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ICAT, Art & Art History, CS, CHCI (by courtesy)

> For performances and exhibitions of the following works please consult the CV under the heading of "Key Creations & Performances." Additional materials (e.g. Max patches, source code, etc.) have been omitted due to size constrains and are available upon request.

WORKS

1: L2Ork Compositions (2009-present) (five works with durations between 5' and 11')
AUTHOR(S) (in alphabetical order): Ivica Ico Bukvic

Works written specifically for the Linux Laptop Orchestra or L2Ork. Given that the orchestra members consist of both musicians and non-musicians, pieces written for the ensemble call for special attention in designing alternative ways to a traditional score for the purpose of disseminating critical music performance data. The ensemble relies mainly upon Nintendo Wiimotes and Nunchuks for capturing performer movement and gesture data but this is by no means the only way performers interact with instruments. For additional information and highlights regarding the L2Ork project, its infrastructure, goals and advantages, please consult the RESEARCH section below.

NB: Audio recordings of Citadel and Half-LIfe linked below have been made in the Virginia Tech Burruss Hall rotunda and therefore are naturally reverberant.

Figure 1.1 L2Ork in performance.

SERENE (10')
The most ambitious project and one of the most recent works integrating Taiji (Tai Chi) choreography with experimental gesture score and musical performance. A work written solely for the ensemble explores tonal clusters, smooth flowing gestures (through the use of the MotionPlus gyroscope), structured improvisation, and their juxtaposition. VIDEO1 VIDEO2 (YouTube).

HALF-LIFE (9')
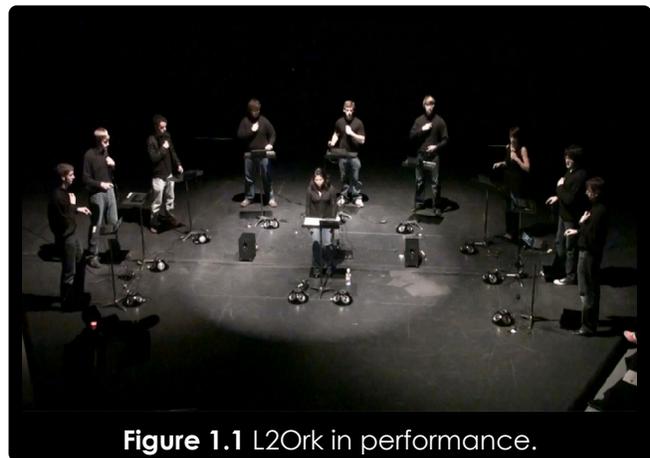A texture-based exploration of electronic percussion inspired by the writings and experiences of Elena Filatova on her solo motorcycle ride through Chernobyl. Through the use of Nintendo Wiimotes and Nunchuks as virtual mallets, nine performers accompany a narrator generating a collage of aural events of varying lengths and shapes. AUDIO (8MB mp3), VIDEO (YouTube).

13 (11')
13 is a structured game of prime numbers and primal instincts pitting timbre against rhythm. Driven by conductor's oversight over an array of performer-specific and ensemble-wide parameters, a networked ensemble acts as one large meta-tracker where each individual

performer contributes its own gesture-driven motives or tracks. The ensuing meta-tracker texture is superimposed against improvised acoustic percussion in a search of a meaningful discourse and ultimately musical synergy. This work was composed in collaboration with percussionist Ron Coulter. VIDEO1 VIDEO2 (YouTube).

RAIN (10')
Second piece integrating Taiji (Tai Chi) choreography into music performance. Like *Serene*, it is a piece written solely for the ensemble where individual performers take turns in performing solo gestures. The work also explores aural cross-pollination of instruments by tightly networking the ensemble, so that every action percolates through other stations in an algorithmic sequential pattern, as if each station is an independent snapshot of a single tap as part of an ensemble-wide multi-tap delay. The ensuing stochastic swarm serves as a foundation above which performers trade improvised soloistic "licks." NB: Video footage features 4th and 5th graders from the Boys & Girls Club of Southwestern Virginia, as part of a K-12 satellite laptop orchestra outreach project. For additional info on this project, please consult the RESEARCH section. VIDEO (YouTube).

CITADEL (6')
First piece written for L2Ork explores an infinite-bow metaphor and monophonic instruments to create lush tonal harmonies and form a consonant and therefore easy-to-assess aural environment. The ensemble accompanies a soprano soloist singing vocal melismae whose text is based on the famous Croatian 17th century play by Ivan Gundulic. Work's deliberately conservative nature can be seen in part as an assessment of ensemble's potential to produce expressive and accessible music using diverse performance forces (some of whom have little or no prior music training) and largely untested technologies in a tightly networked environment. AUDIO (5MB mp3), SCORE (PDF), VIDEO (YouTube).

HIGHLIGHTS
• Focus on physical gesture, live performance component.
• Extending traditional forms (e.g. soloist & laptop orchestra) and juxtaposing them with new genres.
• Multimodal performances (gesture, sound, visuals, etc.).

2: FORGETFULNESS (2009) (N/A)
AUTHOR(S) (in alphabetical order): Ivica Ico Bukvic, Denise Duhamel (Poet)

An interactive audio-visual setting of a poem by Denise Duhamel from her Möbius series. The piece tries to capture poem's infinite nature and consequently unique structure through the use of dynamic audio-visual metaphors. The work has been presented both as an installation and a performance piece. As a performance work, through the use of a wireless controller attached to a lower arm, performer is given an opportunity to shape poetry's pace and drama by changing arm angle and therefore traversing the möbius strip. Throughout the journey, performer and listeners alike are greeted with aural shapes and gestures designed to complement their multisensory experience, and yet whose unpredictable nature allows them to be studied also as entirely independent location-aware soundscapes. In the installation format, audience is given an opportunity to explore the landscape by themselves through the use of a Wii Balance Board.

FORGETFULNESS was devised in the winter of 2009 using Unity3D game engine and in close collaboration with poet Denise Duhamel. It was published shortly thereafter in the New River Journal, oldest hypermedia journal in US. A performance version was premiered by the composer in the spring of 2009. A YouTube preview can be accessed here (NB: footage's jittery framerate is due to the high CPU overhead of the piece coupled by the overhead caused by the video capture software).

The online interactive format is accessible here. It however requires a download of a Unity3D web browser plugin. This format uses keyboard for navigating the virtual space.
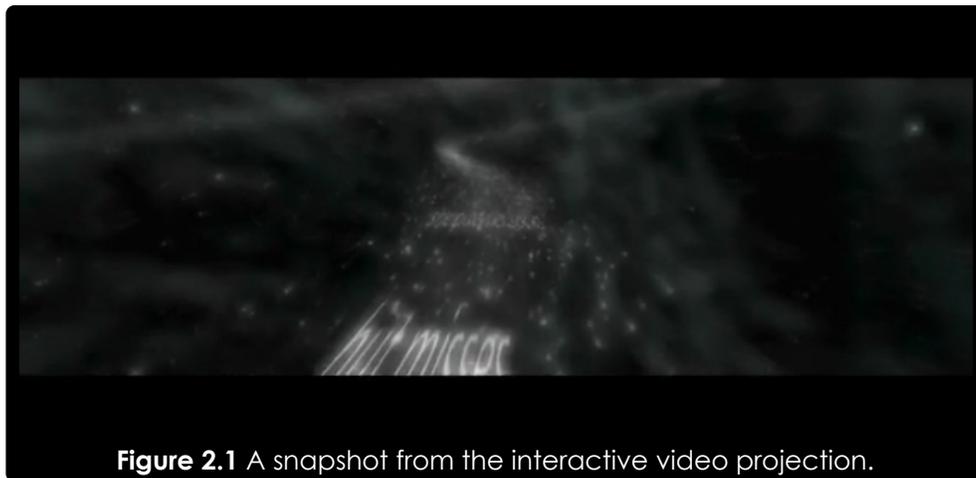

Figure 2.1 A snapshot from the interactive video projection.

HIGHLIGHTS
• Cross-pollination of interactive sound, visuals, and infinite poetry.
• Malleable structure relegated to performer/listener (performance/installation).
• 3D visuals (Fig.2.1) (algorithmic nurb generion, 3D modeling using Blender game engine, shader programming, algorithmic texturing).

3: derelicts of time (2008) (11')
AUTHOR(S) (in alphabetical order): Ivica Ico Bukvic

A work for trombone, computer and 3D visuals. Trombone is captured in real-time (using MaxMSPJitter), and its sound is transfigured to complement acoustic texture both aurally and visually. The piece was commissioned by Jay Crone and in part sponsored by Virginia Tech's CLAHS Faculty Grant. Online compressed version of its premiere can be downloaded by clicking here (15MB Quicktime movie) or viewed via YouTube. For score, please click here.
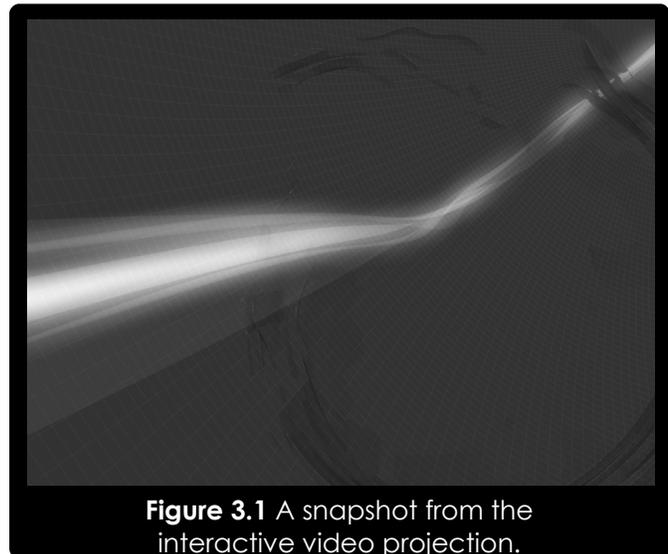
HIGHLIGHTS
• Cross-pollination of interactive sound and visuals.
• DSP techniques (amplitude and attack monitoring, granular synthesis, real-time resampling, reverb, phase vocoder, filters, delays, triggering of prerecorded sounds, spatialization).
• 3D visuals (Fig.3.1) (algorithmic nurb generation, 3D modeling using Blender game engine, shader programming, algorithmic texturing).

PROGRAM NOTES
Do you believe in the "butterfly effect?"

The history of the human race as we know it can be seen as an ever-growing conduit connecting present with the past, a testament to our existence that slowly yet steadily disintegrates before our eyes as it approaches the distant horizon. Looking back, the growing amount of debris hopelessly holding onto the gravitational pull of whatever little is left of the conduit reminds us of the limits of our collective ability to differentiate fact from fiction. In this world of recollections doomed to the effects of a communal dementia, the sound sits on both sides of the fence: as a mere derelict or as the very thread that keeps the fabric of time from unraveling.

Figure 3.1 A snapshot from the interactive video projection.

Long after the essence has all but dissolved, its legacy continues to percolate throughout the continuum with unprecedented clarity—a shining beacon amid the memory graveyard.

4: Symmetries (2005) (7')
AUTHOR(S) (in alphabetical order): Ivica Ico Bukvic, Daniel and Barbara Hayley (Theatre)
ORIGINAL COLLABORATION WITH: Rena Ishii (violin)

A work for violin, computer, hyperinstrument (Peavey 1600x), and 8-channel audio, originally commissioned by Ania Zielinska. Its 2006 version was choreographed by Prof. Barbara Hayley and performed at ICMC 2006. I regard *Symmetries* as an important milestone in my creative portfolio mainly because it has challenged my creative comfort zone on many levels. Through the use of Markov chains, the work's structure including performer's score structure and overall dynamics are relegated to computer, while hyperinstrument part is limited to subtle textural variations. *Symmetries* calls for a custom-built Soundfont (developed in collaboration with violinist Rena Ishii) and utilizes a battery of applications running on Linux (Pd, JACK, JackRack, QSynth, LADSPA plugins, and Python code), including a custom performance interface (Fig. 4.1). The linked score consists of a template for the algorithmic generation of performance score and a linear rendition of an instance performed by violinist Dr. Daniel Mason whose recording can be previewed by clicking here (12MB mp3).
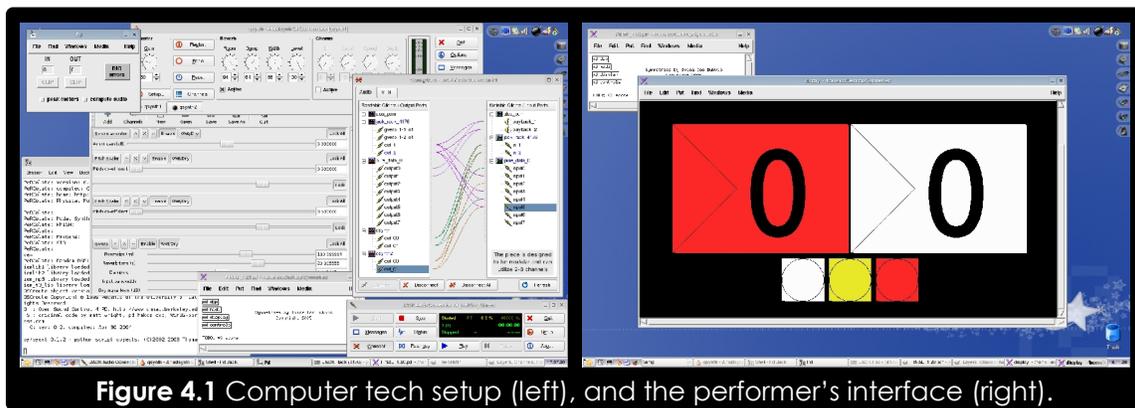

Figure 4.1 Computer tech setup (left), and the performer's interface (right).

HIGHLIGHTS
- Integration of computer music, live performance, and dance.
- Relegation of form, score, and dynamics to the computer through the use of Markov chains.
- Use of hyperinstrument and 8-channel diffusion.
- Reliance upon the interoperability of a battery of Linux applications.
- The design of a custom Soundfont.

5: Tabula rasa (2004) (10')
AUTHOR(S) (in alphabetical order): Ivica Ico Bukvic

This work is included in part as a reference to the roots of my passion for technology, initially encompassing mainly computer music idiom. The piece utilizes piano, cello, flute, and interactive computer part (MaxMSP). Each instrument is fed separately into computer via 3 microphones and is processed in real-time for the purpose of seamlessly integrating acoustic and electronic, live and artificial, reactive and interactive. The work was commissioned by the *NeXT Ens*. Online compressed version of a performance can be downloaded by clicking here (17MB mp3). For score, please click here.

PROGRAM NOTES

Tabula rasa
-- Ivica Ico Bukvic

HIGHLIGHTS
• A collection of reactive and interactive DSP algorithms in conjunction with a traditional acoustic trio.
• An attempt to produce a seamless integration of computer music into traditional performance.

6: with delicate risk (2008) (3')
AUTHOR(S) (in alphabetical order): Ivica Ico Bukvic and Dane Webster (Art)

A linear audio-visual work devised through non-linear collaboration employing ongoing feedback between the co-authors throughout the creative process. An online version of the video is available here (Quicktime video stream).

PROGRAM NOTES
'with delicate risk' explores ideas of creation myth and evolution thru the use of various systems of motion applied to a human arm. The film uses procedural and systematic approaches to animated motion to explore the viewer's notions of gesture and the perceived emotions that are related to those gestures.

Figure 6.1 A screenshot from the video.

HIGHLIGHTS
• A collaboration among a composer and a 3D animation artist.
• Engagement of collaborators across both domains and throughout the creative process.
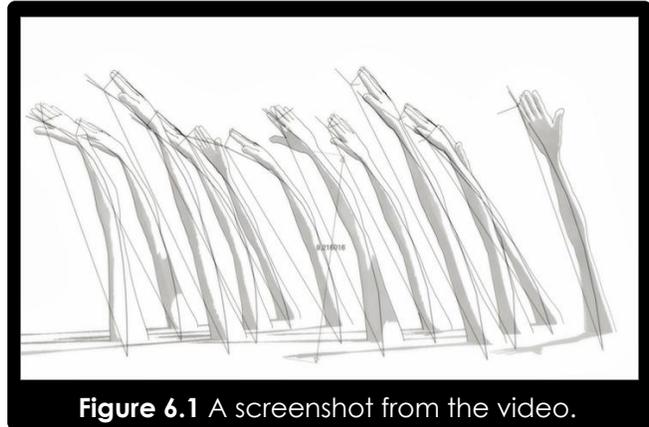
7: Revo:oveR (2008) (N/A)
AUTHOR(S) (in alphabetical order): Ivica Ico Bukvic, Carol Burch-Brown (Art), Steve Harrison (CS), Simone Paterson (Art), Joy Rosenthal (Art), Eric Standley (Art), and Dane Webster (Art)

Revo:oveR is a collection of installations created by the Digital Arts Research Collective consisting of six artists and commissioned for the grand opening of the new Taubman Museum of Art in Roanoke, VA. Own contributions include *Elemental* interactive communal soundscape and interactive audio-visual content for the two sculptures titled *Cyrene Reefs* that were created in collaboration with conceptual artist Eric Standley. Online version of the footage can be viewed by clicking here (32MB Quicktime movie).

HIGHLIGHTS
- Collaboration with a team consisting of a 3D animation artist, architect, conceptual artist, CS researcher, film artist, musician, and new media artist.
- A "techosystem" consisting of six interdependent pieces co-located within the same exhibit space.
- Retrofitting conventional webcam with filters and wide angle lens and coupling it with IR LED floodlights to produce a makeshift IR motion tracking system in a controlled dark environment with wall projections.
- Integration of MaxMSPJitter and Unity3D game engine using µ interoperability toolkit developed at DISIS (for more info please consult the Research section below). Use of Max to capture visitors' motion and import data to Unity3D to run a 3D physics simulation that emulates exhibit space and translates visitors' motion into water ripple metaphors. The resulting data is sonified through Max and diffused across a 12-channel ceiling-mounted 4x3 speaker array.
- Use of proximity IR sensors for the arm-based interaction in conjunction with a 3D projection on the smaller dome and two displays on the Cyrene Reef B sculpture.
- Algorithmic nurb visualization of visitors' interaction with the arm holes on the dome (Cyrene Reef A) and the two displays on the (Cyrene Reef B).
- Use of motion tracking on both sides of the Cyrene Reef B and mapping resulting data so that the virtual avatar (*iBot*) appears to follow visitors' location. The development of the *iBot*'s logic to make decisions which side to turn towards and when to disengage.
- Utilization of GPU shaders for iBot's reflective eye resembling camera objective and Gaussian blur of two camera feeds.

Below is a more detailed creative and technical overview of author's contributions to three exhibit pieces:

ELEMENTAL
Elemental functions both as a standalone artwork and as a unifying aural component of the *Revo:Over* installation. Occupying entire exhibit space, the piece utilizes equidistantly spaced 4x3 speaker array suspended from the ceiling. Using infra-red (IR) spotlights and a homebrew IR camera the installation captures visitors' traversal throughout the room and accompanies their motion with sounds of water ripples. The resulting aural landscape portrays a soothing image of navigating a calm waist-deep body of water. Apart from the fact that visitors' motion generates no tactile feedback commonly associated with water, the surreal is further amplified by the aural cues that emanate above, rather than from below. As ripples propagate throughout
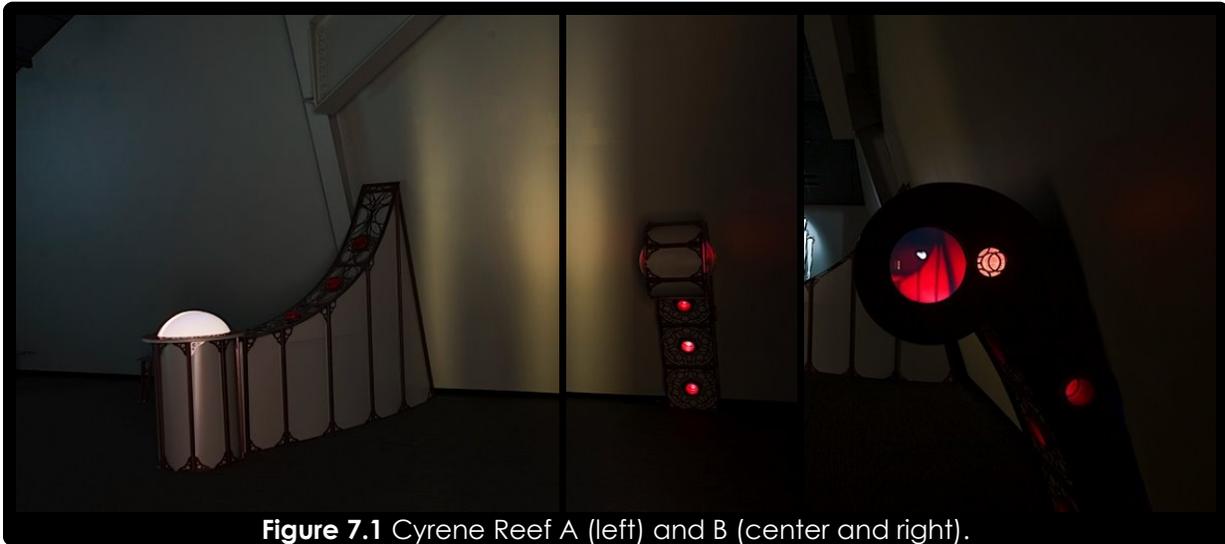
Figure 7.1 Cyrene Reef A (left) and B (center and right).

the space, they are affected by the physical forces that define the world around us, refracting from the walls and slowly dissolving until all of their kinetic energy is drained. Occasionally, ripples clash against each other spawning a flurry of ever-changing sonorities, na aural fireworks marking spots where visitors' paths may already have or are about to cross, or where an individual has caught-up with the wave they generated only a moment ago. The ensuing aural fabric serves as a foundation for a dynamic soundscape whose structure depends entirely upon visitors' actions and interactions.

CYRENE REEFS (two pieces)

Cyrene Reefs can be seen as a pair of ornate musical instruments or sculptural metaphors of instruments that draw inspiration from the mythical story. While at the first sight the installations offer a relatively simple form of interaction, just like any other musical instrument their full potential (akin to virtuosity of playing a real musical instrument) can be uncovered only through patience and persistence.
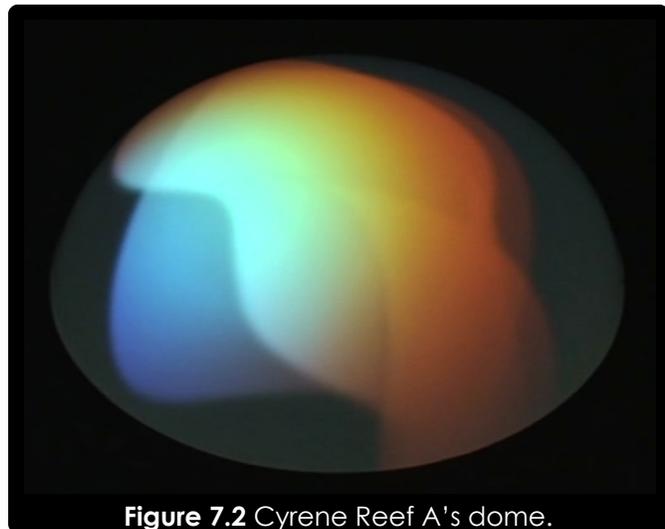

Figure 7.2 Cyrene Reef A's dome.

The first sculpture (labeled as A on Fig.7.1) is populated by three arm-sized holes that can be explored by inserting hands and in return offering aural feedback that builds upon the metaphor of elements, namely fire, water, and air. The interaction with the ensuing soundscape is also accompanied by the visual feedback in a form of an ever-changing organic shape populating the projection dome (Fig.7.2) whose properties are affected by the aforesaid elements. The holes utilize IR proximity sensors allowing for accurate measurement of distance from objects near and inside the holes. As a result, the sounds of the elements that grow as the hand is inserted deeper into respective holes are accompanied by a seductive dynamic melody whose range and loudness grows proportionally to the concurrent presence of the three elements and whose character is designed to complement the *Elemental* soundscape.

The second sculpture (labeled as B on figure 7.1), populated by five smaller hand holes offers audio-visual feedback that builds upon the metaphor of elements established in the first sculpture, in this case the element of earth. The interaction with the ensuing soundscpae is also accompanied by the visual feedback in a form of distorting camera projection found on both sides of the sculpture. Just like the first instrument, only through patience and persistence does the sculpture disclose all of its multisensory secrets. In this case, through the use of multiple hand holes, a wooden wind chime drone melody emerges encouraging improvisation with different sonorities ascribed to each of the hand holes.

Figure 7.3 Cyrene Reef B's iBot.

From a visual perspective, the two sides of the second sculpture are populated by homebrew infrared (IR) cameras that project their respective images on the opposite sides of the sculpture, suggesting that one can see directly through the large circular openings found on each side of the artifact. Inside this "transparent" space resides a tiny *iBot* (eye-bot) (Fig.7.3) that is capable of observing nearby visitors, often by uncomfortably staring at them for prolonged periods of time. In the event there are visitors on both sides of the artifact, the *iBot* will shift its attention from one side to the other as it sees fit, encouraging observers to seek its undivided attention. This sole "living organism" of the *Cyrene Reefs* stands as its endemic protector, while its seemingly simple behavior serves as a catalyst for spawning many different interpretations in visitors' minds regarding its role within this virtual "techosystem." Although an intricate hard shell separates the real world from the *iBot*'s (and whose visual manifestation is also found in the smaller red circle projections located on each side of the artifact), through the use of hand holes, visitors are able to momentarily "dip" their arms into the *iBot*'s world, generating aural feedback and consequently temporarily altering their own visual reflection in amusing and engaging ways.

8: VT Stakeholders Project (2007) (3')
AUTHOR(S) (in alphabetical order): Ivica Ico Bukvic and Dane Webster (Art)

A commission by the Virginia Tech Arts Initiative to produce a PR concept video of the newly proposed Arts and Creative Technologies facility for the purpose of raising $30 million. This particular project is a typical example of traditional production with a tight schedule. An online version of the video can be downloaded by clicking here (58MB Quicktime movie).

Figure 8.1 A screenshot from the video.

HIGHLIGHTS
- A traditional audio-visual production of a PR video on a tight schedule.
- Supported by an internal $25,000 grant from the VT Arts Initiative.

9: Borealis Desktop Sound Theme (2004) (N/A)
AUTHOR(S) (in alphabetical order): Ivica Ico Bukvic

A desktop sound theme originally designed for the KDE Linux desktop and released under the Creative Commons license. Since its release in 2004 it has seen over 250,000 downloads and has been included in a number of Linux distributions. It is currently the most downloaded and one of the most popular theme according to the user-driven www.kde-look.org website. "Borealis" has also served as a foundation for several commissions including SUN Microsystems (now part of Oracle) *OpenSolaris* sound theme project. The theme can be downloaded here.

HIGHLIGHTS
- Sound production and sonification.

10: Out of Doors Suite Part 2 (2003) (3')
AUTHOR(S) (in alphabetical order): Ivica Ico Bukvic

A linear audio-visual satire inspired by the Bela Bartok's legacy. To view an online version of the video please click here (16MB Quicktime movie) or here (YouTube).

PROGRAM NOTES
An apparently random title with [not so] subliminal references to Bela Bartok's legacy, in a desperate author's attempt to [quite blatantly] cash in on such an association, as well as in part due to utter sleep deprivation which had eventually resulted in a flu with benefits, Part 2 therefore stands as an unauthorized [and arguably abysmally botched] sequel [as usually all commercial sequels and prequels are] to its forerunner. Dubiously, through the interference of the [sparse] gray matter of its deranged parent [no, not Bartok, the other guy] the idea inexplicably grew into a buoyant play on words and stereotypes of our times.
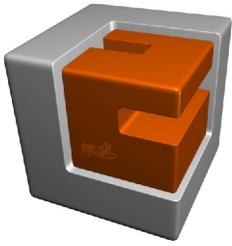

Figure 10.1 A screenshot from the video.

To put it bluntly, if you ever wondered what Monty Python would do if he did electroacoustic music…

HIGHLIGHTS
• Cross-pollination of sound and visuals.
• Use of Adobe Flash platform for animation.

11: Linux Laptop Orchestra (L2Ork) (PI) (2009-present)
AUTHOR(S): Ivica Ico Bukvic, Thomas Martin (ECE), and Eric Standley (Art)

Linux Laptop Orchestra (L2Ork) is latest addition to the Virginia Tech Music Department's curriculum. Its aim is to combine centuries of quintessential form of collaboration unique to a traditional western orchestra with contemporary creative technologies and through the ensuing synergy explore innovative uses both as an artistic ensemble and a hub for interdisciplinary scientific research. L2Ork draws inspiration from its precursors, PLOrk and SLOrk from Princeton and Stanford respectively. Unlike its forerunners, however, L2Ork's focus is on ultra-affordable design in part made possible through the use of the Linux operating system. This choice has effectively made L2Ork into world's most affordable and first Linux-based laptop orchestra.

L2Ork's affordable design is a product of a research project conducted in summer 2009 whose focus was on optimal hardware and software implementation. The six-week project engaging nine undergraduate student researchers and three faculty has received broad financial support across the campus as well as several corporate sponsors (for a detailed list of our sponsors, please visit L2Ork's website), resulting in a $750/seat setup which includes a laptop netbook, custom 6-channel hemispherical speaker, external soundcard, Nintendo Wiimote and Nunchuk, all supporting cables and accessories, and all software necessary for multimedia content creation and production. Apart from hardware-related milestones, summer project has resulted in a number of open-source software contributions to the Linux audio community.

L2Ork's significant cost savings have also helped spawn partnerships with regional K-12 initiatives, including Boys & Girls Club of Roanoke VA and the Music Lab at the Jefferson Center. One of the opportunities presented within the context of K-12 is cross-pollination of STEM and Arts. Students engaged in L2Ork curriculum are exposed to innovative technologies and pd-l2ork, in-house variant of Pure-Data free open-source real-time graphical programming environment for audio, video, and graphical processing (for additional info on pd-l2ork please see RESEARCH below) through which they are encouraged to explore the world of computation yielding near instant multisensory feedback.

Figure 11.1 L2Ork setup (top) and hemispherical speakers (bottom).

HIGHLIGHTS
• A collaboration among Virginia Tech Music, Engineering, and Art.
• Twenty on-campus Stakeholders (largest interdisciplinary initiative on Virginia Tech campus) and four corporate sponsors.
• Focus on open-source and affordable design to facilitate interfacing with K-12 education research opportunities.
• Exploration of alternative score delivery for users with diverse backgrounds (both musicians and non-musicians), including experimental GUIs and haptic feedback.
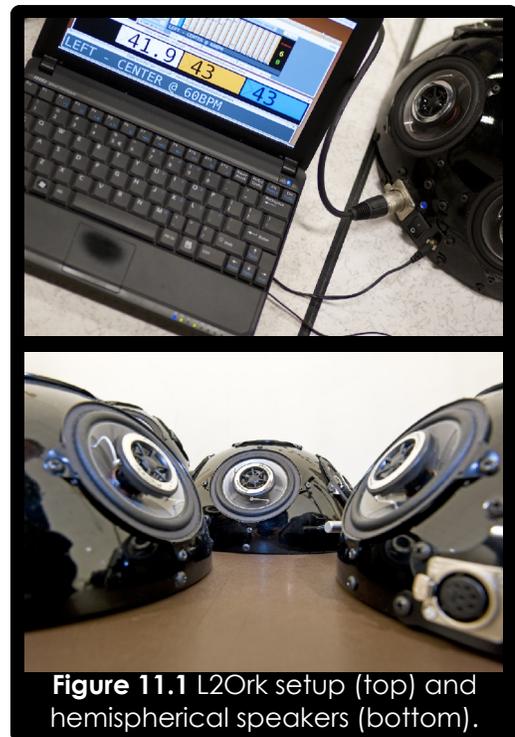
- Featured on TV, Radio, online media, newspapers, magazines, and journals. For a complete list of features please consult the CV.
- *Half-Life* written for L2Ork received first place in the first international laptop orchestra composition competition.
- Secured $50,000 in internal and external grants for the summer research project.
- Raised $50,000 for a 3-week European tour (Spring 2011) covering 7 countries and 11 performances/workshops.
- Received $20,000 through the Boys & Girls Club (21st Century and Bank of America) for the K-12 research.
- Served as a foundation for creation of 2 Laptop Orchestras (UNCG and an independent ensemble in Puerto Rico).
- Broader impact and outreach implementation as the core element of research.

Additional info on L2Ork, including research project footage and milestones can be found at L2Ork's website and VTDISIS YouTube channel.

12: Discrete REconfigurable Aural Matrix (DREAM) Interface (PI) (2007-present)
AUTHOR(S): Ivica Ico Bukvic, Denis Gracanin (CS/CHCI), Francis Quek (CS/CHCI)

Discrete REconfigurable Aural Matrix (DREAM) is a multi-speaker array technology designed for sonifying spatial visual data using human anterior discrete spatial aural perception potential. DREAM treats each individual speaker as an aural counterpart to a pixel or a pixel cluster of an anterior visual display surface, such as an LCD screen. The pilot study was conducted to assess DREAM's ability to sonify geometric shapes ranging from simple static objects to more complex layered compositions and consequently to ascertain its potential as a complementing technology in a number of interaction scenarios, most notably as a foundation for the arguably novel art genre, **the aural painting**. Apart from spawning new creative and research vectors, the preliminary study has also yielded promising results with 73% users being capable of perceiving geometric shape, 78% shape location, and 56% shape size, thus warranting additional studies with larger speaker arrays and additional applied scenarios. For a paper presented at the ICMC 2008 conference containing additional information on the preliminary study please click here here. The second phase was conducted using improved prototype in 2009 suggesting that over 85% of all users were capable of discerning up to four concurrent shapes as well as understanding implied meaning of the overall composition through the use of familiar sounds of nature. The new DREAM engine utilized 24-channels of audio per layer, three layers per shape, for up to four shapes for a total of 288 concurrent audio channels calculated in real-time. Additional publications currently pending.
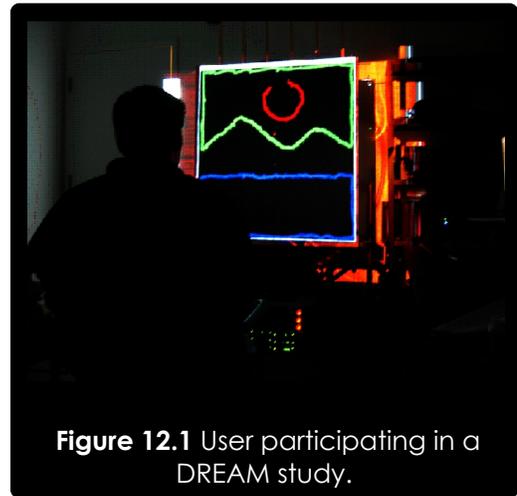

Figure 12.1 User participating in a DREAM study.

HIGHLIGHTS
- Collaboration between Virginia Tech's CS/CHCI and Music/DISIS/CCTAD.
- Use MaxMSPJitter, Javascript, and Java in conjunction with three networked OS platforms to run the simulation (Linux for OpenGL-based drawing interface, OSX for Bluetooth communication with the Wiimotes, and Windows for running the sound using RME HDSP9652 PCI interface).
- Secured $52,000 in phase I funding.
- Filed provisional patent with the VTIP office.
- Two publications.

13: Intelligent Space (PI) (2008-present)
PROJECT AUTHOR(S): Ivica Ico Bukvic, Dan Fogel (Wake-Forest MBA), Scott Betz (Winston-Salem Art), and Peter Marsh (Workplace Strategies)
PHASE I AUTHOR(S): Ivica Ico Bukvic (PI) and Dane Webster (Art)
PHASE II AUTHOR(S): Ivica Ico Bukvic (PI)

Externally funded project whose goal is to seamlessly integrate series of interdependent interactive multimedia installations into the Wake-Forest/Wachovia floor as part of the newly designed high-rise that will be built in downtown Charlotte, NC. The purpose of the proposed installations will be to promote intelligent and sustainable space that reacts to human presence and fosters awareness of and participation in the new facility. The main focus of the resulting ecosystem is collaboration that will manifest itself in a form of three interdependent modules: Transitional Space and Zen refuge, Café X, and Educational Avatar. The installation will consist of audio-visual stimuli that will react to and more importantly cognitively interact with human presence. Actions of participants will affect modules in different ways, resulting in an ever-changing malleable form of art that will offer reflection of past activities and their correlation to present dynamics on the floor and beyond.

The project revolves around the notion of sustainability. This fact manifests itself in all facets of the deliverables, including materials, concepts, feedback and

Figure 13.1 A screenshot from the Phase I Prototype.

awareness. The resulting installation will also project a sense of live adaptive space, providing invaluable information while exposing its participants to a collection of pleasing and engaging multimedia art.

PHASE I: Virtual Prototyping (completed summer 2008)
The final version of the phase I deliverable is viewable through a browser using Unity3D plugin (Mac or PC only) here.

Funded by the Wake-Forest's MBA program, the first phase focused on producing a virtual tour of the space using Unity3D game engine. We focused on the "imagine if" approach simulating proposed modules and experimenting with their potential scope and impact. This has allowed for the assessment of the proposed technology and its creative, artistic, and collaborative impact in promoting notions of an intelligent and sustainable space, before investing in a more costly physical prototype. As a result we relied upon utilizing first-person gaming paradigm through which user can navigate the space, interact with contextual information billboards and partake in simulated interactions with the aforesaid three modules.

PHASE II: Physical Prototyping (fall 2008-present)
The second phase, funded by matching internal grant funds from VT's ISCE and ICTAS, focuses on prototyping hardware necessary to support envisioned interactions with estimated completion in the summer 2009.

HIGHLIGHTS
• Collaboration among Virginia Tech DISIS/CCTAD, Wake-Forest MBA, Winston-Salem Art Dept. and Workplace Strategies Inc. (architects).
• Use of advanced gaming engine (shaders, positional sound, optimized meshes, animation, physics engine) as a sandbox for the exploration of various approaches to generating series of space-, purpose-, and location-specific interactive multimedia art installations that would foster collaboration among its inhabitants.
• Physical prototyping using MaxMSPJitter, Javascript, Unity3D (C and C#), and μ framework (please consult Research section for additional information).
• Received $14,000 external grant (Wake-Forest MBA, phase I) and a matching internal $10,000 grant (VT's ISCE and ICTAS, phase II).

14: Ultrasonic Gesture Sonification (UGS) & Interactive Taiji (PI) (2007-present)
UGS AUTHOR(S): Ivica Ico Bukvic and Denis Gracanin (CS/CHCI)
TAIJI AUTHOR(S): Ivica Ico Bukvic (PI), Isabel Bradburn (Human Development), Denis Gracanin (CS/CHCI), Matthew Komelski (Taiji Instructor), and Kelly Parkes (Music Ed)

A set of preliminary studies to develop practical and efficient means of monitoring human body motion and gestures. In its first version (Ultrasonic Gesture Sonification), the protoype relied upon the MaxMSP for data analysis and sonification and Jitter for visualization of observed gestures. For data acquisition the system utilized 4 MIT iMotes (a.k.a. Crickets) capable of measuring distance using ultrasonic impulses. The resulting prototype consisted of one hand-held iMote listener whose position was triangulated through the use of three floor-mounted iMote beacons. An online demonstration of the first prototype is available here (YouTube video).

The second phase of the project titled *Interactive Taiji* was funded by the $5,000 Virginia Tech's Education Enhancement Seed Grant that explores the potential of creative technologies in the K-12l curriculum. For this purpose we developed a Max external capable of interfacing with the *Wii Fit* platform (for more info please consult the Max Externals project included below). The current prototype interfaces with the art of Taiji (Fig.14.1) offering:

Figure 14.1 *Interactive Taiji* game.

- A one-click Max-based Taiji lesson production system consisting of balance data, weight, audio and video footage packaged in an optimized portable format.
- Taiji lesson integration into a game platform built using MaxMSPJitter.
- Dynamic audio and visual engine that responds to user performance.
- User progress monitoring through the use of Excel-compatible performance reports.

As part of our partnership with the public schools of SW Virginia, during the spring 2009 semester we are planning to assess prototype's impact on student's development, physical health, and ability to focus by introducing it in the 3rd grade PE curriculum.

HIGHLIGHTS
- Collaboration among Arts (Taiji), CS, CHCI, Human Development, Music, Music Ed, and K-12 Education.
- Use of MaxMSPJitter, Javscript, custom disis.aka.wiiremote external, and Wii Fit balance board.
- Integration in the K-12 curriculum.
- Received $5,000 VT's EECG seed grant for the phase II.
- Received $3,000 VT's EECG seed grant for the phase III.
- Received $5,000 VT's IDDL (distance learning) seed grant for the development of the first online physical education module.
- $600K NSF Smart Health & Wellbeing grant proposal pending.

15: μ (mu) Max-Unity Interoperability Toolkit (PI) (2008)
AUTHOR(S): Ivica Ico Bukvic, Ji-Sun Kim (CS/CHCl), and Keith Wooldridge (CS)

Object-oriented rapid prototyping tools geared towards multimedia, such as MaxMSPJitter and Pd/Gem, serve as a powerful foundation for efficient multimodal cross-pollination and integration. Although both Max and Pd support OpenGL, the lack of scalability, user-friendly 3D editor, and physics engine makes them less desirable solutions for the rapid development of complex environments and physics simulations. Unity3D is a powerful rapid 3D video game prototyping platform with an integrated physics engine. Its audio capabilities, however, are limited mainly to triggering and spatialization of audio buffers. μ is a toolkit offering easy integration of Max/PD with Unity3D, allowing for exchange of control data, as well as importing of dynamic Jitter textures into Unity3D. The former makes it particularly suitable for efficient sonification of physics simulations. μ has been utilized in Elemental, an interactive communal soundscape installation (part of the Revo:oveR exhibit) allowing for visitors' motion (Max) to drive a physics engine (Unity3D) and sonify ensuing data across a 12-channel ceiling-mounted speaker array (Max). μ is also currently used in as part of the physical prototyping phase of the Inelligent Space project. For a paper (publication pending) with additional information please click here here. A video demonstration of the toolkit is available here (YouTube).

HIGHLIGHTS
- The design and development of an interoperability toolkit to expand rapid prototyping capabilities of MaxMSPJitter and Unity3D.
- Use of Max, Unity3D API, C, C#, and Javascript.

16: pd-l2ork – L2Ork version of Pure-Data (PI) (2010-present)
AUTHOR(S): Ivica Ico Bukvic, Mike Hawthorne (CS), Deba Pratim Saha (EE)

Pd-l2ork, L2Ork's in-house Linux-centric fork of the Pure-Data free open-source real-time graphical programming environment for audio, video, and graphical processing came out of a need for a stable and robust system for both K-12 Satellite Laptop Orchestra and the Virginia Tech's Linux-based laptop orchestra. The result is a fully backwards compatible, yet entirely new platform offering over 200 bug fixes and new features, including mouse-centric editing of visual properties (e.g. resizing of objects, graph-on-parent, etc.), infinite undo, signal flow monitoring, extended canvas properties, improved scrolling and redrawing algorithm, more robust networking code, half-dozen new externals, refreshed Tcl/Tk GUI, and a number of stability improvements. The system is the backbone of L2Ork's infrastructure.

HIGHLIGHTS
- Robust, stable environment with new features, a number of which are currently being adopted upstream.
- Focus on usability and reliability.

17: Max Externals (2007-present)
disis_munger~ AUTHOR(S): Ivica Ico Bukvic, Ji-Sun Kim (CS/CHCI), Dan Trueman (Princeton), and Thomas Grill (Vienna Conservatory)
disis.aka.wiiremote AUTHOR(S): Ivica Ico Bukvic and Ji-Sun Kim (CS/CHCI), code in part based off of Masayuki Akamatsu's *aka.wiiremote* external

disis_munger~ (a.k.a. munger1~) (2007)
A flext port of Dan Trueman's munger~ with additional enhancements and optimizations presented at ICMC 2007. As a result the new version uses identical code to run on Max and Pd (Linux, OSX, and Windows). For additional info, please download the external with supporting documentation by clicking here.

disis.aka.wiiremote (2008)
An enhanced version of Masayuki Akamatsu's *aka.wiiremote* external, including Wii Fit balance board support, connection, and stability improvements. For additional info, please download the external with supporting documentation by clicking here. As part of the testing phase we also retrofitted Neverball open-source game to enable interfacing with the Wii Fit balance board via Max using UDP protocol. For an online video of this concept please click here (YouTube).

HIGHLIGHTS
• Cross-institutional collaboration including CS, CHCI, and Music/DISIS/CCTAD.
• Building upon existing open-source frameworks to bridge the platform gap and broaden capabilities of both MaxMSP and Pd.
• Use of C and C++.

18: RTMix (2002-2004)
AUTHOR(S): Ivica Ico Bukvic

RTMix is an open-source (GPL-licensed) software application designed to provide stable, user-friendly, standardized, and efficient performance interface that enables performer(s) to interact with both the computer and each other with minimal amounts of distraction. For this purpose RTMix offers an array of visual stimuli that can be utilized on-stage in order to coordinate various performing forces utilizing diverse media. For additional info, please consult the online manual.

NB: RTMix being my first serious effort at predominantly self-taught C++ programming and GUI-based application design, its source is very poorly structured. The application, however, apart from a few minor bugs is fully functional and should cleanly compile against latest Linux distributions.
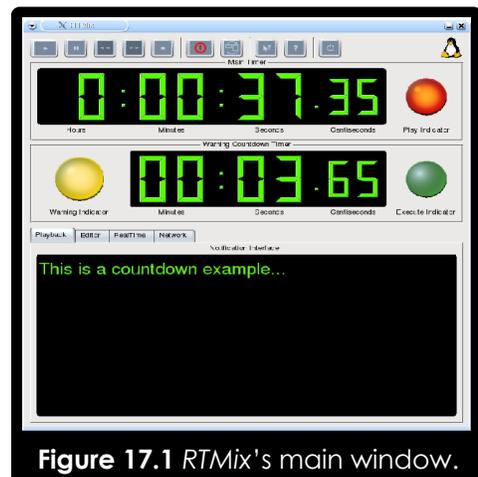

Figure 17.1 *RTMix*'s main window.

HIGHLIGHTS
• Built using C++ and Qt cross-platform GUI toolkit.
• Fostering interoperability using a script with RT-like syntax.
• Ability to trigger system calls, and establish bi-directional communication using MIDI and OSC protocols.

- Use of visual cues and timers to keep performers informed while keeping distraction levels to a minimum.
- Includes composite visual metronome, relative and absolute timers, and internal variables.
- The documentation also includes a version of the Simon game demo presented at the ICMC 2002 and LAC 2004 conferences.

18: Early Revo:oveR Prototypes (2007-8)
POPCORN AUTHOR(S) (in alphabetical order): Ivica Ico Bukvic, Simone Paterson (Art), and Dane Webster (Art)
iBot AUTHOR(S) (in alphabetical order): Ivica Ico Bukvic, Carol-Burch Brown (Art), and Steve Harrison (CS)

POPCORN
A communal immersive environment prototype using MaxMSPJitter. Flocking animated popcorn-like entities populate a three-screen L-shaped audio-visual surface and are attracted to sounds made by visitors. The aim of this interaction is in part to facilitate communal interactions among the visitors. The prototype is powered by two machines (one dual video card G5 for 3 projections and one PC with RME HDSP9652 for audio) (Fig.18.1). Practically none of the early prototype has made it into the final show. Instead, it is currently being used as an entirely separate installation project.

HIGHLIGHTS
• Collaboration among music, 3D animation, and video artists.
• Use of a 3-screen projection (3 independent scenes, use of frustum).
• 3D mesh morphing.
• Boid (a.k.a. flocking) algorithm.
• Interactive attraction logic through sound cues (using a microphone array).
• Aural spatialization using 3D 8.1 speaker matrix.
• Use of granular synthesis for Boids' individual voices.
• 3D structures by Dane Webster.
• Background skybox video by Simone Paterson.

Figure 18.1 *Popcorn* prototype (top) and tech setup (bottom).

iBot (a.k.a. arm pit demo)
An early concept coupling arm videos (part of the *Revo:oveR* exhibit) with the scripted behavior of a 3D *iBot*. For an online demonstration of this prototype please click here (YouTube). For an *iBot* screenshot please consult the *Revo:oveR* documentation.

HIGHLIGHTS:
• Collaboration team consisting of music and arts.
• Focus on seamless integration of video and 3D content (e.g. inclusion of noise textures to foster blending of the two layers).
• *iBot*'s ability to track entities using a camera tracking algorithm.
• The design of an efficient scripting language to render iBot's motion and/or behavior.

19: Touchless Interface (2008-present)
AUTHOR(S): Ivica Ico Bukvic and Ji-Sun Kim (CS/CHCI)

A study in the design and development of a cost-efficient touchless interface for the purpose of investigating expressive potential of common arm gestures. Nine infrared (IR)-based proximity sensors were used to detect the position and trajectory of an arm. The resulting data was used to build a library of feasible gestures recognizable by the said interface. Apart from cost-efficiency, the newfound hyperinstrument also offered unprecedented simplicity of the gesture recognition framework, making it a compelling platform for interaction with aural and audio-visual content. In order to assess its expressive potential, the preliminary prototype was tested in two interactive art installation scenarios community and Heads will Roll (linked to respective YouTube video demonstrations).
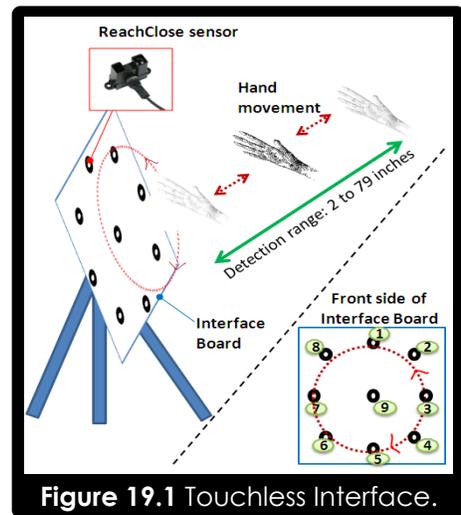

Figure 19.1 Touchless Interface.

HIGHLIGHTS
- Hyperinstrument research coupled with HCI usability study.
- Use of 9 i-cubeX ReachClose IR proximity sensors (Fig.19.1) and MaxMSPJitter to build an efficient touchless gesture interface.
- Future plans include additional tests and studies, refining of the interface design, and focus on further lowering of the cost through the use of the Arduino hardware platform.

20: Pandora (2007) (7')
AUTHOR(S) (in alphabetical order): Ivica Ico Bukvic

Pandora is a structured improvisation/technology demo hybrid for laptop, quad audio, video, and performer. Employing a simple color-tracking algorithm in conjunction with backlit colored bottle caps, performer's hand gestures are transformed into a versatile hyperinstrument. The work builds upon the mythological story, basking in the very point of no return. A demo footage of the 2007 version can be viewed via YouTube by clicking here.
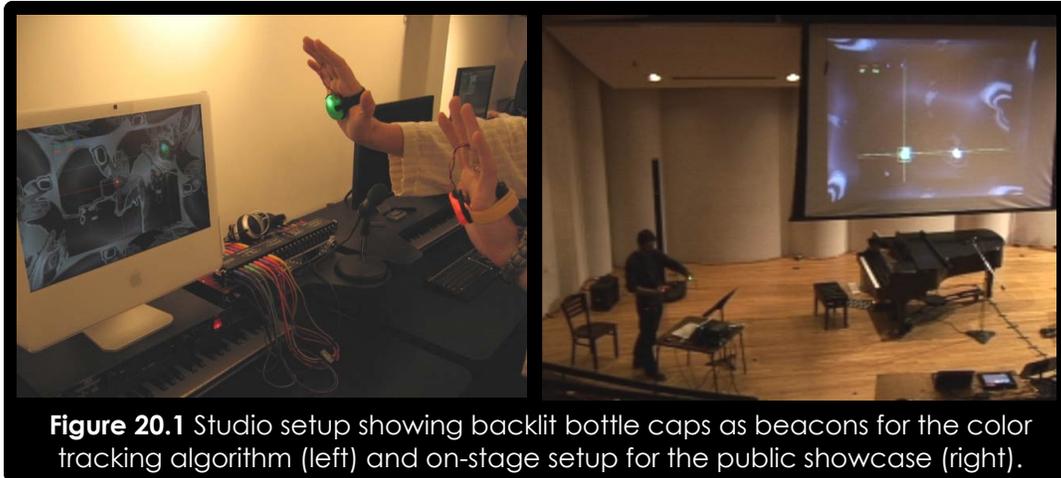

Figure 20.1 Studio setup showing backlit bottle caps as beacons for the color tracking algorithm (left) and on-stage setup for the public showcase (right).

HIGHLIGHTS
- Integration of aural and visual in the form of a hyperinstrument.
- Sound: use of author's disis_munger~ real-time granular synthesis MaxMSP external (a.k.a. munger1~, an enhanced port of Dan Trueman's munger~ from the PeRColate library—please consult research section for additional information).
- Visuals: use of convolution, algorithmic textures, GUI effects, basic camera color-tracking algorithm, and 3D primitives.
- Homebrew hyperinstrument consisting of backlit bottle caps with a battery pack that can be strapped on hands.