic pitfalls associated with keyboard-based performance, the piece calls for sweeping hand motion (e.g. keys A through H) that trigger an array of prefabricated audio samples and offer a theatre of clearly observable gestures. The economy of aural material and relative sparseness of the texture allows for intricate exploration of L2Ork's spatial potential. The conductor's role in this piece was shared among all ensemble members—some sections required the composer to provide critical cues while others resulted in

cascading relegation of responsibility as performers awaited cues from each other in specific predetermined order.

5. EMERGING AESTHETICS

Undoubtedly, one of the cornerstones of laptop orchestra aesthetics is that there very well may never be a single preferred aesthetic to uphold above everything else. Yet, what we have learned from our fall endeavor is that Wiimotes indeed possess a tremendous potential in delivering compelling theatre while offering unprecedented flexibility at a competitive price. We have also observed a growing reliance upon physical presentation and theatre, regardless of the input device. Another component of our presentation we found compelling was positioning notebooks on music stands as if to acknowledge that these are not only our instruments but also our scores. It is not entirely unlikely that in the future iterations of L2Ork we may continue to steer in the direction of minimizing technology's physical footprint and shift even more attention towards human presence.

6. LOOKING AHEAD

Since the fall debut featuring 9 performers (including ensemble director), the ensemble has grown to 18+ members. Currently L2Ork has no specific target size and, infrastructure permitting, encourages further growth.

As we begin shifting towards discrete treatment of the hemispherical speaker's output channels, there will be undoubtedly a need to move to a more expensive soundcard which will in turn result in higher costs. We however envision this kind of spatial treatment to be best served in a more intimate environment involving fewer performers and therefore see the monaural system continuing to maintain its relevance within the context of L2Ork as a growing ensemble.

Another component of particular interest to the L2Ork team is branching out into the multimedia domain. After all, laptops can do many different things and even though L2Ork will always strive to retain what has made it such a uniquely exciting endeavor by intertwining human performance and technology through a quintessential form of real-time collaboration typical of a traditional orchestra, having several performers participating as real-time collaborative sculptors of a 3D shape whose composition both affects and reacts to sound produced by the remainder by the orchestra and variations thereof (e.g. involving dance, theatre, poetry, video, etc.) are particularly exciting to the L2Ork team. This is undoubtedly one of the many directions we look forward to embarking in the coming years.

6.1 K-12 EDUCATION

Perhaps one of the most compelling research angles made possible through L2Ork's cost-efficient design is its potential impact on K-12 education with particular focus on cross-pollination of STEM and Arts. Arts, and particularly music, offer a uniquely efficient way of providing near instantaneous feedback to those interested in exploring Math and Computer Science concepts. This feedback loop is particularly apparent in *Ork models, with the cost remaining the only formidable limitation preventing it from tighter integration into the K-12 curriculum. Considering this concept is still in its early stages, we will reserve discussing its design and potential impact for another time.

7. STARTING A LINUX-BASED *Ork

In hope to encourage adoption of L2Ork's approach to the *Ork ensemble, we've generated a growing body of documentation, including YouTube video "instructables" discussing the design and development of the speakers and other infrastructure, equipment list with estimated cost, and other supporting documentation. Additional Linux resources are available on the L2Ork website, including a complete Linux disk image with all the necessary software preinstalled as well as *pd* patches, abstractions, externals, and enhancements. For additional information visit http://l2ork.music.vt.edu.

8. ACKNOWLEDGMENTS

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