"The Birth and Rise of the Laptop Orchestra"

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THE BIRTH AND RISE OF THE LAPTOP ORCHESTRA!

Directly out of Perry and Dan’s work on embodied interfaces and speaker arrays, the Laptop Orchestra pushes the idea of electronic chamber music to a new (cy)logical extreme. Not one, but an ensemble of embodied interfaces with humans in the loop.

In 2005, the first of its kind and scale was born: The Princeton Laptop Orchestra (PLORK).

Laptops? Orchestras? Never the twain shall meet! And yet...

How does it change the way we compose...

And design instruments, and craft live performances?

Scott Smallwood

...and find a good balance between human and technology?

DAN TRUeman

...this strange pairing makes it all the more intriguing!

SLOrk In Beijing 2014

Ensembles in this medium can be comprised of more than 20 laptops, humans, and...

...custom multi-channel hemispherical speaker arrays...

...designed to provide each computer meta-instrument and human performer with their own sonic identity and presence.

The laptop orchestra is capable of fusing a powerful sea of sound with the immediacy of human music-making, attempting to capture the energy of a live ensemble as well as its sonic intimacy...

In what we think of as a form of electronic chamber music.

The laptop orchestra embodies many of the ideas we’ve encountered: re-mutation, body, co-design, interfaces as extensions...

Plork’s west coast sibling, Stanford’s Slock was founded three years later in 2008...
THE ORCHESTRA VS. THE LAPTOP (IN PERFORMANCE)

- **THE ORCHESTRA**
  - Is large
  - Typically lives in a reasonably large performance hall with good musical acoustics
  - Sound is net sum of many relatively proximal instruments in this hall
  - Is divided into sections according to the nature of these instruments
  - Instruments typically take decades to master, and have been under refinement for even longer, sometimes centuries
  - Is usually conducted

- **THE LAPTOP**
  - Is typically used alone
  - Plans in all sorts of spaces: bars, clubs, sometimes concert halls
  - Sound is typically amplified through a centralized PA system
  - Instrument design is constantly in flux, sometimes even generated during the actual performance (live coding), often created by the player
  - Mastery of instruments can take a few minutes or much longer
  - What? A conductor?

**THE LAPTOP ORCHESTRA**
- Typically between 4 (quartet) and 20 (full ensemble) performers in size
- Each human performer is paired with a meta-instrument, so-called because it’s a laptop station that can be designed into different and more specific instruments
- A meta-instrument consisting of a laptop, multi-channel audio interface, and -- crucially -- a multi-channel hemispherical speaker array
- Sound is local and proximal to each instrument and player
- Instruments are often designed on a case-by-case basis, tightly tailored to each work in question, as bespoke experiences for each piece
- The notion of playing the instruments are as varied as the instruments
- Formats of pieces range from free-form or structured improvisation to rigidly scored pieces, no prescribed limitation on types of music (e.g., genre)

**TYPICAL SETUP FOR EACH META-INSTRUMENT IN THE STANFORD LAPTOP ORCHESTRA**

- **HEMISPHERICAL SPEAKER ARRAY** keeps sound local to the instrument
- **MEDITATION PILLOW** might as well be comfortable
- **MEDITATION MAT** we sit close to the ground
- **LAPTOP** for interaction, programming, and sound synthesis
- **BREAKFAST TRAY** for holding the laptop
- **AUDIO INTERFACE** multi-channel audio signal to speaker array

IT IS IN THIS REAL-WORLD CONTEXT THAT SUCCESS IS MEASURED. IT’S ABOUT FINDING THE RIGHT INTERPLAY BETWEEN WHAT PEOPLE ARE GOOD AT DOING AND WHAT COMPUTERS ARE GOOD AT DOING (WHILE EMBRACING THEIR RESPECTIVE LIMITATIONS) TO ACHIEVE AND EXPLORE AN AESTHETIC GOAL.

THAT WE HAVE TO DESIGN THE INSTRUMENTS FROM THE GROUND UP FOR EACH NEW WORK IS BOTH A BLESSING AND CURSE.

CENTRAL TO THE LAPTOP ORCHESTRA IS THE IDEA OF DESIGNING DIFFERENT TYPES OF MUSICAL INTERACTIONS THAT BRIDGE THE TRADITIONAL HUMAN-CENTRIC ASPECTS OF MUSIC-MAKING AND THE UNIQUE (AND LESS UNDERSTOOD) POSSIBILITIES OF TECHNOLOGY.

THE SOUND OF A VIOLIN DOES NOT NATURALLY COME OUT OF SPEAKERS AROUND YOU, BUT RATHER FROM THE ARTIFACT ITSELF...

OUR SPEAKER ARRAYS ARE DIRECT DESCENDANTS OF RESEARCH THAT PERRY AND DAN CONDUCTED IN THE 1990s. MUCH LIKE THE BOSSA HEMISPHERICAL SPEAKER ARRAYS APPROXIMATE OUTWARD-RADIATING SOUND SOURCES, EMULATING THE WAY ACOUSTIC INSTRUMENTS RADIATE SOUND.

THEY PROVIDE A SONIC PRESENCE AND THE IMPRESSION OF A PHYSICAL ARTIFACT MAKING THE SOUND IN PROXIMITY TO YOU. IN STARK CONTRAST TO THE DISEMBODIED SOUND FROM SPEAKERS THAT SURROUND YOU.

IF IT FAILS ANY OF THESE CHECKS, THEN PERHAPS THE DESIGN, AS IT STANDS, ISN’T THAT INTERESTING OR SHOULDN’T USE THE TECHNOLOGY. DESIGN IS COGNIZANT OF SPECIFICITIES OF THE MEDIUM, AND WE TRY TO SEE HUMANS AND COMPUTERS AS TWO FUNDAMENTALLY DIFFERENT TYPES OF ENTITIES, EACH WITH BUILT-IN ADVANTAGES AND LIMITATIONS.

COMPUTERS VS. HUMANS

- NO INHERENT NOTION OF INTENTION OR AESTHETICS
- FOLLOW CLEARLY DEFINED INSTRUCTIONS AND LOGIC
- CAPABLE OF PRECISELY CARRYING OUT SEQUENCES OF SIMPLE OPERATIONS
- CAN SYNTHESIZE SOUNDS TO SPECIFICATION
- CAN BE NETWORKED

GOOD DESIGN EMBRACES EACH SIDE FOR WHAT IT IS. HERE, THE MEDIUM IS THE MIXTURE OF COMPUTERS AND HUMANS.

- INHERENT DESIRE TO EXPRESS
- CANNOT HELP BUT INTEND
- NATURALLY SOCIAL
- CAPABLE OF REASON
- CAPABLE OF AESTHETIC JUDGMENT
- REMARKABLY ADAPTABLE (WE ARE JACKS-OF-ALL-TRADES); SPECIALIZATION TAKES TRAINING

DEPENDING ON ADDRESSABLE MEANING WE CAN SEND DIFFERENT SOUNDS TO EACH SPEAKER, MAKING POSSIBLE TECHNIQUES FOR SPATIALIZATION AND EFFECTS.
ADVENTURES IN BUILDING THE STANFORD LAPTOP ORCHESTRA!

STEP 1: GET SALAD BOWLS

IT BEGAN WITH A TRIP TO THE LOCAL IKEA TO PROCURE 25 WOODEN SALAD BOWLS...

C.C.R.M.A.

IN THE CALIFORNIA SUN, ON THE STEPS LEADING UP TO CCRMA...

SALAD BOWLS

READY TO DRILL!

I WORKED OUT THE SCHEMATIC!

LET'S DO THIS!

STEP 2: DRILL!

YEAAAAH!!

MEASURE AND MARK THE CENTERS OF SPEAKER LOCATIONS

WITH 30 HEMIS AND 6 CHANNELS EACH, WE HAVE TO DO THIS 120 TIMES!

KzzzNNNNNHHzzzNN

WITH SEVERAL HOLESAWS BURNED OUT IN THE PROCESS.

ANOTHER ONE DONE...

...117 MORE TO GO.

STEP 3: INSTALL SPEAKERS

AND UNFORESEEN ISSUES AROSE...

HAM, IT DOESN'T FIT, WHAT THE...

IT WAS SPRING BREAK 2008, WHILE MANY PARTIED ON BEACHES ELSEWHERE, A SMALL GROUP OF DEVOTED BUILDERS HAD DIFFERENT PLANS.
THE NEXT DAY...

THE SALAD BOWLS’ NEW GROOVES!

GOTTA MAKE ‘EM LOOK NICE AND FEEL SMOOTH...

LATE NIGHT, AT STANFORD’S PRODUCT REALIZATION LAB...

STEP 5: CUT AND ROUTE BASE PLATES

THE BASE PLATES ARE CUT FROM LARGE SHEETS OF POPLAR WE GOT FROM A HARDWARE STORE. THEY WERE ROUTED FOR A SMOOTH FINISH.

NO ONE IN THE AUDIENCE WILL EVER DISCERN THIS DETAIL, BUT IT WAS IMPORTANT TO US...

STEP 4: MAKE THINGS FIT

THE MEASURING, DRILLING, AND FILING WENT WELL INTO THE NIGHT...

UHH, THE SPEAKER DRIVERS HAVE CORNERS SLIGHTLY LARGER THAN THE HOLES...

DRILLING, DRILLING, DRILLING...

OKAY NO PROBLEM! WE’LL JUST GRIND SOME GROOVES UNTIL THINGS FIT!

WWW THAT’S LESS THAN SPECTACULAR...

LEADING TO SOME MANUAL FILING...

SEVERAL ROTARY SANDING MACHINES WERE IN THE FOLD, HELPING THE PROCESS...
Meanwhile, a parallel team worked on the electronics and circuitry!

Tinker, wire, solder, fit...

HMM...

Prototypes of various form factors and sizes were built!

Nope...

...hear anything?

Let's check the wires again.

WHERE IS THAT OTHER AMP CIRCUIT?

MAYBE THIS SWITCH WILL FIT BETTER...

How could this not work?

STEP 6: ELECTRONICS

For the next two weeks, Corinne's Max Lab (named after Max Mathews) transformed into an around-the-clock venue for soldering, circuit bending, drilling, cutting, gluing, experimenting, assembling the laptop orchestra.

Each hemispherical speaker array (or "HEMI") houses three stereo Class-D "T-Amp" amplifiers wired together, for a total of six channels each. Multiplied by 20 HEMIS for a total of 120 channels.

We drilled holes in metal strips through which we installed audio jacks.

A view behind the strip...

Drawer handle for carrying the HEMI.
STEP 9: TEST-DRIVE

BEST WAY TO TEST A LAPTOP ORCHESTRA: MAKE MUSIC WITH IT!

FROM CONCERT HALLS...

TO AN OUTDOOR SCULPTURE GARDEN...

MEH THIS LAPTOP GOES TO ELEVEN.

TO INTIMATE CHAMBER MUSIC SETTINGS...

...WHERE WE DEPLOY FEWER STATIONS...

...AND THE AUDIENCE SITS AMONG THE ENSEMBLE.

AND FROM CALIFORNIA TO BEIJING...

ALEX

ROMAN

HANA

NI HAO

SUMMER 2014

WE CREATED NEW WORKS INSPIRED BY THE SOUNDS, CULTURE, AND PEOPLE OF BEIJING...

AND PERFORMED IN THE MIST...

KITTY

BEIJING CAN BE GORGEOUS, ON DAYS WHEN THE SUPER SMOG LIFTS...
STEP 10: DESIGN NEW WORKS!

The instruments in the laptop orchestra are as diverse as the works themselves. This is a truly a testament to Perry’s make a piece, not an instrument, principle. Computers as a design medium seem to uniquely support the model of pieces in search of a custom instrument, where interfaces are designed specifically to support each piece.

Indeed, we usually don’t design general-purpose instruments and then write music for them, but rather we start with an idea for a piece, and work backwards to invent the instrument(s) specifically for that piece, or we co-design the piece with the instrument(s). It’s a good way to discover what features the interface actually needs.

NON-SPECIFIC GAMELAN TAIKO FUSION (2005)
BY PERRY R. COOK & GE WANG

This piece is an experiment in human-controlled but machine-synchronized percussion ensemble. Performance: various percussion sounds are temporally positioned in patterns by each player (and are synchronized by network across the ensemble), and the piece gradually transitions from tuned bell timbres to drums as the density and intensity grows and slows according to instructions conveyed by a conductor.

Each instrument is part of a networked step sequencer that precisely synchronizes all the machines, leaving the players to construct and evolve the musical patterns on a discrete temporal grid.

A conductor signals the density (“wicked sparse” to “very dense”) and timbre (which colors to use) in the patterns. Each player is constrained to individual channels.

A conductor holds up pieces of the score.

The score sheets are printed live on the fly during the performance, further underscoring the improvisational nature of the piece.

CONDUCTOR

ENSEMBLE

Occasionally also included: acoustic bells and drums

MAGNET PRINTER

ON THE FLOOR (2005)
BY SCOTT SMALLWOOD

A c-major chord drone carpets the soundscape and ramps up intensity over the course of the performance.

Choices of wager: one, two, or three, resulting in algorithmically generated melody fragments.

You will notice when you walk into a casino that the machines are all tuned to the same key: a c-major chord. This chord floats around the space, in and out of every crevice, constantly artefacting: humming, droning, twittering, echoing, sometimes incorporating snippets of melody. This happy drone soothes the nervous customers as they slowly drop their money into the machines. They create a sea of c-major, each and every one of them, pressing buttons on the machines, credit after credit, all day and all night.

A TOTALLY DIFFERENT PIECE, AND INSTRUMENT

THE INSTRUMENT INTERFACE IS A MOCK SLOT MACHINE, WHERE THE PLAYERS MAKE WAGERS OF ONE, TWO, OR THREE VIRTUAL COINS (CHOICES REPRESENTED AND VISUALIZED BY COLOR-ENHANCED BY PLAYING THIS GAMBLING SIMULATION, THE ENSEMBLE RECREATES THE SOUNDSCAPE OF A CASINO.

REMAINING GONS FOR PLAYER

ready...

[ 30 ]

As part of the theatrical gesture of this performance, players continue playing until they lose all their credits, at which point they physically get up and slowly walk off the stage...

THE PIECE ENDS WHEN EVERYONE LOST THEIR VIRTUAL MONEY!

I AM VIRTUALLY BROKE!

THE CONDUCTOR (A.K.A. "THE HOUSE") SURVEILS ALL THE PLAYERS FROM A CENTRAL MACHINE AND CAN REMOTELY CHANGE THE ODDS OVER THE COURSE OF THE PERFORMANCE (WHICH ALSO HELPS TO ENSURE THE PIECE ENDS ON TIME)
IN ADDITION TO BEING AN ENSEMBLE AND DESIGN LAB FOR NEW INSTRUMENTS...

...THE LAPTOP ORCHESTRA IS ALSO A CLASSROOM THAT EXPLORES MUSIC, PROGRAMMING, INTERACTION DESIGN, COMPOSITION, AND LIVE PERFORMANCE AS PART OF A SINGLE CONTINUUM.

STUDENTS COME FROM MUSIC, COMPUTER SCIENCE, ARCHITECTURE, BIOLOGY, ECONOMICS... BUT AS PART OF OUR TEACHING PHILOSOPHY, WE DO NOT EXPLICITLY DIVIDE UP STUDENTS ACCORDING TO RESPECTIVE BACKGROUNDS (E.G., COMPUTER SCIENCE, MUSIC, DESIGN, ETC.). INSTEAD WE EXPECT EVERYONE TO NEGOTIATE THE FULL CREATIVE PIPELINE, EMBRACING THE CO-DESIGN OF ELEMENTS.

LIVE PERFORMANCE SERVES AS AN END GOAL, A FORCING FUNCTION TO BUILD SOMETHING THAT WORKS AND IS AESTHETICALLY COMPLETE.

A LOT OF WORK HAPPENS LEADING UP TO AND ON PERFORMANCE DAY...

...AUTO INTERFACES, WIRES, POWER ADAPTERS, POWER CONDITIONERS, TRANS, CONTROLLERS, SUBWOOFERS... ARE WE FORGETTING ANYTHING?

TO TRANSPORT SPEAKERS, COMPUTERS, MATS, PILLOWS...

MAYBE THIS COWBELL?

BING CONCERT HALL

SETTING UP THE ENSEMBLE TAKES A FEW HOURS.

ANYONE SEEN THE ROUTER?

SOFTWARE CONFIGURATIONS

SOUNDCHECK...

REHEARSAL...

SHOWTIME!

LET'S UP THE REVERB MIX TO .06 FOR THIS SPACE!

AND DEBUGGING -- BOTH MUSICAL AND TECHNOLOGICAL

KITTY

ROGER

RANY

HMM...

TROY

MICHAEL

ADNAN

JIANFENG

AUDREY

CHARLES

JIEUN
“TWILIGHT (2013)
BY GÉ WANG

INSPIRED BY THE CLASSIC SCIENCE FICTION SHORT STORY “TWILIGHT” BY JOHN W. CAMPBELL (PUBLISHED IN 1934 UNDER THE PSYNOYM “DON A. STUART”), THIS PIECE RUMINATES NOT ON THE DAWN, ASCENSION, OR TRIUMPH OF THE HUMAN RACE, BUT ON OUR POSSIBLE DEMISE. SET SEVEN MILLION YEARS IN THE FUTURE, THIS END IS NOT ONE OF ANNIHILATION THROUGH WAR, NOR DEIFICATION FROM FAME OR DISEASE, BUT A GOLDEN DECRESSENDO OF DEFEAT BROUGHT ON BY THE GRADUAL PEACEFUL, BUT UNSTOPPABLE UPSURING OF TECHNOLOGY AND MACHINES — AND THE LOSS OF HUMANKIND’S CURIOSITY AND SENSE OF WONDER — FROM THE ORIGINAL TEXT!

MOVEMENT ONE
THE DEAD CITY

“And all the great city structure throbbing and humming to the steady gentle beat of perfect, deathless machines built more than three million years before. — and never touched since that time by human hands. And they go on. The dead city, the men that have lived, and hoped, and built — and died to leave behind them those little men who can only wonder and look and long for a forgotten kind of companionship they wandered through the vast cities their ancestors built, knowing less of them than the machines themselves.”

“THE METAPHOR”
THE PRIMARY INTERACTION IN
MOVEMENT ONE IS BASED ON THE
ABSTRACT IDEA OF PULLING A
SOUND OUT OF THE GROUND.

THE INTERACTION IS MAPPED INTO GRANULAR
SYNTHESIS, SUCH THAT THE VERTICAL POSITION
DIRECTLY CONTROLS THE PLAYBACK POSITION
OF ANY INPUT SOUND EFFECTIVELY SCRUBBING
THROUGH THE SOUND. IF THE MOTION STOPS
HALFWAY THE SOUND WILL CONTINUE, BUT IT IS
FROZEN AT THE CURRENT PLAYBACK POSITION.
GRANULAR SYNTHESIS MAKES THIS EFFECT SEEM
SMOOTH AND TIMELESS.

GRANULAR SYNTHESIS
CHOPS UP AN INPUT SOUND INTO TINY
(10-100-MSP) WINDOWED PARTICLES (CALLED
GRAINS), TRANSFORMS THEM IN PITCH,
DENSITY) AND RECONSTITUTES THEM INTO
IMPRESSIVE IMPACT SOUNDS

THE RESULTING EFFECT IS A SENSE
OF SOUND BECOMING UNSTUCK IN
TIME, ALLOWING US TO “SCRUB”
THROUGH IT WITH OUR GESTURE.

IT CREATES THE HAUNTING SOUND
OF THE DEAD CITY, A SONIC MELTDOWN
OF HUMANKIND'S SCALING-UP AND DEFEATING
MACHINES, LONG LIBERATED FROM
HUMAN DESIGN AND MAINTENANCE.

THE ENSEMBLE MIRRORS THE CONDUCTOR’S MOTION, MOVING IN UNITY GIVING VOICE TO A CITY OF MACHINES.

THE DESIGN BRINGS TOGETHER A CLASSIC
SCIENCE FICTION NARRATIVE, A PHYSICAL
METAPHOR (PULLING A SOUND OUT OF THE
GROUND), AND A SYNTHESIS ALGORITHM
(Granular Synthesis).
DAY TURNS TO DUSK. THE ENSEMBLE -- WHO EARLIER ASSUMED THE ROLES OF MACHINES AND THE CITY SPIRES -- NOW REPRESENT HUMANITY, LYING DOWN TO SLEEP PHYSICALLY, METAPHORICALLY...

TO DREAM...

...A SONG OF LONGINGS.

MOTION V TWO

A SONG OF LONGINGS

"AND THE SONGS... THOSE TELL THE STORY BEST, I THINK. LITTLE, HOPELESS, WONDERING MEN AMID VAST UNKNOWNING, BLIND MACHINES THAT STARTED THREE MILLION YEARS BEFORE -- AND JUST NEVER KNEW HOW TO STOP. THEY ARE DEAD -- AND CAN'T DIE AND BE STILL."

THE SONG OF LONGINGS IS RENDERED USING A SOLO INSTRUMENT INSPIRED BY THE SOUND AND GESTURAL INTERACTION OF THE THEMEN.

PITCH IS CONTROLLED BY THE HEIGHT OF THE HAND.

THE HIGHEST PITCH TRIGGER A SWELLING SEA OF CHIMES THROUGHOUT ALL THE MACHINES...

WHILE A LOW DRONE THROBS ACROSS ALL THE MACHINES, SOMEBY ACCOMPANYING THE SONG...

PUSHING FORWARD SOUNDS THE PITCH, AND GRADUALLY ADDS VIBRATO.

PULLING BACK SILENCES THE INSTRUMENT.

TO HELP ACCURACY... PITCH IS SMOOTHLY QUANTIZED TOWARDS THE NEAREST SCALE PITCH.

THE SIMPLE MELODY RISES AND FALLS WITH EACH GESTURE...
THE FINAL BOW OF HUMANKIND
IS A QUIET EXIT FROM THE STAGE.

AS THE MACHINES DRONE ON...

BECAUSE NO ONE TOLD THEM HOW TO STOP.

THERE IS OLDER BEAUTY
EVEN IN DESTRUCTION
AND DESOLATION.
"TWILIGHT" IS AN IMAGINING
OF HUMANKIND'S SUNSET,
MAKING US EXAMINE OUR
PRESENT TIMES.

THIS WAS A PERFORMANCE
DESIGNED TO EXPRESS THE
PSYCHOLOGY,
LONGING, AND SADNESS OF A
TWILIGHT OF HUMANITY ENDING NOT IN A
BANG, BUT AN IRREVERSIBLE POWERDOWN,
BASKED IN THE GOLDEN,
LINGERING, DYING GLOW OF OUR DUSK.
TOLD, FITTINGLY PERHAPS, THROUGH
THE TECHNOLOGICAL MEDIUMS OF OUR PRESENT.