

Conference Paper

Presented at the 26th Annual Conference of the Society for Electro-Acoustic Music in the United States
January 20–22, 2011
University of Miami Frost School of Music
Miami, Florida

Papers presented at SEAMUS 2011 have been blindly peer reviewed by members of the paper selection committee on the basis of a submitted abstract. The paper presented here is reproduced directly from the author's or authors' manuscript without editing or revision by the conference committee.

Moving Beyond Academia Through Open Source Solutions—Introducing L²Ork, Virginia Tech's Linux Laptop Orchestra

Ivica Ico Bukvic¹, Thomas Martin², and Michael Matthews³

¹ Virginia Tech, Blacksburg, VA, 24061, USA
ico@vt.edu

² Virginia Tech, Blacksburg, VA, 24061, USA
tlmartin@vt.edu

³ Virginia Tech, Blacksburg, VA, 24061, USA
matthem5@vt.edu

ABSTRACT

In recent years we've seen a growing number of laptop orchestra ensembles emerging across the World. In part due to the inherent cost and technological complexity these incredibly diverse and innovative vehicles for artistic expression have been limited largely to higher education. Founded in 2009, L²Ork, Virginia Tech's Linux Laptop Orchestra builds upon the foundations established by Princeton's PLOrk and Stanford's SLOrk, seeking maximum compatibility with existing ensembles while

providing a predominantly gesture-driven alternative performance practice and integrated turnkey system with minimal cost overhead. L²Ork utilizes MSI Wind notebooks in conjunction with Nintendo Wii Remote controllers, sub-\$250 hemispherical systems, Linux operating system, and a custom Pure-Data real-time graphical programming environment. The aforesaid focus on an affordable turnkey solution has proven critical in spawning partnerships with K12 initiatives, most recently including a design and development of a satellite 6-seat laptop orchestra for the Boys & Girls Club of Western Virginia. Targeting 5th graders, the project's goal was to encourage learning by cross-pollinating music with STEM through creative technologies. In the following paper we would like to share milestones that have made the K12 initiative possible. By exposing features of L²Ork's prototyping toolkit, supporting software, and growing documentation our goal is to offer an insight in the technical and creative foundations of our existing infrastructure and by doing so encourage further collaboration with the computer music community, as well as to extend an open invitation for contributions in a form of new works and software/hardware enhancements.

1. INTRODUCTION

Laptop orchestras as a standardized ensemble are a relatively recent phenomenon. Starting with PLOrk [1] in 2005, they have garnered an unprecedented amount of interest, particularly in Academia. In the last year alone five new orchestras have been added according to the *International Association of Laptop Orchestras (IALO)* [2].

Driven by an exciting and innovative array of technology-driven opportunities, laptop orchestras fuse a traditional orchestra genre with the age of computing, energizing physical presence, performance practice, and perhaps most importantly placing human-to-human interaction at the very epicenter of the computer music genre. The fact today one can easily network an entire ensemble of computers in innovative and intuitive ways, affording its participants attainment of a heightened awareness of the overall group's activity on both micro- and macro-level is just one of many new possibilities that beg further exploration. Similarly, the network framework can be utilized to cross-pollinate participants' (re)actions often with unpredictable aural and structural results. Offering an entirely new set of research vectors that often elide with other disciplines, it comes as no surprise the laptop orchestra genre has attracted so much attention.

1.1. Introducing L²Ork

The very first mention of the Linux Laptop Orchestra or L²Ork (pronounced as "l2ork") [3,4] was in the fall 2008 in a form of a white paper proposal to a select group of potential Stakeholders. Its purpose was seeking adequate financial support needed for the fabrication and development of its infrastructure. Following a six-month campaign during which the project has attracted over a dozen initiatives across the Virginia Tech campus, secured grants, as well as several corporate sponsors, L²Ork was officially founded in May 2009.

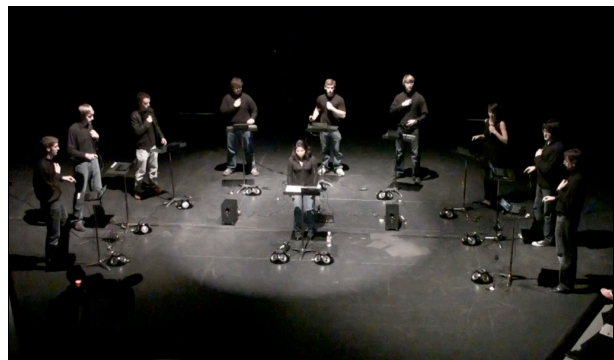


Figure 1. L²Ork 2009 debut.

2. THE L²ORK ANGLE

While its very name reveals a fundamentally different platform than its precursors, its core philosophy is relatively similar to that of PLOrk

[1] and consequently SLOrk [5]. More so, L²Ork seeks to encourage maximum conceivable compatibility with other orchestras by supporting near-identical array of DSP-oriented software packages, with Pure-Data (a.k.a. PD) [6] vs. Max [7] being only notable exception.

One of the few original goals of practical nature that continue to resonate with L²Ork's current mission is producing an affordable infrastructure without sacrificing its overall quality. With the anticipated cost of \$750/seat, L²Ork setup includes everything necessary for out-of-box experience, including MSI Wind U100 [8] notebooks, UA-1G Roland soundcard [9], a Nintendo Wii Remote (a.k.a. Wiimote) with Nunchuk and Wiimote Plus extensions [10], a custom hemispherical speaker, supporting cables and accessories, a headset, and a carrying bag. The aforesaid cost also includes partial amortization of a subwoofer that is shared among up to five stations, as well as a wired network switch shared by the entire ensemble.

In part to circumvent some of the rougher edges associated with optimizing Linux for audio work, L²Ork has been conceived as a "turnkey" solution, offering a full hard drive image download with a system completely preconfigured. This approach also posits that the computers are treated more as a traditional instrument where their sole purpose is that of making music. Consequently, L²Ork participants instead of using own laptops are provided with custom prebuilt machines.

Ironically, a number of seemingly insignificant practical choices, including some of the ones mentioned above, have over time evolved to take on a much more important role, shaping the very aesthetics of the ensemble.

2.1. Practical vs. Aesthetic

The choice of a seemingly underpowered Atom-based notebook (a.k.a. netbook), apart from the obvious cost-savings and a welcome lower maintenance overhead (due to use of homogenous software and hardware environment), has resulted in a series of unexpected, yet profound changes to the ensemble's aesthetics, including:

- focusing on distributed computation for the purpose of producing complex textures, thus essentially compelling composers to factor this aspect into the very core of their creative process,
- consequently, on an individual instrument level there was also a fundamental shift towards simpler DSP algorithms whose complexity was achieved through human control and human-to-human interaction, and
- ability to position each notebook onto a traditional music stand with spare room for controllers and accessories (Figure 1).

Similarly, considering the said notebooks lacked embedded accelerometers and thus were unable to fully emulate PLOrk setup, we opted for complementing them with Nintendo Wiimotes and supporting accessories as standard complements for each station. We believe this choice of rugged hardware designed to withstand considerable physical stress has resulted in greater gestural freedom and control and has in turn resulted in greater on-stage presence and choreography potential.

In part due to braving a steep learning curve both technologically and aesthetically, the ensemble's early works have focused on timbral homogeneity, refashioning the orchestra in an electronic alternative to a traditional ensemble, e.g. a string orchestra. It has also relied

predominantly upon soloists (vocalists, narrators, percussionists). This has allowed in turn for the ensemble to shift focus towards developing physical practice and presence, something that remains a predominant area of our focus. Unavoidably, the ensuing aesthetics quickly became focused on physical presence, full body gesture, and motion. It has also planted seeds towards current exploration of coupling Martial Arts, choreography, and musical performance.

Some choices, while remaining primarily in the practical domain have spawned secondary creative opportunities that may yet play a role in shaping of the orchestra's aesthetics. For instance, the ensemble moved away from wireless towards wired network switch setup, as we discovered that wireless solutions resulted in unpredictable amounts of latency and as such have proven inadequate for time-critical musical cues. In turn, the newfound high-bandwidth setup has afforded us opportunities for streaming audio among musicians while retaining low latency advantage, which is one of the many exciting research vectors we look forward to pursuing in the near future.

2.1.1. pd-l2ork

In addition to ongoing hardware improvements, as of fall 2010, the L²Ork team has put a genuine effort towards overhauling PD for the purpose of streamlining user interface and supporting libraries. Due to considerable changes to the PD code base and in part based on the feedback from the PD community L²Ork has introduced and currently maintains its own iteration of PD (a.k.a. pd-l2ork [11]), offering an array of bug fixes, documentation and packaging improvements, features that advance the overall user experience, and enhancements for the purpose of streamlining building of a performance user interface. This seemingly pointless exercise amidst mature commercial alternatives such as Max [7]

has proven an invaluable complement to the research and educational potential of the project. Since its inception L²Ork initiative has funded more than a dozen exclusively undergraduate student researchers, some of whom have maintained funding throughout the entire project and have made critical contributions to the PD code base.



Figure 2. 5th graders from the Boys & Girls Club learning to control a laptop-based instrument.

3. L²ORK IN K12 EDUCATION

One of the unique opportunities of a laptop orchestra is in that it offers a level playing field— one can engage in real-time collaborative performance in a laptop orchestra (something that was until very recently an experience restricted solely to those participating in a traditional musical ensemble) and can do so regardless of their educational background. This naturally offers great opportunities for linking higher-education programs with the K12 education particularly in the wake of ongoing budget cuts and reforms that have all but decimated the Arts education [12]. The ongoing struggle to reintegrate Arts with STEM [13], coupled by the Commonwealth of Virginia's latest focus on strengthening K12 education has afforded us a unique angle in which a laptop

orchestra would serve as a catalyst for linking STEM with the Arts, providing a curricular enrichment in the Arts domain while maintaining a tangible link with STEM, effectively addressing all four core areas in various capacities.



Figure 3. 5th graders from the Boys & Girls Club engage in fabrication of “ladybug” speakers.

3.1. Boys & Girls Club Pilot

L²Ork’s official debut in the fall 2009 was greeted with prevailing enthusiasm among student performers and audience alike. After receiving unsuspecting regional media coverage, an opportunity arose to explore potential collaborations with the Boys & Girls Club of Roanoke, VA. Funded by external grants from 21st Century Federal Learning Grant and the Bank of America secured through the Boys & Girls Club, the ensuing semester-long initiative took place in the spring 2010. The funds were used to purchase infrastructure for a 6-seat satellite laptop orchestra (5 + 1 backup) as well as support three students for the purpose of fabricating the custom hardware as well as weekly rehearsals with students in Roanoke. The rehearsals took place twice a week for an hour as an afterschool program for the inner city children engaging ten 5th graders. The program’s ultimate goal was to stage a joint performance as

part of the spring DISIS [14] event at Virginia Tech.

We relied upon the experience attained during fabricating of the original sixteen black hemispherical speakers and applied it towards building of improved iterations specifically for the Boys & Girls Club. The resulting speakers were colored red and dubbed “ladybugs.” As part of the learning process, a visit to Virginia Tech DISIS facility was organized to allow for 5th graders to participate in the fabrication of the “ladybug” speakers (Figure 3).

3.2. Spring 2010 Debut

Throughout the semester, we produced a series of exercises as well as adapted some of the existing works to Boys & Girls Club students’ skill level. Their feedback has helped us identify optimal approaches that would build upon their familiarity with the Wiimote controller (attained through playing Wii video games) and cross-pollinate it with the uniquely collaborative nature of ensemble performance. The spring event featured two numbers adapted for the satellite orchestra. First was a 5-part adaptation of a work originally written for L²Ork and solo soprano titled “Citadel.” It simplified some of the control mechanisms, thus seeking a balance between a stress-free co-performance with L²Ork and a level of challenge that retains their interest and attention. Second was an adaptation of “Everybody Needs Somebody to Love” by Bert Berns, Solomon Burke, and Jerry Wexler for a 5-member Boys & Girls Club satellite laptop orchestra, saxophone, and percussion, with solo instruments being added as a last-minute improvisatory layers on top of the laptop orchestra part. Both works were performed as part of the 7pm program for children and parents and at the beginning of the 8pm DISIS event whose proceeds were donated to the Boys & Girls Club.

In "Everybody Needs Somebody to Love" arrangement, the 5th graders' parts consisted of both the theatric introduction and the actual performance. First, each performer was asked to sing any note of their choosing into the headset in front of a live audience. After being captured, their voice was automatically pitch-shifted and adjusted to match a predetermined frequency. After all performers have essentially generated their instruments on the spot, a performance began in which students, led by a conductor would generate a note by shaking a Wiimote while pressing an appropriate direction on Wiimote's D-pad which corresponded with a particular predetermined pitch. The ensuing texture was a simplified version of harmonic accompaniment matching that of the song in question.

4. CONCLUSIONS

Although no formal study has been conducted, the children participating in the pilot program have shown consistently high level of engagement and we encountered virtually no disciplinary issues. Likewise, feedback provided by a diverse audience attending the debut was overwhelmingly positive.

As we look forward to the spring 2011 project whose scope will be in many ways similar to the one conducted previous year, we are enthused by the support and encouragement we received both from the University and external sources. We are also hopeful that as the initiative matures we will be able to quantify our contribution towards enhancing Arts education in K12. Another aspect we are keen on exploring within the K12 context is a recent introduction of Taiji (a.k.a. Tai Chi) martial art into L²Ork's performance practice and its potential benefits towards improved focus and attention in a classroom setting.

Challenges remain, however. Some, purely practical will simply require time (e.g. improving software infrastructure to the point where students can write their own pieces). Others, more philosophical in nature offer a fertile ground for innovative research vectors. For instance, while a networked laptop orchestra may allow for adaptive scaling of difficulty in order to engage individuals at various skill levels, such an adjustment may also fall short of expressing musicianship, providing instead an oversimplified gaming experience akin to that of early generations of "Guitar Hero" [15]. One might argue, however, that an adjustable difficulty may be better in terms of retaining individual's interest by avoiding pitfalls of overwhelming learning curve and consequently disinterest. Consequently, adaptive difficulty can be seen both as an opportunity and a challenge that begs further examination.

4.1. Call for Collaborators & Contributors

We would like to hereby extend invitation to our fellow Institutions to consider joining us in spawning similar initiatives across the United States and beyond. We are also openly seeking collaborators who will help us further improve upon our core infrastructure through collaboration and exchange.

5. RESOURCES

L²Ork's resources, including instructions on how to fabricate a sub-\$250 hemispherical speakers, an enhanced distribution of Pd (a.k.a. pd-l2ork), as well as support mailing lists are all available on L²Ork website [4,11].

6. ACKNOWLEDGEMENTS

L²Ork team hereby wishes to acknowledge all our Stakeholders and corporate sponsors, students researchers, as well as l2orkists who have made

L²Ork a reality. Likewise, we would like to extend special thanks to our Boys & Girls Club partners in Roanoke, VA for making this exciting initiative possible.

7. REFERENCES

- [1] Trueman, D., P. R. Cook, S. Smallwood, and G. Wang. PLOrk: Princeton laptop orchestra, year 1. In Proceedings of New Interfaces for ICMC 2006.
- [2] The International Association of Laptop Orchestras, <http://ialo.org/doku.php/start>. Last accessed Jan. 2011.
- [3] Bukvic, I., T. Martin, E. Standley, and M. Matthews. Introducing L2Ork: Linux Laptop Orchestra. In Proceedings of New Interfaces for Musical Expression (NIME), June 2010.
- [4] Virginia Tech Department of Music L2Ork - Linux Laptop Orchestra, <http://l2ork.music.vt.edu/main>. Last accessed Jan. 2011.
- [5] G. Wang, N. Bryan, J. Oh, and R. Hamilton. Stanford laptop orchestra (SLOrk). In Proceedings of the International Computer Music Conference, Montreal, Canada, 2009.
- [6] Puckette, M. Pure Data: Another Integrated Computer Music Environment. Second Intercollege Computer Music Concerts, Tachikawa, Japan, 1996.
- [7] Puckette, M., and Zicarelli, D. Max/MSP. Cycling 74/IRCAM, version 5.1, 1990-2010.
- [8] MSI Notebook Official Website, <http://www.msimobile.com>. Last accessed Jan. 2011.
- [9] Roland U.S. - UA-1G: USB Audio Interface, <http://www.rolandus.com/products/productdetaiils.php?ProductId=1089>. Last accessed Jan. 2011.
- [10] Controllers at Nintendo :: Wii :: Console, <http://www.nintendo.com/wii/console/controllers>. Last accessed Jan. 2011.
- [11] Virginia Tech Department of Music L2Ork - Linux Laptop Orchestra, http://l2ork.music.vt.edu/main/?page_id=56. Last accessed Jan. 2011.
- [12] Brouillette, L. (2001). How colleges can work with schools. *The Chronicle of Higher Education*, 47, B16-B17.
- [13] Wallace, D., B. Vuksanovich, and K. Carlile. Work in Progress – Building up STEAM –Exploring a Comprehensive Strategic Partnership between STEM and the Art. In proceedings of ASEE 2010 North Central Sectional Conference, Pittsburgh, Pennsylvania, March, 2010.
- [14] Virginia Tech Department of Music DISIS - Digital Interactive Sound and Intermedia Studio, <http://disis.music.vt.edu>. Last accessed Jan. 2011.
- [15] Guitar Hero Home, <http://hub.guitarhero.com>. Last accessed Jan. 2011.