GESTURE AND LISTENING

Towards a social and eco-systemic hyperinstrument composition

Nicola Baroni

The University of Edinburgh 2015

PORTFOLIO OF COMPOSITIONS

Nicola Baroni

-interactive software,

-supporting performance instructions (PDF and video),

-audio and video recordings

COMPOSITIONS

1) *Four Kafka's messages*

for hypercello

-45' (a 30' shorter version is allowed)

-Vor dem Gesetz

-The Wish to be a Red Indian

-Odradek

-The Trees

2) *Awakening*

for Interactive Harp Quartet -10'

3) *Le Demoiselles d'Avignon*

for Interactive Cello Quartet and Live-Video -11'

4) *Wire's*, Hyper-cello solo

from the Live-electronics duo *Shaman's Wires* *-7'/10'*

5) *Suite*, audio-video interaction -sound installation (demo version 10')

for 8 self-observing audio files

APPENDIX

Demo documentation of collaborative interactive works.

Gentilini-Baroni	*Tanpura* for hypercello
Messieri-Baroni	XXth capriccio from *Zadig* for Hypercello
	A.H. Cello trio and interactive conductor
Pavia-Baroni	*Sobre Sombras y Reflehos* for Hypercello and Piano duo
Baroni-Fabbriciani	*Kobane* for Bass-flute and interactive system

ABSTRACT

The research implements interactive music processes involving sound synthesis and symbolic treatments within a single environment.
The algorithms are driven by classical instrumental performance through hybrid systems called hyperinstruments, in which the sensing of the performance gestures leads to open and goal-oriented generative music forms.

The interactions are composed with MAX/Msp, designing contexts and relationships between real-time instrumental timbre analysis (sometimes with added inertial motion tracking) with a gesture-based idea of form shaping. Physical classical instruments are treated as interfaces, giving rise to the need to develop unconventional mapping strategies on account of the multi-dimensional and interconnecting quality of timbre.

Performance and sound gestures are viewed as salient energies, phrasings and articulations carrying information about human intentions, in this way becoming able to change the musical behaviour of a composition inside a coded dramaturgy. The interactive networks are designed in order to integrate traditional music practices and “languages” with computational systems designed to be self-regulating, through the mediation of timbre space and performance gestural descriptions.

Following its classic definition, technology aims to be mainly related not to mechanical practices but rather to rhetorical approaches: for this reason the software often foresees interactive scores, and must be performed in accordance with a set of external verbal (and video) explanations, whose technical detail should nevertheless not impair the most intuitive approach to music making.

PUBLISHED PAPER

http://www.ems-network.org/spip.php?article405

Acknowledgments

I would like to thank my PhD supervisors, Dr. Michael Edwards and Dr. Martin Parker for their insightful presence, knowledge, and their energising empathy; Owen Green, Kevin Hey and Jules Rawlinson for their competent help; Mike Webb for his supportive and precise assistance with my foreign English language; Marco Biscarini and Stefano Albarello for their musical and professional collaboration; Donald Bell, Dante Tanzi, Robert Hamilton, Marcellino Garau, Francesco Erdas, Andrea Melega and Tommaso Peregalli for their technical support during the concerts. A passionate thank you to all the wonderful musicians collaborating in my endeavours: Antonello Manzo, Antonio Mostacci, Clea Friend, Ms. Angelica Ferrari, Nicola Vendramin, Cristina Centa, Cristiana Passerini, Pete Furniss, Dimitri Papageorgiou, Emma Lloyd, Akiko Nakada, Elena Zivas and Giacomo Serra. Special thanks to Prof. DK Arvind and the Speckled Computing team, who generously offered me the concrete possibility to experiment and develop music through the inspiring Orient Motion Tracking System.This research would never have been started without Machover's leading ideas and implementations of the hyperinstruments, hyper-strings, hyper-cello developed at the MIT since the 90s. Further significant aspects of my compositional work rely on and develop the concepts of Performance Ecosystems by Eigenfeldt, and Audible Ecosystems by Di Scipio.

Submitted in satisfaction of the requirements for the degree of PhD in the University of Edinburgh, 2015

Declaration

I composed this portfolio, the work is my own.
No part of this portfolio has been submitted for any other degree or qualification.

LIST OF CONTENTS

The performance instructions are given here in bound paper as a verbal score.

The full documentation is available inside the attached hard-drive and online at:

nicolabaroni.com/phd/documents

password: music

Each composition is inside a separate folder containing: -List of contents

-PDF instructions

-Software -Audio-video_docs

The documentation at nicolabaroni.com/phd/documents follows the same structure, with the only difference that the software is given there as a downloadable standalone MAX application.

Audio-video documentation:

The files of the studio recordings are given inside the hard drive, as well as the files of the video performance instructions, which are also accessible from within the application (performance-notes section). The whole audio-video documentation is online

INDEX

A detailed list of externals and a specific index are given after each presentation

K_messages

hyper-cello

PRESENTATION

The work is a cycle of four interactive compositions inspired by Kafka's short novels.
Every "message" can be performed as a single piece or as a part of a complete work in four movements. The optimal duration of the whole cycle is about 45’, though reduced versions until 30' are possible. The composition is focused on the central role of the soloist (the hyper-cellist), who develops the electroacoustic music in real-time, sharing part of the responsibility of the composer. It is not essential to be skilled in computer music in order to perform the work, but the appropriate equipment is necessary. The interaction and its performance trajectories are visually monitored by the cellist on the laptop screen (replacing the classic score and music stand).

Sound is the absolute means of communication between the cellist and the electronics. In other words the cellist feeds the live electronics with his/her sound, but at the same time the cello sound gives the machine some information necessary to execute compositional choices in real-time.

By understanding the essence of the composition and properly monitoring the sounds and functions, the cellist will be able, by playing, to drive and influence the music composition in real-time.

However, this compositional empowerment is driven through the computational language of the machine, which is not exactly the same “language” as perception, performance and composition.
The machine "understands" the cello sound through spectral analysis, while the cellist drives the interaction by listening and playing.
True connections and true distances can be found between these languages and dimensions of experience, allowing for non-obvious interactions, which require new symbols and performance styles.
The cello sound is exploited by the performer as a mediating technology between acoustic music and composition processes.
The musical results (maybe powerful or illuminating, maybe conflicting or complicated) are dynamically linked to the poetic realism of Kafka, where hyperbolic desires, inflexible laws, unexpected reflexions drive human situations towards extreme conditions of appearance.

Fig.1 Franz Kafka

Simple animated graphic/verbal scores are provided in order to properly mediate the interactive composition, autonomously evolving without the help of any external Live Electronics performer. This total autonomy puts the cellist in the condition of a direct contact with the electronic processes through an expanded knowledge of his/her sound and musical actions.

PLAN

Message_1) *Vor dem Gesetz* (duration from 6 to 15 minutes, default 10')
Message_2) *The Wish to be a Red Indian* (duration 4')
Message_3) *Odradek* (minimal duration approx. 10')
Message_4) *The Trees* (from 10' to 15', default 13')

The duration of the "messages" (movements) 1 and 4 has to be set in advance by the performer, otherwise it is left as default.
Message 2 has a fixed short duration.
The section-advances of message 3 are dependent on the sound of the cellist,
who decides the durations in real-time.

RECORDINGS

Studio recordings

Audio

K_1 https://soundcloud.com/nicola-baroni/vor-dem-gesetz
K_2 https://soundcloud.com/nicola-baroni/the-wish-to-be-a-red-indian
K_3 https://soundcloud.com/nicola-baroni/odradek
K_4 https://soundcloud.com/nicola-baroni/the-trees

Video

K_1 **(Antonello Manzo)** https://www.youtube.com/watch?v=FW3ho-6fPfk
K_4 https://youtu.be/-7NAoElhXPQ

Live recordings

Compilation https://www.dropbox.com/s/441azkw88z2usfo/kafkas.mp4?dl=0
K_1 https://youtu.be/KiivIwgPM7I
K_1 **(Clea Friend)** https://youtu.be/jbMAJYYDoOA
K_2 https://youtu.be/UwzEVNd_rjA
K_2 **(duo)** https://youtu.be/X9lqKw64TSE
K_3 https://youtu.be/MHpixGI1xMQ
K_4 https://youtu.be/-7NAoElhXPQ

EQUIPMENT
Movements 1, 2 and 3 require:
1 microphone for the audio,
1 pickup for the sound analysis
1 sound card (at least 4 outputs)
1 laptop containing the Applications (or the native MAX patches)
My personal equipment involves DPA4099, Cello-Fishmann pickup, RME UCX.
A different set of equipment needs careful calibration of the analysis data
(see technical section below).
Some main calibration parameters should anyway be checked before any performance,
at least for movements 1 and 3.
The pickup input has to guarantee a full isolation of the cello sound from the environment (not always gained through piezoelectric or directional microphones)

<u>Movement 4 "*The Trees*"</u>
Movement 4 requires the same equipment, but with the addition of:
- 2 small speakers
- 2 condenser microphones (possibly omnidirectional)
- 1 inertial sensor (3 axis accelerometer and gyroscope)

The extra speakers and microphones have to be positioned on stage, close to the cellist in order to produce controlled audio feedback. In case of a small sound card,
1 mini-mixer is necessary in order to allow the additional phantom power inputs.

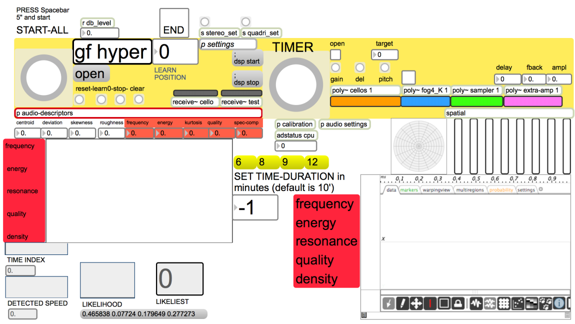
Every single piece is a dedicated MAX Application working on MAC OS 10.8 (or above).
The performance is also possible through the original code if MAX/Msp 6.1 (or above) and the externals listed in the appendix are installed: a Mac dual core is sufficient, more powerful HD is suggested at least for Message_3. In Message_4, running the Orients_15 Motion Tracking system, a native Bluetooth 4 Mac version is the minimal requirement (see page 49).
The spatialization is quadraphonic. Options for 8 speakers are foreseen.
Stereo diffusion is allowed but not ideal.

Message_1 “Vor dem Gesetz”

Video instructions at: https://www.dropbox.com/s/x6t37zoczi67xrg/K_1_instructions.mov?dl=0
Novel at: http://www.kafka-online.info/before-the-law.html

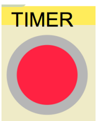
COMPOSITION

Invent and perform a music introduction segmented into **four contrasting phrases**.
Don't think of your music too much in terms of notes, but mainly in terms of contrasting timbres, dynamic shapes and pitch registers, organised in four "phrases".
Every "phrase" should be best conceived as a well characterised sound-gesture, a sculpted sound expression internally changing and moving towards the next one.
Each gesture ("phrase") lasts **20"** and the overall duration of these four divisions is precisely **1' 20”.**



The machine "listens" to your music, but instead of recording your sound it records, as flowing numbers, five features of your analysed sound: *pitch, loudness, resonance, quality, density.*
Your initial task is to find and perform music contrasts and developments in these terms.

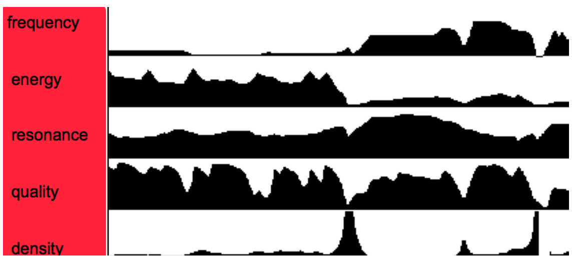
Fig.1-K_1 The interactive screen *(Message K_1)*



Two close red flashes in the upper part of your screen signal the beginning of every phrase. **One single red flash** (after 10") tells that you are passing the middle portion of the phrase.

Fig.2-K_1 The Timer flash

You can see in the left part of the screen the monitor of what is tracked in real-time by the system, and on the right how it is stored inside the memory machine.



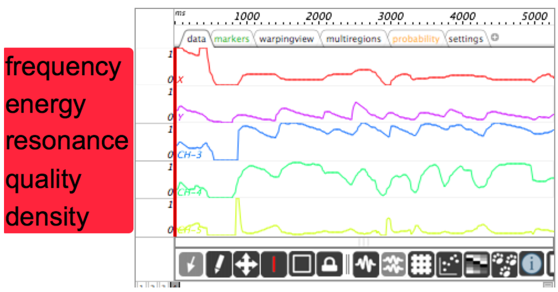


Fig.3-K_1 Sound analysis in real-time

Fig.4-K_1 Sound features stored in memory and later recalled during the performance

INTERACTION

After 1' 30" from the beginning the computer starts to play electronic music, and from this moment until the end your cello performance is interactive. During the continuation of the piece, the software predicts which one of the four “phrases” (the **previous 20" sound-models**) is matched by the music you are **“currently playing”.**

Technically, the process happening in your 1’ 20” initial acoustic performance is called **“machine learning”**, and the continuation until the end is called **“gesture following”**.

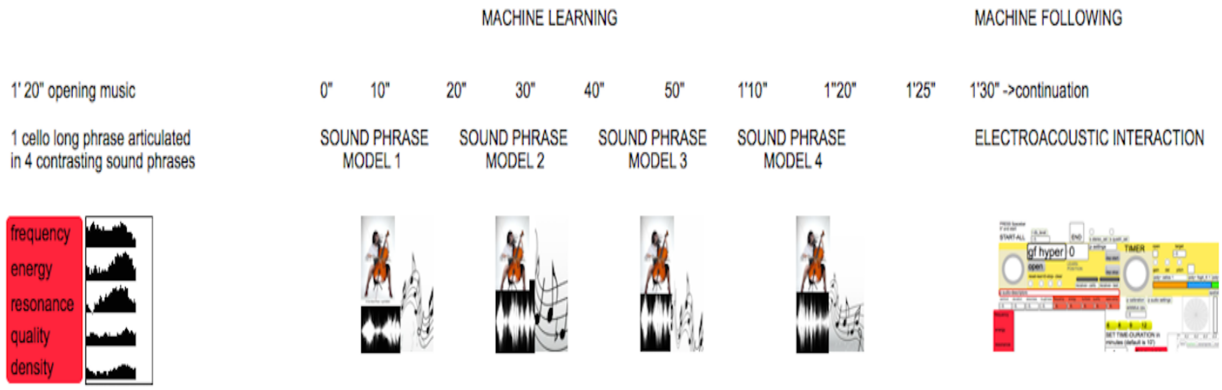


Fig.5-K_1 Machine learning and machine following

The computer performs a “data driven” work of **“feature recognition”** within the time of your music. In machine learning mode you define and perform four music models, in machine following mode you vary these models in order to creatively interact. Compositionally you have to:
-carefully invent the four contrasting **cello “sound-gestures**” and shape them in an overall music introduction (you can write sketches, partial pentagrams or playing by memory)
-vary these models in order to improvise a new cello music, which contextually drives the electronics by means of parameters of similarity/difference between the current and the previous music (you will follow the screen monitors as an interactive score).

<u>Machine following and music variations:</u>

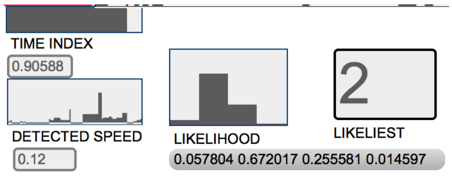
-If you try to repeat one of the opening phrases perfectly, the system should be able to tell you precisely which portion of the phrase you are currently playing and if your speed of execution is the same or different.
-If you insert some variations compared to your previous performance, the machine starts to jump in order to identify which part of your previous music you are imitating.
-If you radically change your sounds the machine still attempts (with unpredictable results) to recognise which is the model phrase and which is the point and speed of reproduction.

You can see all of this in the monitor on the right of your screen.
The machine is natively built in order to recognise perfect imitations of previous models and slight time variations upon them, but I have increased its "tolerance" parameter in order to allow for some more variations inside your performance.

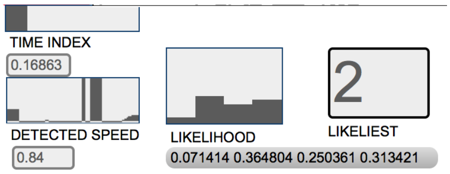
SYSTEM

In the bottom part of the screen you see which one of the four initial gestures the machine is telling you are performing. Since it is a **statistical system** you can see the percentage of probability with which your performance is pertaining to one model instead of the other ones. The more you perform strict imitations of a previous phrase, the more the machine recognition should be straightforward. The more you vary the music, the more the machine starts to take time to gain a consistent response, and the four models of similarity could be moving around middle ranges of probability.

The figure shows two different possible states of sound recognition.
In both cases it appears that the current sound recalls the second phrase ("likeliest"), but the parameters of **"likelihood"** are different.



In the first case the system shows that the currently played sound is similar to the second model-phrase, but it also has some degrees of similarity with the third phrase.



In the second example the currently played music should be quite different from any previously played model because all the parameters of similarity are quite low and levelled.

Fig.6-K_1 Pattern recognition

The Time-Index parameter shows, from "the point of view" of the machine, which portion of the 20" model you are currently imitating (the upper example detects the final part of the phrase, and the second example the initial part), the same detection is shown through a **moving bar** inside the bottom-right monitor (see fig. 8-K_1).
The Detected-Speed predicts if the imitation of the model is performed more slowly or faster.

We are using **this system as a musical instrument**. You can influence the machine predictions as you wish: any different prediction about how you are playing creates a different electronic music.

Through previous rehearsals you will gain a refined technique of electroacoustic sound modelling in real-time. Obviously a careful choice and timbre contrast of the sounds performed in the four opening 20" music gestures is extremely important.

In other words you can compose live electronic music by carefully balancing imitations and variations of your initial cello performance. The four parameters of "likelihood" act as a **mixer** because they are mapped to the amplitude of four different **Virtual Music Instruments**
(each VMI processes the live sound of the cello in a radically different way).
Therefore as an example, if your current music is detected as totally similar to your second initial phrase you will interact with the sounds of VMI nr. 2 at full amplitude, but if your music ambiguously matches different initial models (as in the shown cases of the figures above) you will produce a mix of different Live Electronics (VMIs) with variable relative amplitudes.

THE NOVEL

Kafka's novel presents a country-man who asked for a meeting with the emperor. The man stands in front of the door of the fabulous palace waiting for admission. A porter tells the country-man how difficult and dangerous it is to get inside, the country-man waits an immensely long time to get in until the porter closes the door telling him: "the door was opened for you, but now you are dying and I have to close it". The music interaction asks the cellist to dramatise **the theme of expectancy,** by provoking the question: "What if you were the country-man?".

The computer response could sound alien in terms of sound (and maybe also in terms of pattern recognition!) as in the case of the Kafka novel, but the cellist is provided with many possible solutions in order to gain "desired" music responses (in terms of music narration, experienced anxiety, or interactive music play).

REAL TIME COMPOSITION AND ANALYSIS

The common language between the cellist and the machine is the **real-time analysis of the cello timbre** as it is performed, therefore spectral analysis is the grammar of the computer and sound is the means of control by the cellist upon the machine and the **real-time composition** (RTC).
Obviously **sound and spectrum** are different aspects of a unique entity, and the cellist's means of control upon the system involves complex strategies of musical navigation, whose output could be technically successful, confused or unexpected. The machine can "listen" differently to the cello sound compared to human expectancies, because its system is abstract and computational.

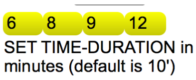
The conceptual and technical virtuosity of the cellist could be in the direction of finding a deep reciprocal common control and understanding with the machine, but also challenging the system with unexpected sounds, or otherwise musically exploiting possible reciprocal misunderstandings as an opportunity to produce interesting music.
The theme of the interaction is real-time composition through expectancy and variation, in which Kafka's novel represents the state and the affect of a "threshold of failure".

The cellist is free to repurpose sequences perfectly identical, varied or mingled in order to extract in real-time different machine evaluations of similarity between music sequences. The parameters of these evaluations are mapped to a **macro-form** (the **"sound narrative"**) of the current electroacoustic music. In this way the musical choices of the cellist, as high-level decisions, drive the composition, treating the parameters of similarity vs. variation as means to control the overall result.

The choice to help or to confuse the machine through linear vs. scrambled patterns is a possible option involving the possible misunderstanding of the HCI interaction as a musical instrument and opportunity. On the other hand the success of the machine is not absolutely guaranteed and it could sometimes suggest the need for possible revised music strategies on-the-fly by the cellist.

The whole composition is driven by the cello sound which feeds the audio of the electronics, and at the same time modifies the kinds of electronic sound treatments interacting with the audio analysis of him/herself. This last compositional interplay can be developed by the cellist **intuitively or through a deeper understanding** of the spectral data and mappings.

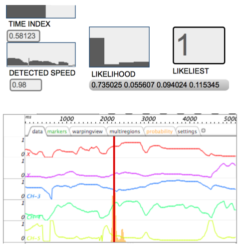
PERFORMANCE NOTES



The overall duration of the pieces is 12 minutes by default, but it can be set differently beforehand by the performer, by pressing the dedicated message-number.

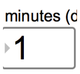
Fig.7-K_1 Setting time-duration

Press the "Spacebar" to begin:
-during the first part (the acoustic interactive seed of the work) you will follow the red **"Timer" flashes** (see p. 3) and the increasing section number.
The two bottom monitors show the incoming analysis of your cello sound.



During the electronic continuation you will follow the **interactive mixer (called "likelihood").**
The **bottom-right monitor** will be showing the stored analysis data of the "phrase" model in action, and the predicted point of time-occurrence of your music inside the currently active model-phrase.

Fig.8-K_1 Monitors of interaction



A number shows (in minutes) the time point of the current performance.

Fig.9-K_1 Monitor of duration

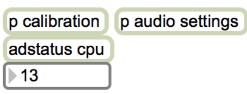
When the piece is ending the electronics fade out.

Rehearse mode:

It is possible to **simply explore the sound analysis system without starting the piece**, or when you **calibrate,** press the icon "DSP start" using the mouse.

Fig.10-K_1. Rehearse mode

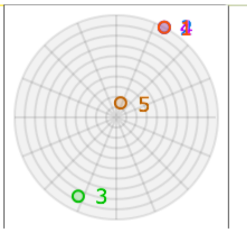
Calibration:



A following section explains how to set up optimal parameters of sound analysis

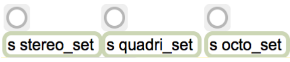
Fig.11-K_1 Calibration icon

Spatialization:



Spatialisation is driven by *Ambisonics* (azimuth, distance, velocity of source shifts). Each of the VMI outputs are automatically positioned in space accordingly with features coming from their individual real-time sound analysis. You can monitor them.

Fig.12-K_1 *Ambisonics* interface



Spatialisation is quadraphonic by default, but it can be **differently set** to 8 speakers or as a stereo.

Fig.13-K_1 Setting the speakers

MICRO-SHAPES

If the overall sound narrative is shaped by the main mixer called "likelihood" (see above), multiple mappings allow for local and micro controls/influences upon the electronics.

The electroacoustic sound is in fact made from four Virtual Music Instruments, dynamically mixed by the main parameter of likelihood.

The VMIs are fed by the cello sound, processing itself in real-time through variable parameters; these variables are at the same time modified by the same cello input.

In other words the cellist creates the material and the means of control of the electronics through the same sound gestures. Despite the aurally distant result, the electronics thus keep an intimate connection with the cello sound in terms of textural and gestural distributions of common materials.

This mixed music is not created before-hand by a composer, nor driven by a score, but it is functionally designed as a creative interaction in order to be explored and revealed on-stage by the cellist, who feeds the open system in terms of sound and control.

Artificial sounds are not intended as extensions, direct processing nor responses to the cello, they are instead conceived as a parallel music.
The complexity of the performance underlines that it is a compositional task, sonically driven by the cellist.

INSTRUMENTS

The software composition is based on the final mixing of the following VMIs:

1) Harmonizer, 2) FOG synthesis, 3) Sampler, 4) Delay plus feedback.

The output of the VMIs is strongly influenced by the cello sound through local mappings. A detailed analysis of the complex internal mappings of each single instrument can be done by navigating inside the MAX application and reading the annotated comments inside every abstraction.

The **index number** of each of the VMIs is the same number as tagged inside the **main mixer called "likelihood"** which controls the referenced amplitudes of every single VMI.

The parameters **"time-index" and "detected speed"** shown in the bottom part of the screen, influence in many ways the electronic sounds of each instrument. They refer to the time location and speed of performance as they are predicted by the computer recalling the initial music phrases (see the section "system", p.5).

The VMIs are called: **1) cellos; 2) fog4_K; 3) sampler; 4) extra-amp**.

It is suggested, but not mandatory, to feed the initial four phrases (which reference the four instruments) with:

1) light/expressive sonorities;
2) dense textures;
3) extreme gestures;
4) subtle extended techniques.

Sonorities well fitting with the reciprocal VMI should be found and explored.

A few small monitor cues are given, including the amplitude monitor of each effect.

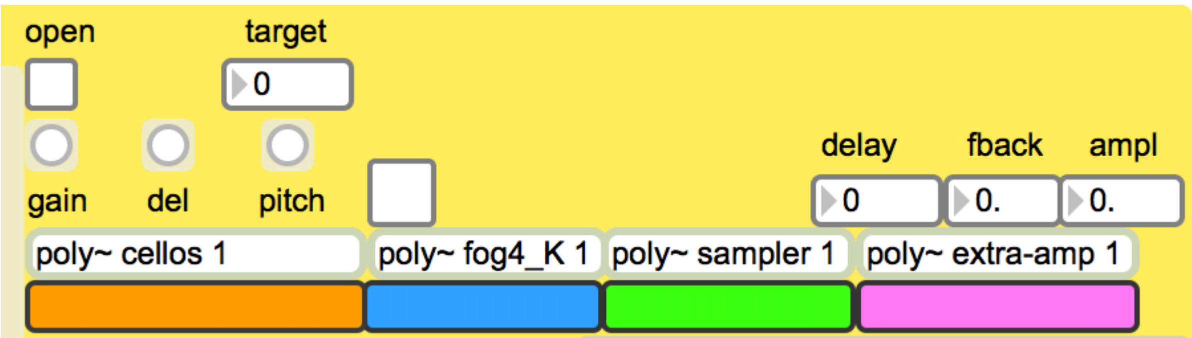


Fig.14-K_1 VMIs interface

-1) "Cellos".

The four voice harmoniser multiplies the cello output.

Each voice can be independently pitch-transposed and shifted in time. The system drives a **non-continuous transformation** of these parameters: globally an increasing **variability and contrast** of the live cello timbres pushes towards a much more dynamic and changing behaviour of the voices, which conversely tend to be fixed in delay and transposition when the cellist plays softer and more stably. **Extreme sounds** allow for bigger changes: very **high/low pitche**s drive extreme transpositions (until 2 octaves high and low), while **spectral centroid** tracking pushes away the individuated delayed copy of the cello sound by 10 seconds (when the performed timbre is harsh and high-pitched), or approaches it by less than 1 second when the performed timbre is low, soft and fat. The performed **noisiness** increases the feedback (the density of transposing delays). The whole harmoniser is modified in timbre, especially by the parameters of "**time-index"** and **"speed-detection"** (the "imitation" parameters of the referenced "phrase" 1, shown by the monitors in the bottom part of the screen). As shown in Fig.14-K_1 small yellow flashes signal when the main parameter are changing, and the number box called "target" signals which of the four voices is involved.

-2) "Fog4_K".

FOG synthesis granulates the cello sound cyclically live recorded.

The most prominent influences on the parameters of granulation are:

-**live cello density**: full live sound increases the speed of the effect making it more intense, rhythmic and similar to a recognisable cello sound; airy sounds and pizzicato slow down the effect until a sort of "spiritual drone".

-**live cello amplitude**: by playing loud you rarefy and distance the grains of sound output, by playing soft you intensify the textural overlapping. Moreover, by lowering the "fog parameter" inside the calibration module (from the default 10 until 5 or less) you can anyway gain more textural overlapping, by setting it higher (until 20 or 25) you increase the tendency to granular rarefaction (see the calibration section, and the referenced calibration patcher)

-**pitch and brightness of the live cello** playing influence different timbre qualities of the FOG synthesis (which are to be mainly experienced by listening).

-again the parameters of change in the granulation are **not continuou**s: the **rate of change** of the granulation parameters is faster if the **"time-index"** of the imitated phrase approaches the end of the model, and slower if it is at the beginning. High "**speed-detection"** lessens the smoothing parameter, driving for impulsive changes.

-3) "Sampler"

outputs chunks of a prerecorded cello sound file (rhythmic and aggressive)

-**the sound character of the live cello** recalls similar sounds stored in the file

-high **pitches and brightness** of the live cello increases the overall density

-a high **"time index"** (final portion of the referenced phrase) decreases the overall density, while the detection of its initial portion increases it.

-c**rescendos** allow for upward glides, **decrescendos** for downward glides

-**pitch classes** of the live cello like C, C sharp, D dramatically increase the density of the output;

B, B flat, A instead scatters the sampling into detached groups of sounds, the other middle notes (in a chromatic scale) maintain the effect at middle ranges

-4) ”Extra-amp” (variable delays)
-the output gain is set to high amplitudes in order to allow **special effects** such as noisy sounds, extended techniques or subtle textures
-the **“time index”** crucially modifies the delay line and its feedback: when the initial portion of the phrase is detected the output produces short delays (reverb-like), on approaching the final part of the phrase the delays are distanced.
-**live sound amplitude** is mapped to up-down glides of the output
-inside instrument 4 the time-index parameter is much more prominent, therefore it is advised to invent the model-phrase 4 (at the beginning of the performance) in order to start with a textural sound developing towards a rhythmic patterned continuation
-a small monitor of the parameters is given above the patcher

TECHNICAL REMARKS

AUDIO ANALYSIS
The five "timbre" descriptors feeding the interaction need a brief discussion.
Traditionally the word "timbre" indicates a sort of ill-defined condition (we clearly perceive timbre features but it is hard to objectively define them with shared words).

The five audio parameters centrally involved in the interaction are:
pitch, loudness, resonance, quality, density.
- *Pitch* and *loudness* are extracted by the central frequency and the amplitude of the cello sound. Classical theory considers them as quantifiable aspects of sound independent from “timbre”. They are indeed timbre aspects of sound, but in any case clear concepts to be experienced, and straightforward to be spectrally tracked in real time (respectively through the “yin” algorithm and the envelope-following).
Loudness needs calibration.

The other three parameters are more concerned with the traditional idea of timbre and they need specific levels of treatments, filtering and compression.
- *Quality* is the most direct timbre descriptor in this context, referencing the noisiness vs. periodicity of the spectral components (through the “yin” algorithm). The noisy vs. purely tuned cello sound can be intuitively monitored by the performer (but note that chords and double stops are tracked as much less pure in “quality” than single notes). The numeric output in any case needs compression in order to be tuned to the physical specs of a cello and to the individual character of different performers: therefore it could be calibrated in order to get better nuanced responses.
- *Resonance* tracks the gradients of response between free vibration (i.e. after a soft pizzicato), a soft airy bow conduction, a “full-tone”, a compressed sound production.
The more the cello bow stresses the string, the more the value of “resonance” falls down to zero.
The parameter is obtained through filtering, compression and scaling of the flowing value of the spectral statistical distribution called “kurtosis", detecting the peakedness vs. flatness of the real-time spectral envelope.

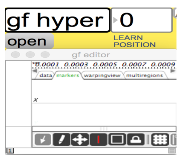
- *Density* deals together with the different parameters of spectral centroid, spectral spread, central frequency and amplitude in order to approach the tracking of “sul tasto” effect vs. full-expressive/near-the-bridge sound, generally obtained by variations in speed and point of contact of the bow. Pizzicato styles should result as zero “density”.

A double threshold sets the main values to zero when the loudness is very low or when the sound is definitely noisy. In this way noisiness can be detected as a special effect. Moreover in this way the sound tracking can be performed within the range of a normal cello playing (avoiding false detections of environmental sounds, and unreliable analysis of noisy components)

All the values are filtered in order to smooth meaningless peaks. These five parameters feed the main motor of the composed interaction, through the *Gesture Follower* system.

Detailed local mappings drive the behaviours of the four VMIs, exploiting further audio descriptors such as *roughness, spectral flux, spectral centroid* and *spectral spread.*

GESTURE FOLLOWER



The GF is a statistic data-driven software developing the technology of machine learning.

Fig.15-K_1 The *GF* editor

It stores and indexes in its memory different lists of incoming numbers (learning): having completed the learning phase and on receiving a new list, the GF evaluates and compares any new lists with the old items previously stored (following). By applying sensing data such as the descriptions of human physical movements (gestures) as inputs to the GF, the system is able to reconstruct and compare previous gestures (stored and indexed during the learning phase) with the new ones, (following phase).
In this way it is possible to extract patterns of similarity between different gestures, and also compute the identity, the percentage of deviation, and the predicted speed of their execution compared to the identified initial models.

In this composition the cello sound is segmented and treated as a shaped sound-gesture.
For this reason the cellist is initially asked to invent and perform the four different “sound gestures” (conventionally called “phrases”), feeding the GF as learning models.
The continuation of the music (gesture-following mode) is the creative interplay between the cellist and the GF: the found patterns of similarity feed the main mixer, which is responsible for the macro-form continuation of the piece. In addition the secondary GF parameters “time-index” and “speed detection” (the temporal point of performance and the speed of imitation of the “learned” model with respect to the currently played sound) are mapped inside each of the four VMIs. In this way the reproduction/deviation modes of the cello music from the previous models have a further influence upon the electronic sounds.

COMPOSITION

In this way the technique of machine learning is framed inside the composition since the four initial cello phrases (corresponding to the four machine-learning steps) are inscribed in the interaction as automatic time lines.

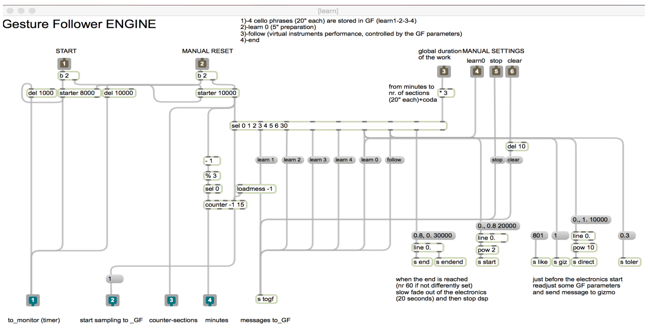


Fig.16-K_1 The timeline to the *GF* and to the composition

After that (1' 30" from the beginning) the GF is automatically set in "follow" mode, while the player continues to perform with the free task of recalling his/her previous phrases, choosing the different degrees of similarity with his/her initial music.

Therefore the performer assumes the responsibility for the overall form-building and the electronic developments. The performance could be considered as a "timbre-motivic" interplay driven by time remote connections between sound gestures, through the mediation of the machine.

Expectancy could be viewed as a non-obvious means of communication between the past, the present and the future of the music through similarity, identity and variation of musical and timbre patterns performed live.

The system is designed as a novel means of real-time-composition (RTC). A high focus is given to timbral descriptions tuned to the cello behaviours in terms of sound and performance techniques. The four sound models segmented by the GF are conventionally called "phrases" inside the performance instructions, but they lack "syntactical" lattice-based structuring: in fact the intention is to segment their features in terms or timbre gestures/textures in order to foster an electro-acoustical approach.

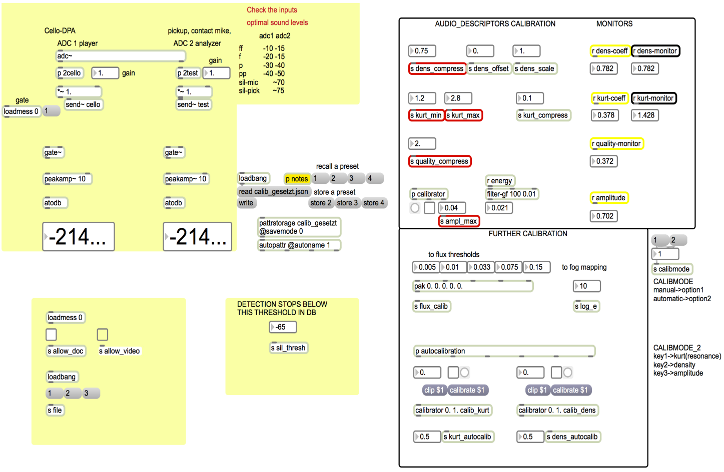
In this context the problem of a cultural continuity between Western instrumental practices and electronic musical thought is far from obvious, and the integration of their approaches is a principal aim of this project. Giving a central creative role to the classical performer raises the problem of which music theory acts behind the composition.

The first of the four K_messages explores this question more radically since the entire macro-form is dramatically dependent on the communication between timbre as it is performed on a cello (and indirectly as it is perceived by the audience), and how it is tracked and reordered by a computational machine.

Moreover timbre is non-linear and involves music strategies that cannot be framed inside any conventional mapping strategy or theory.

Kafka's novel acts as a metaphor and a mirror of interaction.

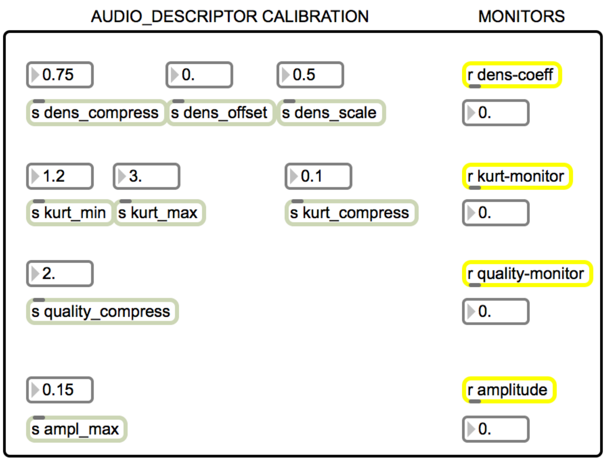
CALIBRATION



All the functions are contained in the main patcher “calibration” allowing for:
-optional software balance of the two inputs (microphone and pickup)
-main calibration settings
-min/mean/max balance for the complex calibration of *density* and *resonance*
-storage of the new values
-simulation from sound files
(in case of conferences)

Fig.17-K_1 The calibration patcher

The storage/recalling of the last calibration setup is automatic (after saving the patcher before closing it) only if the system works as a MAX/Msp patch.
If the system is a MAX standalone application, the calibration values are to be manually stored by pressing the message “store 1”: they will be automatically loaded at the next opening (this manual procedure is obviously possible also inside the native MAX patch).



Calibration has to be performed when the system is in “rehearse mode” (DSP on, without starting the interaction). The monitors coming from the yellow “receives” show the raw values coming from the analysis modules, the calibration numbers on the left have to be set in order to gain the most meaningful normalisation, which is shown on the fly inside the main monitor positioned in the left part of the performance patch.

Fig.18-K_1 Main calibration parameters

The calibration should be done by playing the cello and with the main data monitor visible.

- The *compress, offset, scale* parameters for density allow for a full ranged normalised output between 0. (soft pizzicato) and 1. (dense “saw-teeth-like” sound). The middle ranges should be well shaped by the calibration in order to detect intermediate values for “sul-tasto”, and “ordinario”, and soft vs. full sounds. The density curve cannot be truly flat with respect to the central frequency, therefore the cellist has to be aware that the system unexpectedly interprets some specific notes as “more dense” than others: this makes sense since the timbre responses of a cello are not linear.

- The *min, max, compress* parameters for kurtosis ("resonance") require compression values near to zero (this means very high compression): min and max are the thresholds of clipping between 0. and 1. This calibration is a trial process that can be checked in relation to the flowing *kurt-monitor* number. A soft-low-resonating pizzicato will rapidly rise to the maximum (clipped to 1.), but the lower values should be calibrated in order to give room to some meaningful differences between "airy" and "intense" timbres.

- The *quality_compress* parameter (set to power 2 by default) should give focus to the middle ranges of noisiness vs. pureness of the cello sound. Increasing the power number should improve the tuning of the detection, but when the power coefficient is below 1 it could instead raise the values of half-noisy sounds.

- The *ampl_max* calibration number has to be set at the same value as the maximum amplitude performable by the cellist, in order to set the maximum amplitude as 1.

The threshold below which the analysis is interrupted (detecting silence) is set by default to -65 Db (with respect to the signal coming from the pickup).
It can be optionally modified.

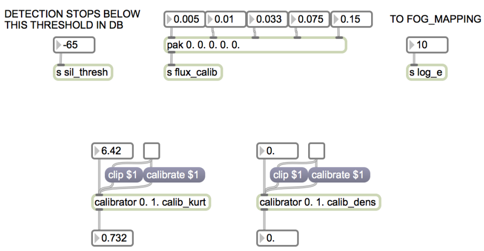


Fig.19-K_1 Further calibrations

New adaptations of the 5 thresholds of the *spectral.flux* can be optionally set differently.

The "FOG" parameter is explained in the above "Instruments" section (pag. 9), it refers to a specific threshold of amplitude following.

After the main calibration, a fine-tuned further calibration of *density* and *resonance* is possible by pressing respectively keys 1 and 2 of the laptop keyboard.
After 2" the automatic calibration starts, lasting 5": the cellist will be performing in order to store on the fly the Min and Max threshold values, the last number received is stored as the Mean value. Min and Max will be clipped as 0. and 1.; the Mean will be fixed as 0.5. The procedure is performed through the abstraction "calibrator" borrowed from the CNMAT MAX library.

Message_2 "The Wish to be a Red Indian"

Video instructions at: https://www.dropbox.com/s/3o9vdfw3jtd5xs3/K_2-nstructions.mp4?dl=0

If one were only an Indian, instantly alert, and on a racing horse, leaning against the wind, kept on quivering jerkily over the quivering ground, until one shed one's spurs, for there needed no spurs, threw away the reins, for there needed no reins, and hardly saw that the land before one was smoothly shorn heath when horse's neck and head would be already gone.

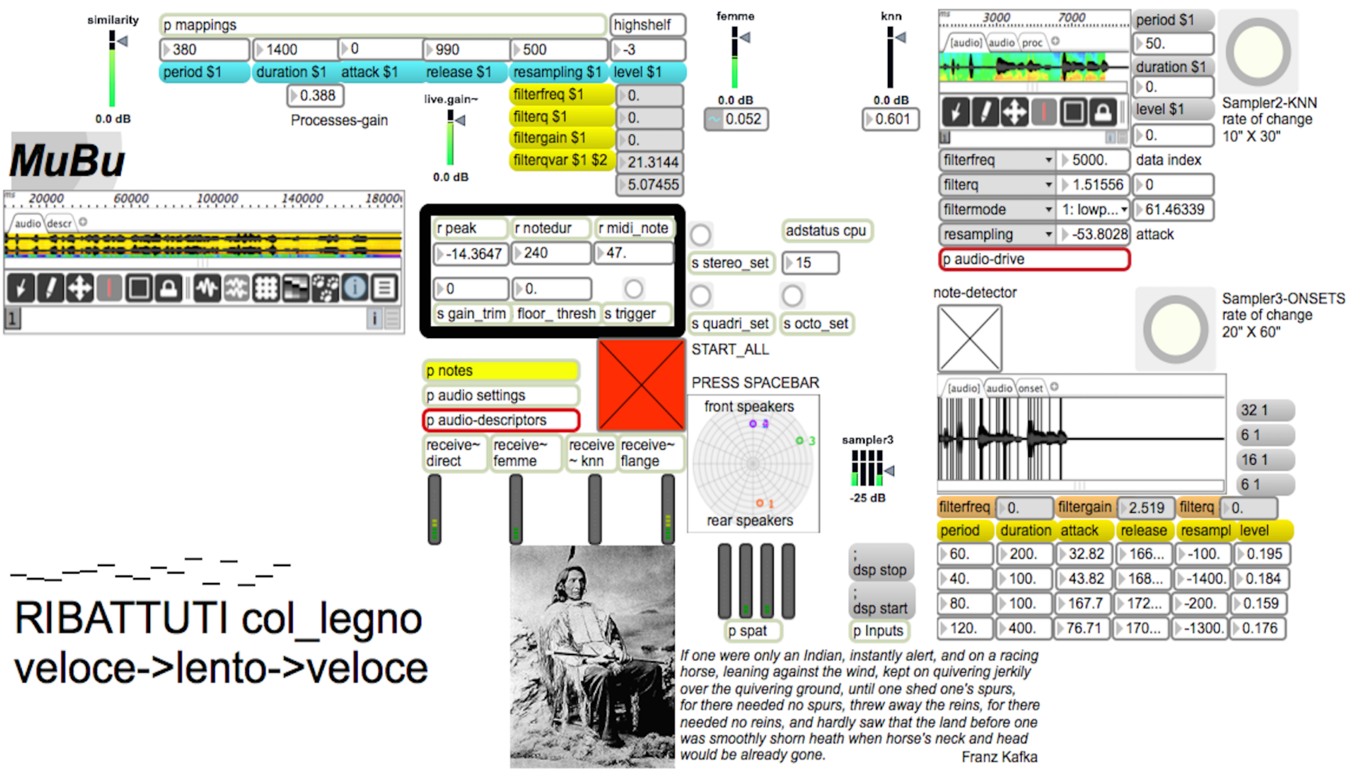


Fig. 1-K_2 The main interactive patch *(Message K_2)*

<u>COMPOSITION</u>

Following the interactive instructions, play with rhythmic flexibility and freedom.
Don't avoid extreme variance in pitch loudness and timbre. In a short time you should cross distant sounds and techniques, including scraping sounds and Bartok-pizzicatos.

The system records your sounds, and you recompose them in many ways in real-time through the sounds of your cello performance.

SYSTEM

This 2nd movement of the "K_messages" is a strict interaction between the performer and a set of live-cello sound memories stored as audio files.

The files are cyclically loaded by the system, and the output sounds are interactively treated and transformed through different cello playing styles. Again the hyper-cellist is responsible for creating the input to the live electronics, and to drive, through performance, the methods of the interaction.

Two different modes of performance are allowed:

a) the audio files come from live recorded portions of the 1st movement automatically stored in the HD and recalled during the 2nd one.

b) the sound contents are directly live recorded on-stage, as a part of the performance.

Press "Enter" to start the performance in mode a)

Press "Spacebar" to start the performance in mode b)

The electronic sound is created by four modules:

Sampler_1, Sampler_2, Sampler_3, Amplified/Flanged-cello.

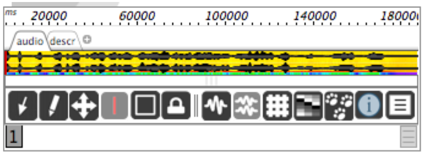
All the electronic treatments are musically driven by the cellist interacting with the sound analysis of his/her incoming cello signal. The live cello is analysed in pitch, amplitude, note onset, note duration, and timbre (brightness, noisiness, centroid and spectral distributions).

These analysis data transform the sound of the audio recordings in order to drive the samplings through a large-grain mosaic technique. The engine of the samplers is granular, but the file fragments (scattering or accumulating) are mainly treated at a note-length time level.

The performer must be aware of the sound interactions described below, designed by an overall automatic time segmentation (macro-form) inscribed in the software.

The performance will be improvised according to functional lines of interaction chosen in advance by the cellist, following some essential graphic animations.

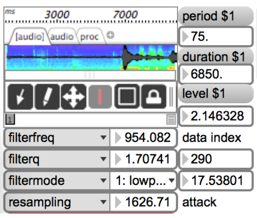
SOUNDS



1) Sampler_1 "femme" (upper left part of the screen) processes a fixed external prerecorded file.

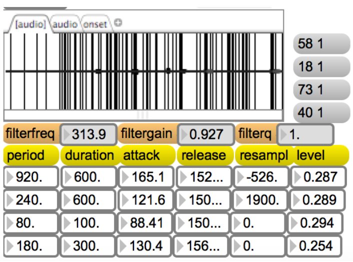
Fig. 2-K_2 Sampler_1 (sound file interface)

The file is quite energetic and rhythmic and has to be freely recalled by the cellist in order to increase music contrast in the course of the performance.
Sampler_1 is a slightly varied version of the instrument called "sampler" operating in the 1st movement. This is a means of continuity between the two movements.



2) Sampler_2 "knn" (upper right part of the screen) is filled with live recorded cello material. New materials are loaded every half minute. The sound transformations partially and continuously alter the timbre/textural contents coming from the cello sounds.

Fig 3-K_2 Sampler_2



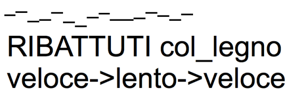
3) Sampler_3 "onsets" (bottom right part of the screen) is also filled with live recorded cello material. New materials are loaded every minute.
Sampler_3 is the main module of the piece: it doesn't transform timbre, but it fragments, overlaps and transposes the sound contents at differentiated note time-lengths in order to operate as an algorithmic composer in real-time.

Fig. 4-K_2 Sampler_3

4) Direct sound: the amplified cello is sometimes "distorted" through a flanging technique, incremented when the cello input is more aggressive and noisy.

TIME MACRO-FORM
Overall duration 3' 40".
The development is created by the alternating fillings of Sampler_2 and _3 with new sound materials, and their treatments in real-time.
You are required to play in sequence:
- 0' -> ribattuto col legno;
- 1' -> pizzicato;
- 2' -> espressivo;
- 3' -> tremolo.

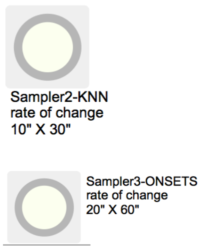
Other interactive instructions regarding playing styles such as Accentuato; Legato/Staccato; Aggressive-pizzicato are intermingled in order to drive the sampling treatments.



Every half minute you are suggested (through graphic-verbal screen animated indications) to feed the music system with a different music style, which at the same time interactively drives the methods of sampling.

Fig.5-K_2 Example of the animated score

The number, width and position of the small graphic bars suggest the density, power and pitch register of the music gestures verbally described.
Sampler_3 is filled with new sound material (lasting 20”) every minute.
Sampler_2 is filled with new material (lasting 10”) every half minute.



You can see two red flashes near the buffers of the samplers, which signal the beginning of this process. The filling process happens in real-time therefore Sampler_2 loads sound material (and processes it at the same time) for 10” and during the following 20” the processing works on the fixed already stored sounds.

The same happens with Sampler_3 at doubled time intervals.

Fig.6-K_2 Flashes signalling the beginning of the recording process

The buffers have a graphic interface: you can see some of the sound qualities of the stored sounds, and the principal processing parameters whose evolutions depend on the sound you are producing (see figures above and below).

The whole interaction starts immediately at the beginning of the piece: therefore every minute the electronics radically process new sound materials (Sampler_2 plus Sampler_3) and every half minute the processed materials will be only partially replaced (Sampler_2 only).

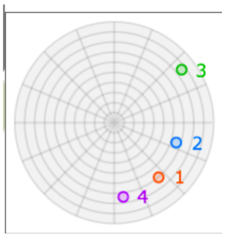
In this way Sampler_3 will be fed with four different and contrasting cello sound materials (every minute), and Sampler_2 with seven different cello sound materials (every half minute). This overall macro-form is shaped and underlined by a chain of automatic amplitude gains, which drive the interaction from:
-an initial long fade in,
-three mid culminating points,
-a last faster fade out allowing a possible brief acoustic cello conclusion.

SPACE MACRO-FORM

The spatialisation is organised in a mixed fashion.

Sampler_3 (the principal electronic instrument) outputs four layers of sampling, each located in a fixed position of the quadraphonic field.

The other 4 electronic sources (Sampler_1, Sampler_2, Amplified_cello, Flanged_cello) are spatialised through dynamic parameters tuned to some live cello sound features:



-the locations in space of the amplified and flanged direct cello are dependent on the pitch of the live performed cello

-Sampler_1 and Sampler_2 spatial movements mainly depend on the brightness of the live cello sound.

Fig.7-K_2 Spatial monitor

Timbre and note densities of the live cello affect the velocities of the spatial displacements of each source, whose distance from the centre of the audience room depends on the periodicity vs. noisiness of the live cello.

Fig. 7-K_2 shows the monitor interface of spatialisation, each sound source is numbered and the monitor shows its current position inside the audience space of listening (the front speakers are represented as being in the upper portion of the diagram, the rear in the bottom).

PERFORMANCE NOTES

The main interactive tasks for the cellist are:

-1-The choice of contrasting sound materials filling Sampler_3 and _2

-2-The amplitude balance between Sampler_1 and Sampler_2

-3-The interactive strategies towards each of the three samplers.

The controls of the flanger and of the spatialisation could be considered as byproducts of the cello performance, not necessarily to be strictly controlled and focused by the cellist.

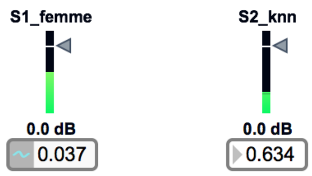
1) SAMPLING MATERIALS

In case of performance mode A, Sampler_3 will be filled by the same cello sounds as played during the beginning of the 1st movement. In this case the four contrasting cello model-phrases (lasting 20” each) already performed in the 1st movement make up the sound contents of the four subsequent contents of Sampler_3.

In case of performance mode B the contents of Sampler_3 will be fed in real-time by the cellist.

In this last case the filling sound contents are to be contrasting in sound (as indicated by the verbal animation).

2) AMPLITUDE BALANCE
The output amplitudes of Sampler_3 are directly responsive to the live cello resonance.



The final gains of Sampler_1 and Sampler_2 are instead balanced by the cellist:
-high pitches proportionally increase the amplitude of Sampler_1 (intensifying aggressive-rhythmic contrast)
-low pitches proportionally increase the amplitude of Sampler_2 (adding colour and textural density to the music)

Fig.8-K_2 Sound monitors of samplers 1 and 2

Middle range pitches obviously mix these sound contents with different proportions.

Sampler_1 is especially suitable for brief energetic commentaries matching the rhythms of the sampler with high-pitched live cello excursions.

3) SAMPLERS
The samplers granulate the sounds after being recorded in their buffers, and output them with a sound-mosaic technique.

Their main parameters are:
-period: defining how many sound grains are output.
The parameter is set in milliseconds (i.e. period 1000 = 1 new sound grain is output every second; period 50 = 20 sound grains are output every second)
-duration: defining the time length of the grain (in milliseconds); if the grain duration is lower than the period the result will be a scattered sequence of sound pulses, if the duration is higher than the period the grains will be overlapping. In case of a large difference (as in the extreme case of figure 10-K_2, where the period is 50 and duration 8700) the result will be a dense overlapping texture of very long sound grains.
-resampling: it means transposition, computed in cents of a semitone (i.e 1200 = 1 octave)
-level: it defines the amplitude increase or decrease with respect to the internal sound materials.
-attack/release affect the clarity and definition of the sound grains
-filtering is also influenced by the live cello

Sampler_3 is the main engine of the music.

Sampler_1 and _2 have a subsidiary role affecting the overall sound character.

__**Sampler_1**__: (upper left of the main patch).
Its internal file is pre-recorded and **very rhythmic**.

The more the cellist plays high notes, the more this sampler plays loudly.

The internal sound file is pre-analysed[1], a similar analysis is performed in real-time upon the live cello sound: the system is therefore able to **select and output the file sound portions more similar in timbre with respect to the sound gestures performed by the cellist.** The different portions of the sampled sounds are then "sewn" in real-time through a sound-mosaic technique.

In addition the cellist can influence the length, the density and the intonation of the output sound-mosaic portions in the following way:
-**if the cellist plays louder**, the sound-file "grains" are transposed higher, but at the same time they become shorter (extremely strong cello sounds output grains lasting less than a second until a fifth of a second, soft cello sounds increase the length of the grains until a few seconds): the file-grains are anyway output at regularly time-cut "note" lengths.
-the density of the events coming from the audio file (the number of grains output within a second) increases **if the cellist plays the first notes of the chromatic scale starting on C** (C, C#, D .....) but progressively decreases on reaching A, A#, B…..).

By interacting through amplitude and pitch (pitch-classes) the cellist can obtain extremely varied methods of sampling in terms of grain density, length and transposition.

More subtle timbre variations of the grains are dependent on timbre variations of the live cello.
The values of the grain-mosaic processing can be monitored on the screen as shown
in figure 9-K_2.

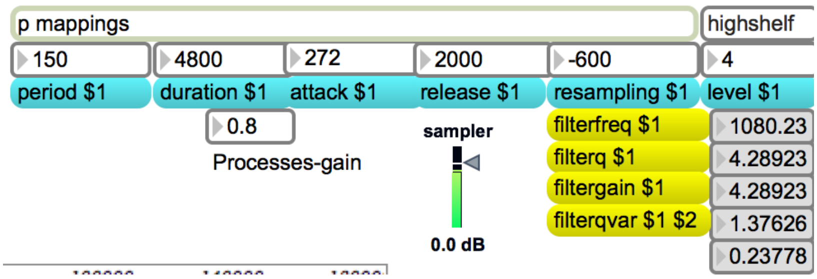
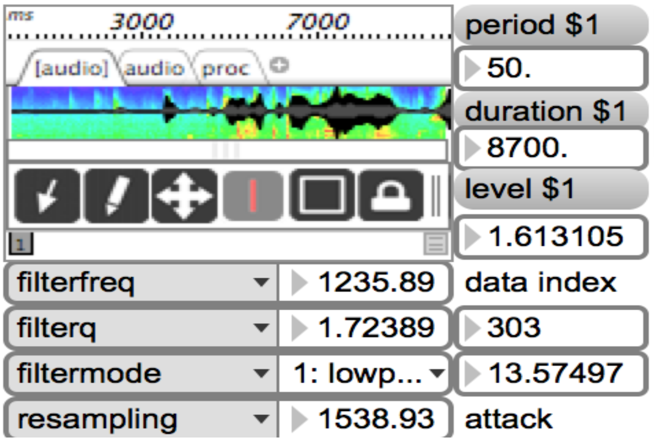


Fig.9-K_2 Sampler_1 engine

[1] The timbre analysis is performed through Mel-cepstral coefficients stored in the software, and the similarity between the stored and the real-time coefficients is computed in real-time by a "KNN" algorithm (key nearest neighbour search).

<u>Sampler_2</u>: (upper right of the main patch)
The sounds coming out from Sampler_2 have a **textural/background quality.**

Their amplitude increases **when the live cello is performing low pitches/sounds**, and decreases in the presence of high pitched sounds. The amplitude balance and the sound character of Sampler_2 are opposite to Sampler_1, and easily controllable by the performer.



The main algorithm of Sampler_2 is also driven by the KNN search (see note 13). The core system is a varied version of Sampler_1, but instead processing dynamic sound contents loaded on the fly. The output is a mosaic of sound fragments (like Sampler_1).

Fig.10-K_2 Sampler_2

The graphic interface of Sampler_2 shows the waveform and the dynamic parameters of interaction.

Pitch, amplitude and brightness of the cello are the principal means of interaction. The density of the sound texture (shorter grain periods) increases proportionally to **low cello pitches.**

High pitches, soft sounds and bright timbre contribute together to increase the length of the grains (i.e. a soft high pitch performed near the cello bridge will contribute to a maximum grain length, as in the example of figure 10-K_2).

Cello amplitude affects transposition. The overall filtering of the sounds is also dependent on the main live cello pitches, passing from no filtering for the lowest pitches, through different light filtering options, until resonant options in case of mid range notes (from middle C upwards).

Brightness, resonance and noisiness of the cellist have a role in the filtering and clarity of the sound mosaics, whose final sounds must be explored through performance rather than intellectually.

Sampler_3: (bottom right of the main patch).
Sampler_3 is the main sound engine of the system.

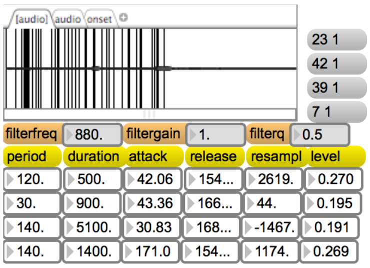
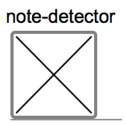


Fig. 11-K_2 Sampler_3

The sound filling its buffer (20" long) is segmented taking into account the **onset energy of the incoming sound.**
Therefore rhythmic sounds will produce much more segments than smoother sounds. The buffer interface shows the attack-segments as black vertical bar lines.
The output will be driven by an onset-detection internal system describing the live cello **rhythmic behaviour.**

The sampler outputs the sound segments following a mosaic technique (similarly to the other samplers), but in this case the segments are output in the same sequence as they were recorded.

The sound segments are distributed in **four separate channels,** each of them with different velocities and densities of fragmentation: the final output will be a "four voice polyphony" of differently fragmented portions of the live-recorded sound, where the segmentation will be guided by the rhythmic salience (onset detection) of the cello sound.



The note (onset) detector is placed above the sampler, detecting (inside the live cello performance) the presence of **a note when a cross appears, and a pause when the cross disappears.**

Fig.12-K_2 Note detection monitor

The note is analysed in terms of its duration, onset distance (time distance from the previous onset), initial pitch, amplitude and quality factor (periodicity vs. noisiness), all affecting the kind of output segmentation inside the sampler. The last four "note detections" determine the parameters of each of the four overlapping output channels of the sampler.

Fig. 30 shows the four groups of parameters organised in rows. When the "period" is lower than the "duration" the sound segments will be output overlapping each other in a dense rhythmic fashion, on the other hand low durations will output brief noise-like sounds, and higher durations will make the sound qualities of the stored segmented sounds recognisable (possibly allowing for more sound overlaps). Period and duration are computed in milliseconds. The parameter called "resampling" is connected with the pitch transposition of the referenced sound segment (i.e. 100 = 1 semitone higher; -100 = 1 semitone lower).
Further timbre details vary in accordance with the cello playing (as it is possible to verify inside the commented abstractions of the application)

The system detects a cello note when an amplitude threshold is passed.
A pause is detected through a double threshold detecting a partial decrease in amplitude.

A new note can be detected only after a pause (tiny or longer).
The system has good reactions with staccato, pizzicato or accented styles.
A straight legato style (with no amplitude decrease between notes) could behave unexpectedly (showing one extremely long note until a next amplitude decrease happens).
Be careful when long notes are really your interactive intention; in general the **music system is preferentially conceived for nervous staccato styles** as suggested by the screen instructions and the subject of the piece.

-A **high density of sound attacks (note-onsets)** by the cellist increases the density of sound events (the sound segments output by the sampler) in the proportion of
Inter-Onset-Interval (of the live cello) -> Period (of the sampled sound segments)
-The **duration of the live cello performed note** proportionally affects the duration of the sampled sound segments.
-The last detected pitch interval performed determines the transposition of the segments with respect to the original recorded sound.
-Only one of the four streams of sampled sound segments continuously follows in transposition your cello intonation, the others remaining fixed at their onset interval value.

TECHNICAL NOTES

CALIBRATION
The main calibration parameter concerns the note-detection.
Two thresholds work in parallel detecting the note-on and note-off when the cello amplitude crosses one of the values of -20 and -30 Db.
Should the cello playing and sound card adjustments be insufficient for focusing the average amplitudes around these Db values, a software calibration is suggested.

If you type inside the “gain_trim” number box a positive or negative value, the nominal amplitude detection will change accordingly (“gain_trim” simply adds or subtracts its value to the actual Db detection). Find the appropriate value in order to better focus an effective note detection.

The system should remember any new calibration by just saving the patch before closing it. A safer way to store data is available by pressing the “write” label inside the calibration set. Further calibrations are present in the system, and they can be explored inside the internals of the patch.

The sound diffusion is quadraphonic by default, in case of a different choice you need to remember, before playing, to press the button above the chosen different option.

Message_3 “Odradek”

Video instructions at: https://www.dropbox.com/s/b84puaj3ovmkyyu/K_3_instructions.mov?dl=0
Novel at: http://www.kafka.org/index.php?aid=284

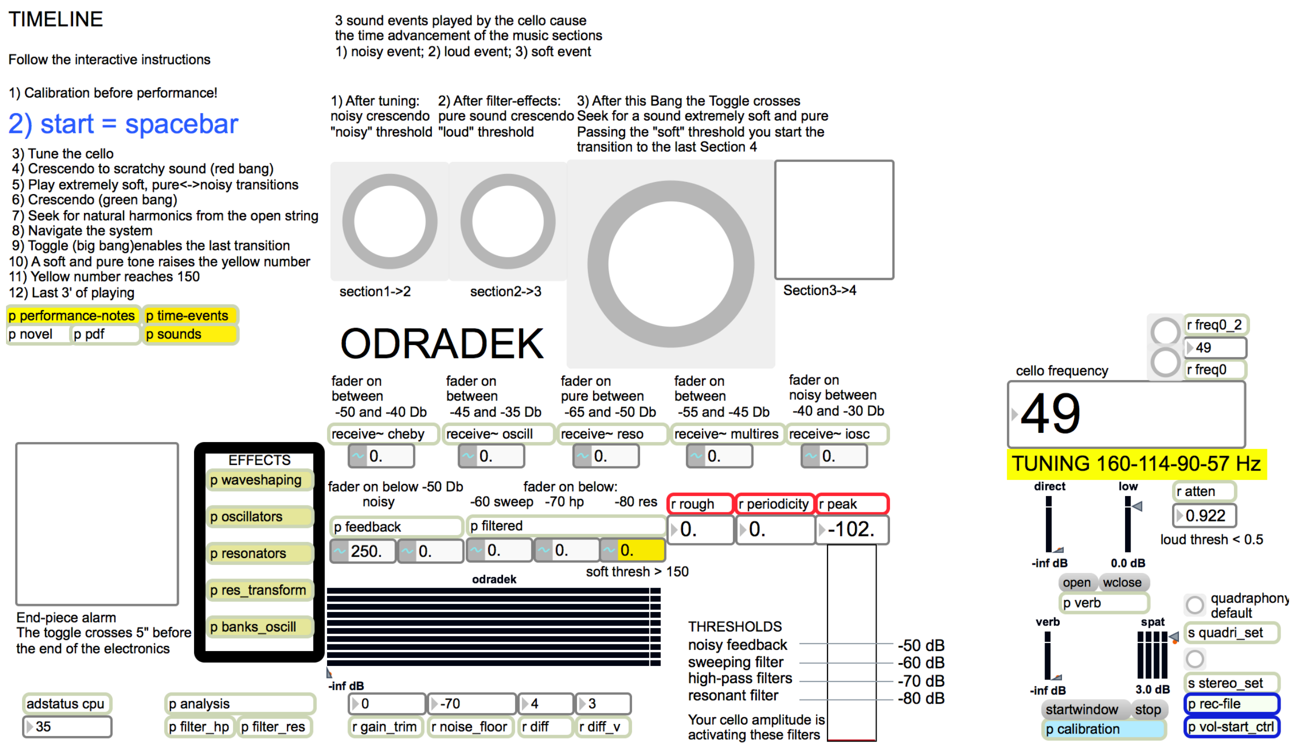


Fig.1-K_3 *Odradek*'s application *(Message K_3)*

COMPOSITION

PERFORMANCE STYLE

By only using the bow on the open strings (no pizzicato and never exploiting the left hand) you will produce different **overtone pitches**.

If the bow pressure is extremely soft, a specific overtone will arise, whose high pitch mainly depends on the bow-bridge distance (the portion of the vibrating string).

Play with extreme softness (below the loudness-threshold of the normal cello tones), gently sliding between different quantities of bow hair and different distances from the bridge.

Keep the bow-motion regular and wait the due time in order to let the harmonic sound grow, as much as possible beyond the loudness of the fundamental frequency of the string: you can softly change the pitch of the overtones as you wish.

You can also create transitions between the purest sounds and soft but rougher and gently scraping tones. You can sometimes play full notes, even loudly, or even loud and noisy, taking into account that all these choices affect the electronic interactive sound results.

When you play low notes with full tone, you can hear that your sound is doubled one octave lower.

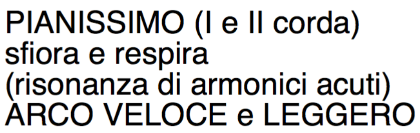
This performance style can be considered as a study on the construction of harmony through timbre.

In this way you extract actual significant components of the sound spectrum, building their sound against the fundamental frequency of the open string.

In this work the main string pitch always acts as a background, just like Odradek's "voice without lounges".

The spectral components of the sound are instead the main sound characters, reversing the importance of note/timbre categories with respect to the classic performance styles: the electronics simply enhance this timbre based attitude, since they only expand what is actually contained in your sound.

INTERACTIONS



The performance is guided by interactive verbal instructions appearing on your screen.

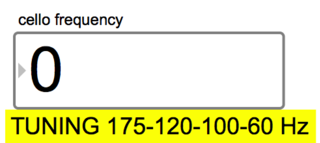
Fig.2-K_3: an example of interactive verbal instructions

The electronic sounds, upon which you have a total control through cello timbre nuances, follow you like a shadow. After a starting section, the electronics will be alternating between two different states, which correspond to **performance mode A and performance mode B.**

The time transitions between music sections and performance modes are the consequence of **three main sound events**. You decide when performing these three events, therefore the advancement of the piece (and its global duration) is at your will.

Performance modes A and B require two different cello modes of interaction, since the electronics will be slightly different, even if the general sound palettes are acoustically rather similar.

At the beginning of the piece you are requested to tune the cello strings unconventionally from high to low as: F, H (quarter tone lower), G (sixth of tone higher), H (quarter tone lower),
at frequencies 175, 120, 100, 60.
Some of these relations foster special string resonances.



The number on the right of your screen tells you which frequency you are currently playing.

Fig.3-K_3 Cello frequency monitor (tuning section)

SECTIONS

Beginning

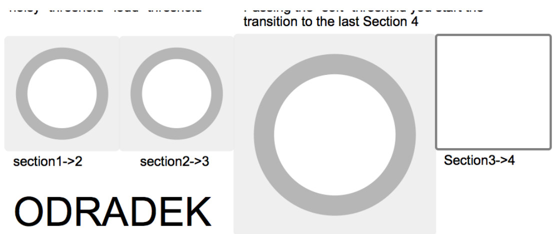
The opening scene consists in the narrator's voice against your **initial cello tuning**.

Tuning should be accurate by means of long, soft, airy bowing (maybe intermingling with a few pizzicatos).

This provocative inclusion as the beginning of the performance requires a theatrical focus, notice that your sound transforms the quality of the spoken voice (as a consequence of single note vs. double step, sound vs. pause, different volumes).

Events

After this prologue, the whole composition advances as a consequence of the three main cello timbre events "noisy, loud, soft": they have to be performed during special moments of the composition.



In the central part of your screen you can see the detectors of these events represented by color flashes and one squared button: the events cause the transitions through sections 1, 2, 3 and 4.

Fig.4-K_3 The event-to-sections monitors

Further monitors, but principally the electronic sounds, make you aware of every new section.

-Event 1 (noisy) is a loud-scraping crescendo:

from section 1 (tuning plus narrator's voice) to section 2 (performance mode A)

-Event 2 (loud) is a crescendo with full-pure sound

from section 2 (performance mode A) to section 3 (performance mode B)

-After 1' 30" the system automatically folds back to performance mode A

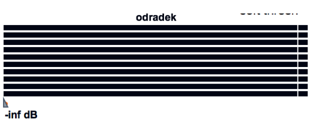
-Event 3 (soft) is a long and extremely pure and soft sound

from section 3 (performance mode A) to section 4 (performance mode B)

The advancements of the sections allow the alternate performance of modes A and B.

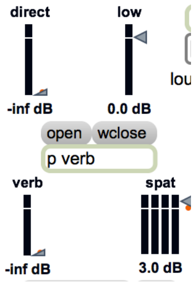
In this way the composition develops 2 principal electronic sound states:

<u>Performance modes A-B</u>



A) filter-resonator effects come out of the 10-channel virtual mixer (bottom portion of the patch). In performance mode A the volume-slider of the mixer is open, but it is closed in performance mode B.

Fig.5-K_3 The 10-channel main mixer (performance mode A)



B) direct/reverberated enhanced cello sound (right bottom monitors)
"direct" displays the volume of your sound coming from the main microphone,
"verb" tells you the quantity of reverberated sound,
"low" tells you when your sound is doubled at the lower octave.

Fig.6-K_3 Direct-verb gain faders (performance mode B)

During the performance mode A the sliders of "direct" and "verb" are closed.
During the performance mode B they move following automatic envelopes.

Sounds A) are produced by filtering and additive synthesis, mirroring the spectral analysis of your sound, captured from the input pickup.
Sounds B) enhances the microphone output, boosting the overtones that you are performing.

When the system is **in mode A you can mix 10 different effects**, **just by playing and balancing at different volumes** full tones vs extremely soft overtones, or alternating very pure sounds with soft bow-string noises.
Put briefly, you control the mixer by means of your amplitude and sound pureness (vs. noisiness).

In mode B you will play only extremely soft overtones, in order to prolong and overlap them through the reverberation, but you will need to be cautious in order not to increase this effect too much, because of the risk of the audio-feedback.

STRUCTURE
You will follow the interactive verbal instructions appearing at the upper right portion of the screen.
You are totally free in choosing the times and the characters of your timbre interaction.

The crucial aspect is the **quality, continuity and harmonic interest of the overtones** performed.
Alternating them with soft bow noises and full tones, represents the main means to navigate the system and the compositional form of the piece (in performance mode A).
A special sensitivity towards the chordal harmonic nature of performance B offers a means of balance.

Below is a detailed description of the event-section time structure, and later on some details are given about the sound effects. The last part of the document involves calibration instructions.

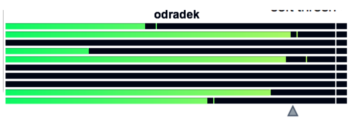
PERFORMANCE

CELLO EVENTS AND MUSIC SECTIONS

After having opened the main application, and checked the presence of the audio card:

0) **press the spacebar** (start music)
tune the cello to the indicated frequencies,
the overlapping voice of a narrator (reciting Kafka's novel) is diffused;
you modulate the voice through frequency, amplitude and cello sound periodicity.
After completing the tuning, keep a long sound on the D open string avoiding full tones:
by playing extremely softly with little hair, search for and keep sounding one D overtone or alternatively play a short sequence of D overtones, gently shifting the bow (ordinario->sul-tasto->ponticello) with slow, free and continuous patterns of bow "drains".

1) **perform a noisy crescendo** until the red flash informs you that the "noisy" threshold is reached.
After that, maintain the previous overtone performance style: you can occasionally change the string you are playing on, but remember that you will be performing only on open strings throughout the piece. After this "noisy" event, the gain of the 10-channel virtual mixer arises: the effects are strong filtering and artificial resonators linked to the spectrum of your current sound.

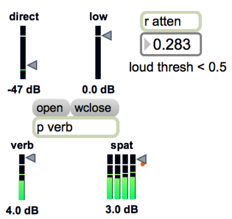


The effects are distributed through the 10 channels of the virtual mixer visible in the bottom part of the patch: you mix the 10 channels through cello amplitude and timbre.

Fig.7-K_3 Main mixer in action (performance mode A)

Keep playing very softly, shifting between the effects. This is the performance mode A.

2) after 30" or 1' ca. (as you wish)
perform a full tone crescendo until the green flash detects that the "loud" threshold is reached.

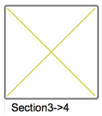


At this point the direct-cello gradually crossfades with the reverberated cello, whilst the 10-channel effects slowly fade out. The artificial effects disappear, and the overtones that you keep playing are now simply increased and sustained by natural amplification and reverb.
This is the performance mode B.

Fig.8-K_3 Reverb in action (performance mode B)

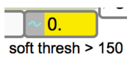
3) **after 1' 30" of this performance state**
the 10-channel artificial effects automatically and gradually fade in again, while the direct and reverberated gains fade out (performance mode A').
After 1 further minute a big flash (and the crossed big button) inform you that the "soft" threshold is now in listening state: freely perform following the interactive instructions until you decide to enter the last section.

4) the last transition starts when you **reach the "soft" threshold:** the yellow number called "soft_thresh" has to surpass 150 (if not differently calibrated).



When the big white button is crossed, the "soft threshold" starts its listening mode, you do not need to reach the "soft threshold" immediately, and you can delay the section advancement at will, navigating the performance mode A in different ways.

Fig.9-K_3 Crossed button (listening mode of the "soft_thresh" enabled)



When you are ready for the last section, you have to raise the yellow number, performing extremely soft and pure tones until the number reaches the set threshold.

Fig.10-K_3 Soft threshold monitor (high numbers = softer sound)

This process could be fast or longer, depending on the quality of your sound. This not trivial task requires a sustained sound possibly lower than the -80 amplitude level, but highly periodic at the same time (keep the "periodicity" and "peak" number monitors under your view).

When this last section is enabled, performance mode B' starts to be in action:
reverberated and direct sound gains fade in again, and the narrator's voice reappears softly.

5) after 1' 30" direct and **reverberated gains automatically crossfade a last time** (now reaching higher gain values), until the whole electronics fade out as underlined by the crossing of the bottom in the left part of the patch.
You can continue to perform overtones without any electronics if you wish.

PERFORMANCE MODES

The whole performance will therefore be segmented by these 3 sound events (as displayed through flashes and crossing buttons) and by a set of automatic gain fades. The principal performance style is the overtone production throughout the whole performance: but the timbre variations and an **extreme control of the cello loudness** permits you to fully navigate the interactive system.

<u>**Performance mode A**</u>

The 10-channel virtual mixer outputs:

-5 artificial voices produced by the "effects" modules called:

waveshaping, oscillators, resonators, res_transform, banks_oscill

-3 strongly filtered cello voices (controlled by the module "filtered")

-2 delayed-feedback filtered copies of the cello sound (controlled by the module "feedback")

All these artificial and filtering treatments are direct consequences of your sound, analysed as: fundamental frequency, spectral periodicity, amplitude, roughness, and individual frequency/amplitude of the first 30 cello partials.

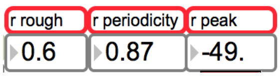


Fig.11-K_3 Cello timbre monitors (roughness-periodicity-loudness in db)

The **5 artificial effects** "sonificate" the spectral cello data as they are tracked in real-time.

The **3 filters** excite the overtone dynamics as they are performed

The **2 feedback voices** problematise the noisy components performed

More importantly **the 10 effects are mixed by the cellist through the amplitude and periodicity** of the cello sound. Visually the sound intensities of each effect appear from top to bottom inside the central mixer (the green moving lines indicating the energies of the output sounds, Fig.7-K_3).

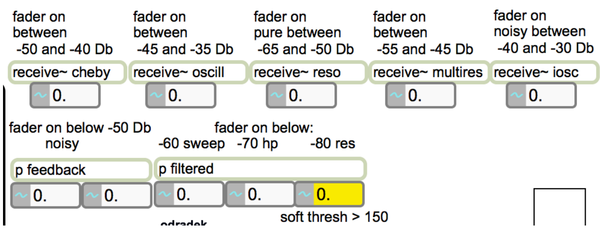


Fig.12-K_3 Gains of each effect (and notes about the cello peak-amplitudes enabling each effect)

Some details of the relations between the cello loudness and the gains of each individual effect can be monitored in the central part of the screen (Fig.12-K_3).

The upper green lines of the main mixer represent the 5 artificial voices: they appear when the cello plays louder, possibly with full tone (contrasting the main soft overtone conduct). **The 3rd effect (resonators) is boosted by Mezzo-piano** with very pure full tone, the others by different graduations of higher intensities and timbre periodicity.

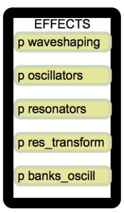
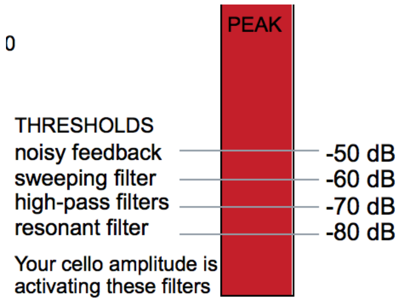


Fig.13-K_3 Artificial-effects modules

The lower green lines represent filters and feedback (the latter appearing in the 2 lowest lines).



Under the numeric gain monitors of these effects you can see the visual peak monitor containing 4 main thresholds driving the most important mixing functions. You can see **the red monitor** showing your current cello amplitude and the points at which the different filtering channels are activated.

Fig.14-K_3 Cello amplitude tracker (and connections with the filtering channels activation)

The 5 artificial effects better respond to louder cello full tones

1) "Waveshaping" returns a vibrating copy of your played note;
it is excited by playing pure tones Forte (-50->-40 dB),
your timbre roughness increasing the artificial vibrato
2) "Oscillators" returns a slightly inharmonic copy of your played note;
it is excited by playing slightly rough tones Fortissimo (-45->-35 dB),
your noisiness increasing its resonance
3) "Resonators" returns a little-bell-like image of your sound spectrum;
it is excited by playing extremely pure tones Mezzo-piano (-65->-50 dB),
your periodicity highly increasing its resonance
4) "Res_transform" returns a harmonic copy (sometimes gliding) of your played note;
it is excited by playing pure tones Mezzo-forte (-55->-45 dB),
your periodicity increasing its volume
5) "Banks_oscill" returns a scattering image of your sound if played noisily;
it is excited by playing very noisy tones extremely Fortissimo (-40->-30 dB),
your noisiness increasing its effect

The 3 filter effects require extremely soft and pure sounds, only playing overtones instead of full notes. These 3 effects will be your main focus during performance mode A.

6) "Sweeping filter" (variable cutoff): this is excited by playing Piano overtones (-> -60 dB),
preferably responding to whistling al-ponticello sounds
7) "Hp filter" (high-pass): this is excited by playing Pianissimo overtones (-> -70 dB),
preferably it requires quick shifts between different bow-bridge distances maybe mingled with small wood/string infra-sounds
8) "Res filter (resonant): this is excited by playing extremely Pianissimo overtones (-> -80 dB),
it requires the most soft amplitude and pureness, and it can sustain the most subtle overtones

9)-10) **The 2 feedback filters react to soft-noisy sound** stimuluses (-> -50 dB);
they time expand (through delay-feedback) the filtered cello noise,
one filter is high-pass and the other one is resonant

Most effort and time focus will be spent on the filtered overtones, taking the noisy-delays and the full tone artificial sounds as a musical contrast. The transitions between filtered and artificial effects will be spontaneously bridged by the "resonators" (3rd effect); the "banks_oscill" harsh effect should instead be possibly performed only once during the whole performance.

By accessing the calibration section you can see that the above amplitude values are nominal, and you can recalibrate the amplitude detection if necessary, in order to make your timbre controls easier.

Performance mode B

This sound state captures the microphone sound allowing for a refined almost naturalistic timbre quality. It ordinarily requires the soft overtone main way of performance, and especially when the reverb is high, it has the power to capture any overtone, raising it as a sustained resonance: by changing overtones you can develop steady polyphonic textures.

But if the resonant system acquires too much power, it can produce unwanted feedback frequencies (outside the natural harmony of the interaction): in this case you can soften the electronics just by playing louder, maybe momentarily killing all the reverbs by playing brief cello noises.
The more you play pure and soft, the more you raise the resonant electronics of mode B
(thus the natural enhancing of your overtones); and obviously, by performing in the opposite way (louder and/or scraping) you can counterbalance possible resonance excesses.

Despite the strict connections between cello and electronics, the work develops as an open form steered by the choices of the cellist. The work is considered as minimalistic because of:

- the continuous search for natural overtones allowed by a special bow technique
- the challenging control afforded by extremely subtle volume balances

Sound tracking (and sound outputs as well) depends on different channels of calibration.
It is likely that the default values do not suit different cellists and instruments.
By double clicking the label “calibration” you can access the module, and the relative
“notes” embedded section.

CALIBRATION

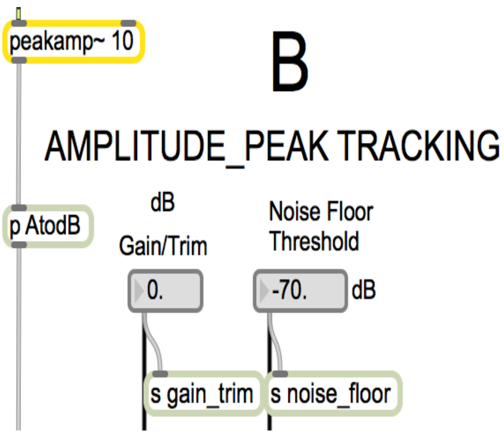
The cello is fitted with 1 microphone (possibly a DPA) routed to **adc~1, feeding the outputs only of performance mode B**. A contact pickup (possibly Fishman) is additionally routed to **adc~2 feeding the outputs of performance mode A, and the sound analysis upon which all the controls and processes rely.** After having set the amplitude balance of the 2 input channels from the audio card, further balance should be set inside the software.

The most important parameters are contained inside the calibration section B (amplitude peak detection) and inside the section C-1 (direct-cello and reverberation expander).

Every new calibration should be remembered by the system after having saved and closed the "calibration" patcher if the system is a native MAX patch. The option of pressing the "write" message can be used, but it is mandatory if the system is a MAX standalone application.

A: cello inputs attenuation.
This is a general purpose gain balance, which could be left unchanged, since more specialised calibrations are contained inside sections B and D.
It can be useful as a pre-calibration amplitude balance test between the two inputs.

B: peak detection



Peak tracking is the main motor of the system in performance mode A. The cellist balances the 10 effects through his/her performed loudness.
The "noise floor" parameter allows for a useful expansion of the salient cello amplitude region: the value set inside the "noise floor" number box shifts that value in dB to a nominal -120 (noise floor). In this way the piano and pianissimo sounds can be better controlled, since their nominal values are expanded. Optionally the "gain/trim" message linearly adds its value (positive or negative) to the nominal dB tracking.

Fig.15-K_3 Peak amplitude calibration

This calibration should be accomplished by taking principally into account the red monitor of the main patch, in order **to ensure a comfortable control of the lower thresholds by the cellist.**

C: parameters calibration

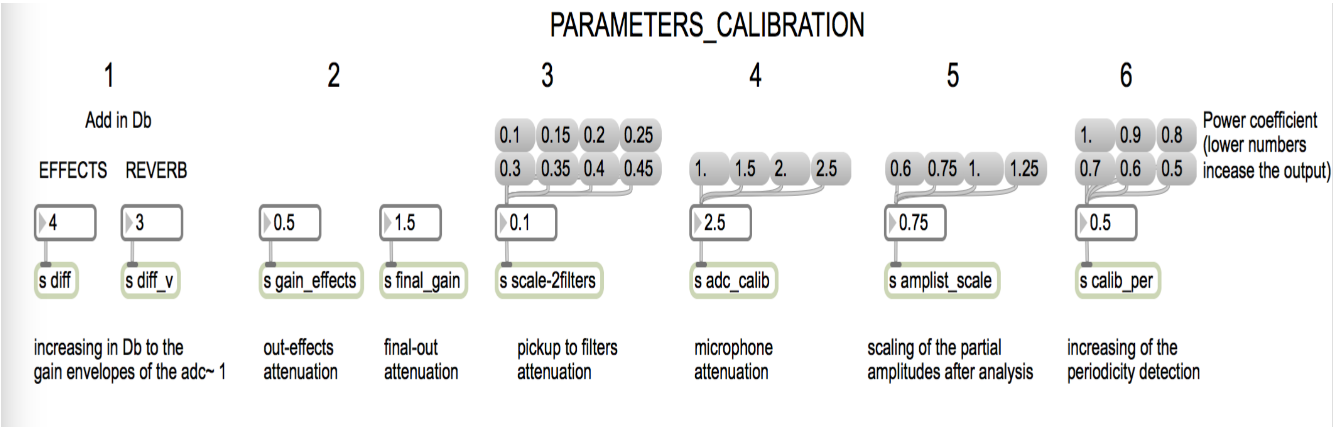


Fig.16-K_3 Multiple calibrations

1) **The values "diff" and "diff_v" add or subtract amplitude in dB to the automated gains which dynamically modify respectively the direct and reverberated cello:** both signals come from adc~1, therefore they are active only during the performance mode B. These gains shift throughout the whole performance (and they are slightly higher during the last part).
Depending on the room/equipment specs, a maximum on stage amplitude has to be gained without instantiating feedback, since the direct and reverberated cello outputs must be enhanced in order to raise and prolong the very soft cello overtones (if the cellist plays louder the internal gains automatically decrease).
These additional gain factors may need to be checked before the performance.

2) attenuation/boosting of: a) the effects coming out of the 10-channel virtual mixer b) the overall final gain. Obviously < 1. attenuates and > 1. increases these final signals.

3) the sounds feeding the 10-channel mixer (performance mode A) need a strong attenuation, which can be differently set.

4) the microphone signal (from adc~1) generally needs to be increased due to the soft performance required, but a lower boosting could maybe help the C-1 calibration.

5) "amplist" scaling affects the amplitude of different filters and resonators: this involves the amplitude scaling of the partials tracking inside the fft module.

6) the periodicity coefficient compresses the output values towards "noisy" when it is lower and towards "periodic" when it is higher. Its mappings particularly affect the final gains of the filters. In case some more nominal "periodicity" is needed, you can very slightly decrease the coefficient (i.e. the power to which the periodicity tracking is raised).

D: threshold setting

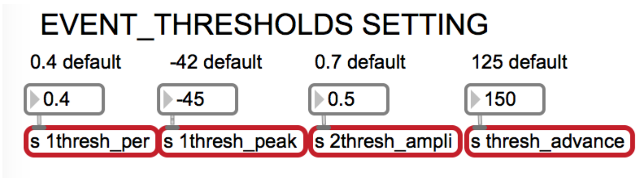


Fig.17-K_3 Thresholds calibration

The parameters underlined in red set the thresholds detecting the 3 cello events which make the composition advance.
After having balanced the B and D sections, some of these thresholds could be changed in case they do not fit a fluent cello performance.

1) the tags "_per" and "_peak" regard the event 1 "noisy".
   They reference the "periodicity" (0 -> 1) and "peak" (-120 -> 0) main monitors: by increasing their values the loud-noise detection is made more sensitive, by decreasing them the cellist has to put more effort to accomplish event 1, respectively in terms of noisiness and loudness.
2) the tag "_ampli" regards event 2 "loud".
   The small number (0 -> 1) on the right of the direct-verb gain sliders is referenced. Increasing the cello loudness this number decreases. Therefore, if this threshold is too sensitive (triggering an unwanted event) you have to lower it. In the opposite case, you have to slightly raise it.
3) the tag "_advance" regards the event 3 "soft".
   The default value should be preferentially higher than 100, making the task hard but not too difficult. The referenced yellow number "soft_thresh" rises when the (nominal) cello peak amplitude is below -80 dB in the context of a high periodicity.

Message_4 “The Trees”

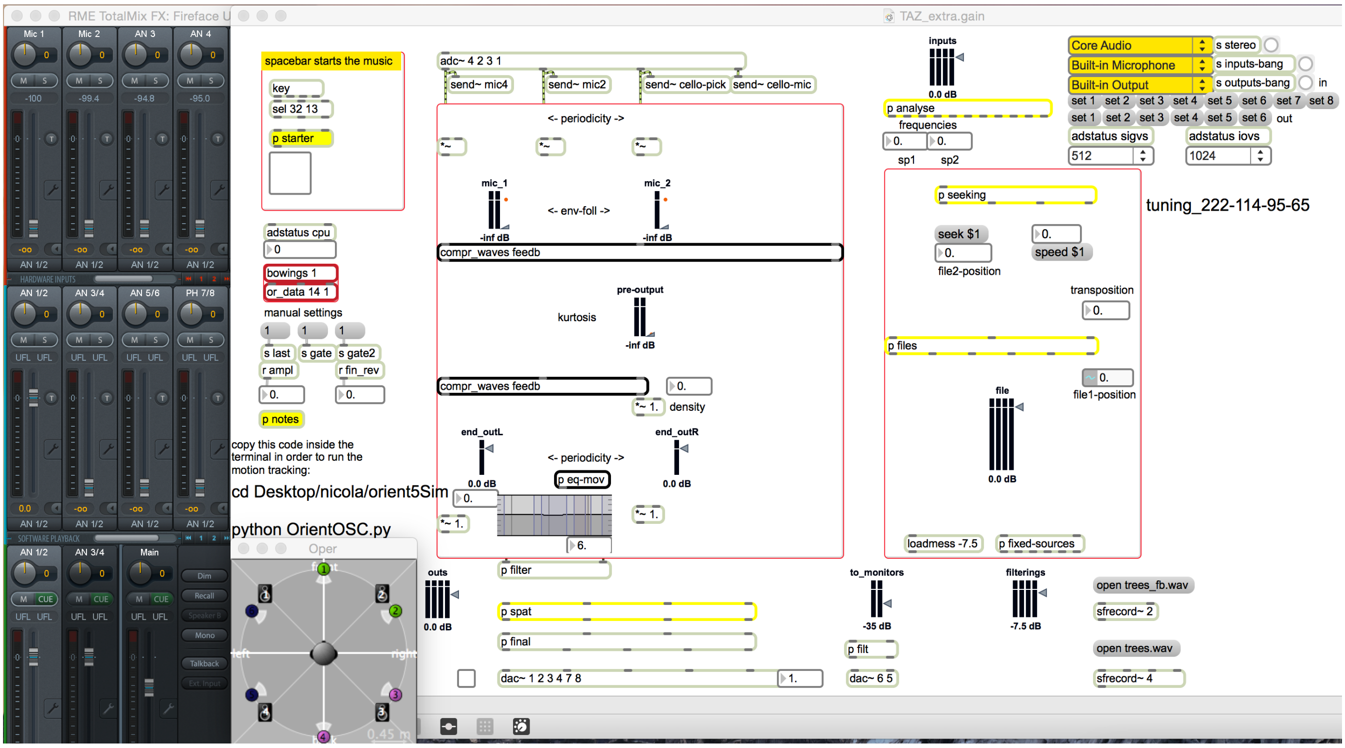


Fig.1-K_4 The main application interface *(Message K_4)*

“For we are like tree trunks in the snow. In appearance they lie sleekly and a little push should be enough to set them rolling. No, it can't be done, for they are firmly wedded to the ground. But see, even that is only appearance.”

Video instructions at: https://www.dropbox.com/s/cb9sdraxga0102x/K_4_instructions.mp4?dl=0

SETTINGS

Arrange on stage a small ensemble of microphones and studio-speakers, in order to conduct a Trio for cello, audio-feedback and tape, through sound-gestural interaction.

The cello is fitted with a microphone and a pickup, exactly as it is in the previous movements of the Kafka cycle.

These 2 cello inputs (possibly DPA and Fishmann) are placed on the cello body.

In addition 2 small speakers (placed on supports c. 1 mt. high) **and at least 2 more microphones** are positioned on stage in order to raise a sound-magnetic field around the cello.

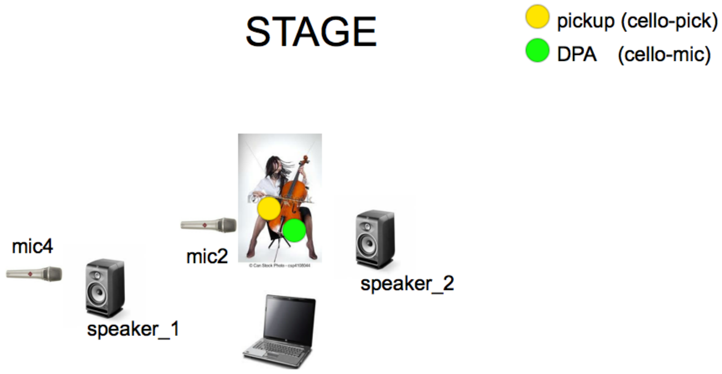
-1st speaker on the right side of the cello (c.1 or 1 and a half meters distance)

-2nd speaker on the left side of the cello and quite close to it in order to resonate with the cello microphone

- 1 omnidirectional microphone diagonally facing the main cone of the first speaker
- 1 additional microphone should be positioned close to the right side of the cello bridge.

SOUND ENSEMBLE.

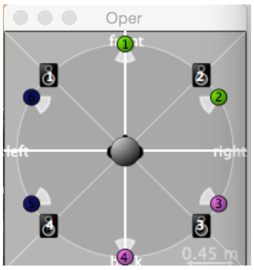
Stage space



-Cello
-Speaker_1: right
-Speaker_2: left
-Microphone_1:
on the cello ("cello-mic")
-Microphone_2:
front/right of the cello ("mic2")
-Microphone_3:
contact pickup ("cello-pick")
-Microphone_4:
close to Speaker_1 ("mic4")

Fig.2-K_4 Stage

Audience space



Quadraphonic spatialisation

Fig.3-K_4 Audience speakers

MAIN INTERACTIONS

The cello is moved and turned within the sound-magnetic field in order to alter the individual contributions of each microphone, collectively creating dynamic "chord" shifts: the resulting **audio-feedback** will be **a small choir of whistles and modulations.**

During the opening part of the work the cellist modulates the audio-feedback only by modifying the cello position, inclination, and distance from the individual pieces of equipment; during the continuation of the performance the cello sound will be treated also as an active source of modulation of the feedback pitches.

-Microphone_1 should be placed in a way so as not to allow an exaggeratedly fixed pitch from its speaker (distance and angle should be experimented beforehand).

-Special cello drifts with respect to Microphone_2 increase, attenuate or modify the sound contribution of this microphone: approaching the right sound-hole, it mostly picks up the first mode of resonance between 90/100 Hertz, while different and not fully predictable resonances will be raised by turning the sides and the back of the cello towards the microphone.

-The pickup has the function to isolate cello noises independently of the environment

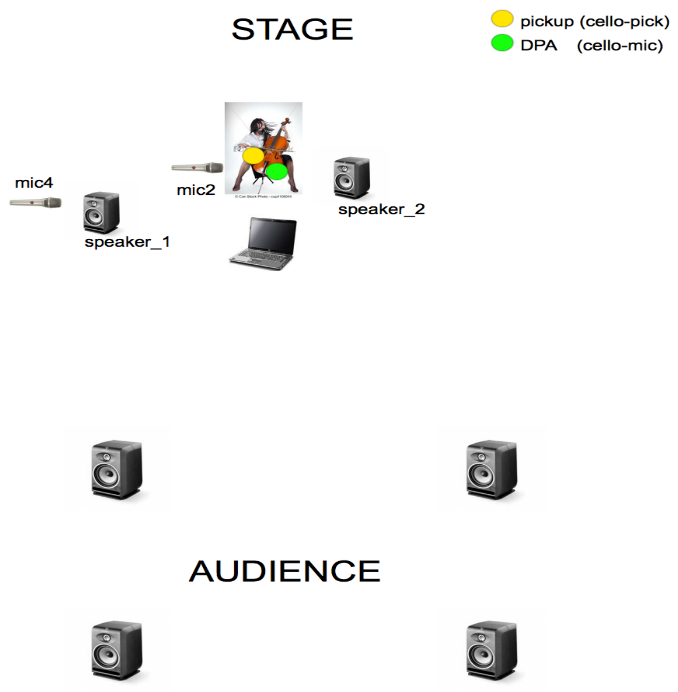
-Microphone_4 is responsible for the cello direct sound, naturally mixed with the feedback occurring on the stage. By occasionally approaching the Speaker_1, the chordal feedback state can be modified.

1 inertial sensor (3axis accelerometer + 3axis gyroscope) is positioned under the frog of the bow (tracking Orientations, Energies and Bowing styles), in order to control the spatialisation for the audience, and further balances and interactions during the composition.

Fig.4-K_4 Bow motion tracking

COMPOSITION

SPATIAL SOUND



The overall sounds come from
2 clearly detached sound fields:
-The stage space
(physical cello plus stage monitors)
-The audience space
(four speakers around the audience)

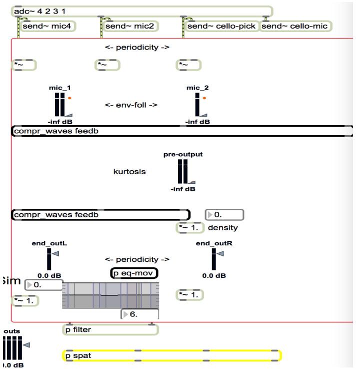
Portions of the outputs are mixed inside these two spaces, but the opposite locations are to be clearly perceptible, as a main central stage source and a distanced mirroring audience space.

Fig.5-K_4 Overall setup

Reflecting the theme of reality and appearance, the spatial distributions are quite ambiguous.

The Stage Space mixes the acoustic sounds (cello plus audio feedback, with their natural patterns of spatial radiation) with the 2 local speakers (routing opposite cello sound features and selected portions of the processed sounds).
The Audience Space mixes the direct and processed sounds, fixing every source at a given location, but also moving their images inside the outer quadraphonic space.

AUDIO FEEDBACK



The system is provided with multiple internal high-amplitude expanders chained with compressors, filters and signal routings.
In this way feedback becomes an active eco-systemic component of the music, and it can be **modulated by the cellist in terms of sound, and of gain controls as well.**
This multilayered system in part follows automations and in part the performing actions of the cellist.

Fig.6-K_4 The audio feedback channels

TIME SECTIONS

TIME	0'00"	0'20" <-> 0'30"	1' <-> 2'	3'	5'	10'20"	10'20"
SECTIONS	slow fadein	SECTION A'	SECTION A"	SECTION A'"	SECTION B	SECTION C	fadeout
GAINS	from silence to very high	very high	very high	dynamically controlled by the cello timbre	quite high	very high	to silence
INTERACTION	waiting	cello movements inside the eco-system	cello pitches modulating the audio feedback cello movements still in action	cello timbre as a main mixer pitch + movements feedback modulations still in action	tape with cello accompaniment tape fragments live triggered feedback modulations still in action as a background	tap-delays upon: audio feedback, triggered tape fragments, cello sounds feedback modulations scattered by the delays	fadeout
SOUNDS	silence	audio feedback (variable pitches)	cello sound feedback chords amplitude modulations	the cello controls 2 channels: -audio feedback -cello enhanced noises	tape + tape fragments cello commentaries occasional feedback	overall mix, delays	fadeout

Fig.7-K_4 Time sections

The overall duration is 13’30” (a 10’ reduced concert-option is allowed). The different sections of the composition afford different kinds of cello interaction with the eco-systemic.
Sections A are mainly focused on the audio feedback.
Section B involves the diffusion (in part interactive) of a 5’ long tape
mixing recorded sounds of audio feedback, cellos, environment, and everyday objects.
Section C is a final commentary mixing previous elements

A' (beginning)

On pressing "start", multiple chains of amplitude gains progressively reach high levels.

The audio-feedback slowly emerges: the cellist modulates it by moving and turning the cello. Different distances and angulations increase or stop emergent feedback frequencies coming from stage-speakers and microphones.

Bow circular motions in the air slightly spatialise the sounds inside the audience space.

A" (until minute 2')

The **audio-feedback** is now principally **modulated by the sound of the cello** (without refraining from modulating through cello movements, as before). Slow microtonal waving ornamental glides of the cello at the edges of the feedback pitches can induce:

-beats (particularly perceivable in low cello-feedback registers).

-the emergence of unexpected and changing feedback pitch patterns.

-resulting amplitude modulations (relating high, loud and steady feedback pitches).

Almost-in-tune 5th and 8th intervals can also influence the chordal feedback response.

In case of high volumes, quasi-haptic string resonances can induce further pitch shifts.

A'" (3' -> 5')

The **input/output gains** inside the system are no longer fixed. From this section till the end, **the cellist can balance them through the amplitude-noisiness-resonance of the cello sound** (see performance notes below). The interaction is now more complex and requires an increase in the cello sound contribution to the performance.

B (5' -> 10' 30")

A pre-recorded sound file (treating cello sounds, recorded audio-feedback, real-life noises) is diffused. The cello plus feedback performance "accompanies" the sound-file.

Impulsive bow movements output and treat in real-time **selected chunks of the audio file.**

C (10' 30" -> 13')

After the end of the previous "acousmatic" section, feedback, cello and file chunks are mixed and scattered through the lens of **a variable delay line controlled by the bowing styles,** until the final fade out.

INTERACTIONS

The performance is improvised and requires knowledge and rehearsal of the software circuits as they change over time. The interactive components of the work are:

-setting of the analogue equipment in order to find an optimal response fitting with the cello. This arrangement will be site-specific with respect to the concert room, in order to find a balance of the principal frequencies coming out the audio-feedback system.

-cello sound (microtonal sustained glides, melodic fragments, harmonic contributions).

-cello rolling positions inducing feedback.

-automatic dynamic equalisation of the main feedback sources. The EQ curve continuously varies throughout the piece, readapting the feedback sound colour.

-part of the quadraphonic main output treated with artificial reverb, whose intensity is dependent on the cello pitch: high cello frequencies increase the reverb, low cello frequencies dry the output.

-spatialisation, in part fixed and in part driven by the bow movements.

-cello pitch and timbre modifying the filter parameters and the internal gains.

SOUND CIRCUITRY

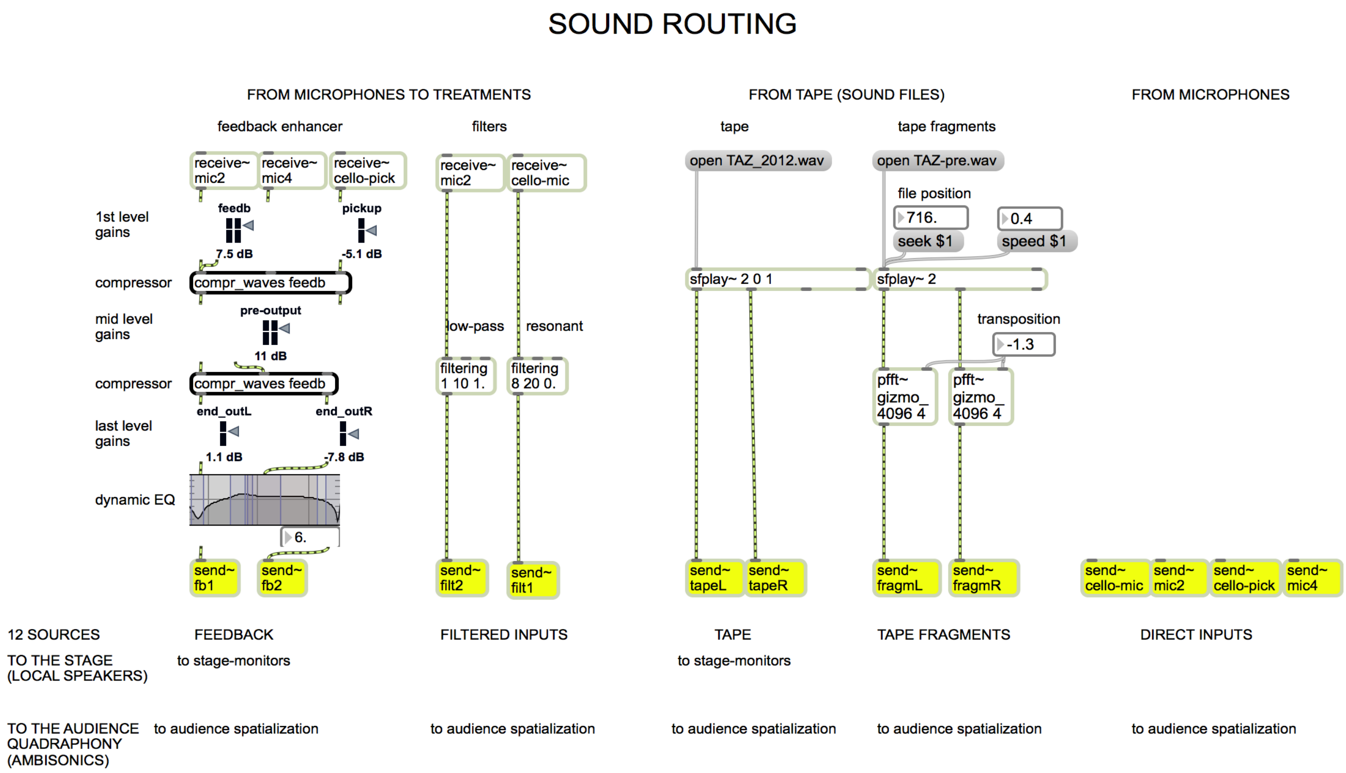


Fig.8-K_4 Processing and routing of the 12 sound sources

Inputs:

4 channel live inputs:

-cello microphone and cello pickup (adc~1 “cello-mic”, adc~ 3, “cello-pick”)

-feedback microphones (adc~2 “mic2”, adc~ 4, “mic4”)

4 channel tape inputs

-stereo tape (active in section B)

-tape stereo fragments (active in section B and C)

Internals:

The 4 live inputs are processed:

-“filt1” = “cello-mic” resonant-filtered

-“filt2” = “mic2” lowpass-filtered

-“fb1” = “mic4+mic2” passing through a chain of high gains, compressors and EQ

-“fb2” = “cello-pick” passing through a chain of high gains, compressors and EQ

“fb1” is the main channel boosting the audio feedback,

“fb2” increases soft-noisy cello sounds, attenuating and lightening the audio feedback.

Audience Outputs:
4 live channel, 4 tape channels, 4 live-treated channels = 12 sources
The quadraphonic audience output mixes the 12 sources, assigning them to fixed locations.
Additionally they are moved in a circle by means of the Ambisonics system: the source movements are driven by bowing styles and orientations through inertial motion tracking.
Section C foresees a multiple delay line of all 12 sources, with fixed output distribution.

The audience spatialisation creates a remote moving image of the sounds produced on stage.

Stage:
Central eco-system (cello, 4 microphones, 2 local speakers).
From the stage are diffused:
-the cello sound
-the emergent audio feedback
-the sounds routed to the stage-speakers:
2 feedback channels "fb1" and "fb2", plus the tape stereo output (during section B).

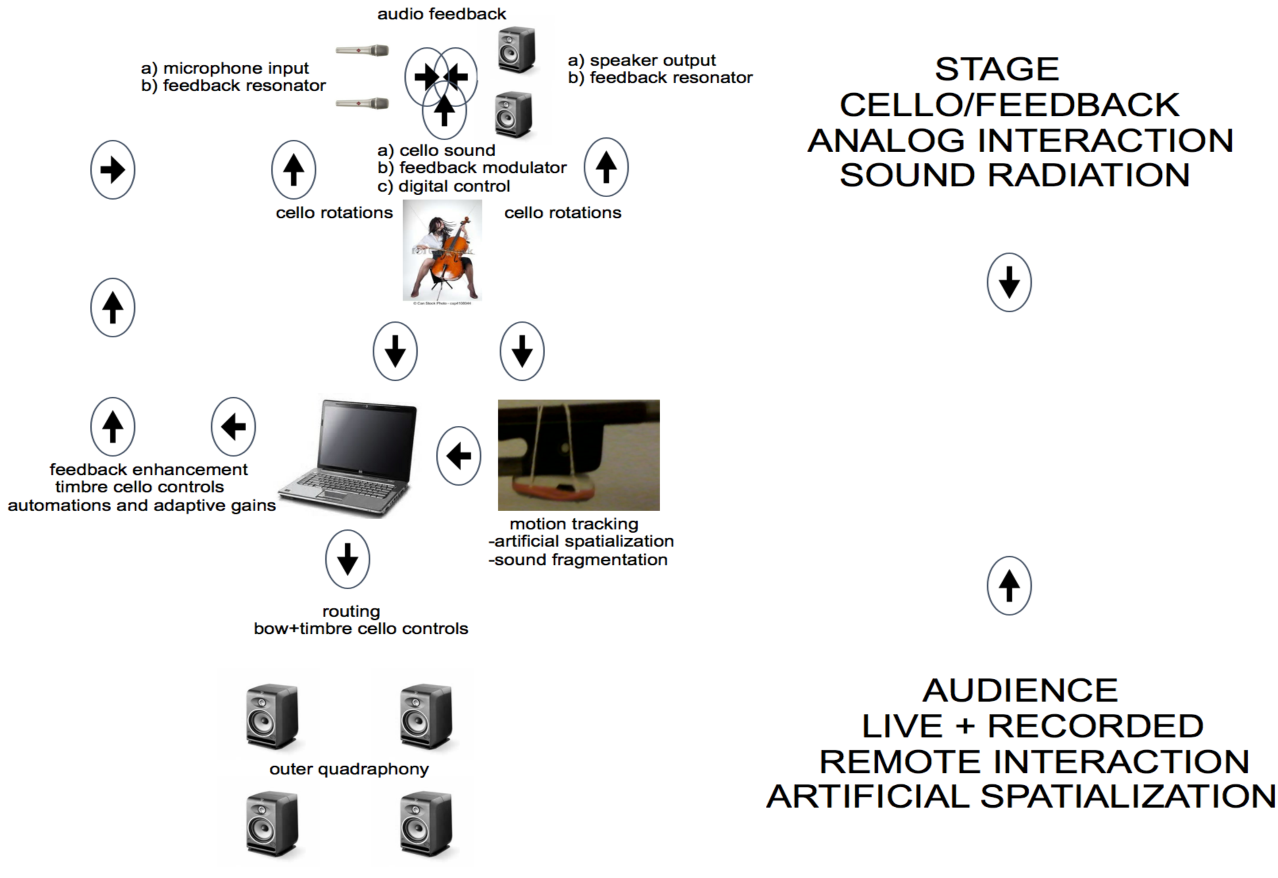


Fig.9-K_4 Analog/digital map

I/O:
Taking into account the central role of the audio feedback, the inputs (microphones) are to be considered as outputs at the same time, and vice versa the speakers (at least the stage monitors) are outputs and inputs at the same time.

The system (including the cello performance as an agent among other agents) is not conceived for a target music result, but instead for **a final balance of different patterns of emergent sound behaviours.**

The sections A-B-C simply shift the essential conditions of the live interaction, in a sense putting the same autonomous system inside different and pre-determined contextual conditions of "survival".

PERFORMANCE

No special software calibration is required, besides the analogue and site-specific setting of the eco system. Quick performance notes are embedded in the software (module "notes").

Position the charged IMU under the frog of your bow, and connect its basestation to the first USB port; the file "OrientOSC.py" needs to be running inside your HD.

By default the folder "nicola" has to be located inside the Desktop, and you need to open the patch, copy the code provided by the patch, "cd Desktop/nicola/orient5Sim python OrientOSC.py" and past it inside the terminal.

Any different folder name and path obviously has to be typed or replaced inside the message.

SECTIONS
Press the Spacebar in order to start the interaction.

-Section A' involves the silent interaction between cello positions and equipment. From the beginning the amplitude sliders slowly fade in and after a short period the audio feedback will be rising, emerging from the silence.

-When you feel the introduction is accomplished (not less than 1', or more than 2'), **you start to play the cello, entering section A".** The cello performance will primarily be involved in giving rise to **different kinds of amplitude modulations** (beats, roughness, phantom glides) **and pitch/chord shifts with respect to the audio feedback.**

-Section A"' starts when the amplitude sliders are no longer fixed, but shifting. Now **you control them through the amplitude, noisiness and resonance of your sound.**
You can see on your screen 3 chained levels of gain and compression.

The upper part distributes your sound in **2 channels, higher amplitudes increasing channel 1 and softer amplitudes increasing channel 2 (channel 1 coming from the feedback microphones, channel 2 from the cello pickup).** The mid gain level depends on the resonance of your sound. The final gain level boosts channel 1 the more your sound is periodic, and vice versa boosts channel 2 the more your sound is noisy.
In this way the balance of feedback vs. soft cello-noises constitutes an added control to the previous activities of sections A' and A''.

-Each new section does not substitute modules or qualities of interaction: it just adds a new means of control. No special music patterns nor music languages are suggested, the cello sounds will be focused on the concept of interplay and modulation.
Melodic and ornamental cello patterns can be performed by alternating as a foreground with the other sound components of the interaction.

-Section B triggers the **audio file** (developing in embedded contrasting sections containing recorded audio feedback). Some preselected noisy portions of the file are to be output through impulsive bow movements in the air.
Different **file fragments** are output through different directions of impulsive bow rotations (see the last section "bow interactions").

The tape must be accompanied by the cello improvisation. The gains of the live sources are again fixed in order to output a reduced portion of audio-feedback.
The stereo components of the audio file are spatialised through bow-tremolo (stereo right portion) and bow rotation (stereo left portion).
The overall amplitude of the file increases proportionally to the global velocity of the bow.

Details about the interactive controls can be explored by navigating inside the internal commented modules of the application.

-At the end of the tape **section C** starts (you can notice the transition also by looking at the tape sound monitor on the right). A system of 4 parallel tap-delays scatters all the sounds, while the audio feedback emerges again. The sound sources most actively involved in this scattering sound process are the **audio feedback, cello percussive-noisy-aggressive sounds, the tape fragments** (still enabled despite the end of the main tape diffusion).

The delay lengths individually increase in response to the intensities of your bowing styles (*Tremolo, Staccato, Balzato, rotation*).

-Final fade out.

SOUND SOURCES

-1) The four input microphones are subdivided into cello and feedback input couples.

Cello inputs:

-DPA (Microphone_1 “cello-mic”) focuses on cello full sound, in part mixed with the Speaker_1 feedback.

-pickup (Microphone_3 “cello-pick”) in particular amplifies and enhances low-amplitude cello noises, which feed channel 2

Feedback inputs:

-Microphone_2 (“mic2”) mainly picks up the feedback coming from the cello sound-hole (low frequencies) and/or any resonance/interference coming from the closed cello placement.

-Microphone_4 (“mic4”), the most distant from the cello, is mainly involved in the feedback coming from Speaker_2 (higher frequencies).

The ensemble of cello/microphones/stage-speakers is a partially predictable analogue circuitry, whose complex interactive sound response (comprising the audio feedback) is naturally mixed because of their close distances, and in which inputs and outputs therefore feed each other.

-2) Each input follows an individual treatment in terms of filtering.

The cello inputs are autonomously enhanced/compressed and equalised

The feedback inputs are filtered respectively Low-pass and Resonant with cut-off depending on the current cello fundamental frequency.

The main inputs are routed in 2 channels: the 1st enhancing feedback, and the 2nd enhancing noisy/high-frequency soft cello sounds.

-3) We therefore have 3 groups of sound sources:

-direct sources (the 4 microphones);

- 2 channels of enhanced sources, plus 2 channels of filtered sources

- stereo tape, plus 2 channels of tape fragments

Section A is mainly involved with the 2nd group (enhanced/filtered sources).

Section B is focused on the 3rd group (file sounds) with the addition of the 2nd group.

Section C is an overall mix.

BOW INTERACTIONS

The bow gestures act indirectly as digital controllers: the gestures can be impulsive (triggers) or continuous (shapes). As detailed inside the above Fig. 10 the system interacts through:

-4 rotational and 1 horizontal triggers

-Orientation (vertical and horizontal)

-Energy (quickness and rotation)

-Styles (tremolo and balzato)

The continuous bow movements affect the spatialisation (circular movements of the output sound sources around the audience space).

These movements can be more effective when performed in the air, but they are active also when the bow interacts with the strings, while playing the cello normally.

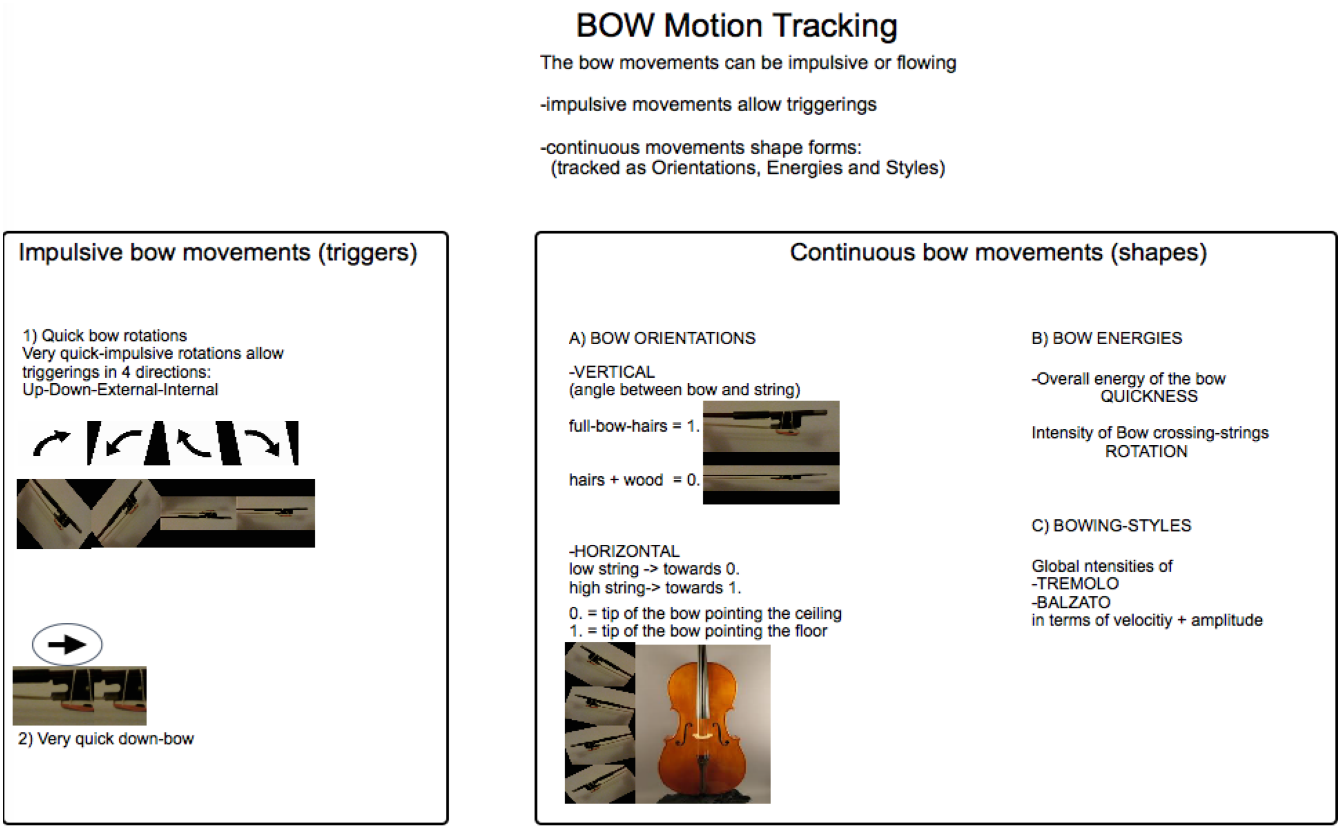


Fig.10-K_4 Bow as a digital controller

Through **Horizontal and Vertical Orientations**, the bow spatializes the 2 main direct sources (“mic4” and “cello-mic”): the microphone close to speaker_1 and the cello DPA.

Through the **intensities of *Tremolo* and *rotation***, the bow spatializes the 2 channels of enhanced signal (“fb1” and “fb2”): respectively the most influencing part of the audio feedback and the small cello noises.
The 2 channels of the stereo tape are spatialised in the same way.

Through the **intensity of *Balzato***, the bow spatialises the file fragments, and the 2 channels of filtered inputs (“filt1” and “filt2”).

Impulsive bow *rotations* in the directions Up-Down-Internal-External trigger different portions of tape fragments during sections B and C.

A very quick down-bow (preferably performed in the air, since more powerful as a gesture) freezes the values of horizontal and vertical bow orientation at the moment of the triggering.
These orientation values affect the speed and transposition of the audio fragment when it is triggered. (see inside the module “seeking” for more details).

MOTION TRACKING

Inertial Motion Tracking is tested with the Orients_15 System, developed by the Centre for Speckled Computing of the University of Edinburgh, [2] running through the orientMac application.This application and the related Readme.txt document are contained in the main folder of this software.
The system needs a native Bluetooth 4 Mac version as minimal requirement.

A different Motion Tracking system is allowed by substituting the abstracion “or_data” with a different OSC udpreceive module, which must contain proper scaling and normalisation.
Details are given inside the module “or_data” and in the Readme text file.

SOFTWARE

K-Message_1
MAX/Msp 6.1 or *K_1-GESETZ* standalone application

LIST OF EXTERNALS AND ABSTRACTIONS

ambiencode~, ambidecode~, ambimonitor (Jan Schacher)
http://trondlossius.no/articles/743-ambisonics-externals-for-maxmsp-and-pd

banger (Peter Elsea)
http://peterelsea.com/lobjects.html

bonk~ (Millar Puckette et al.)
http://vud.org/max/

chroma~ (Adam Stark)
http://c4dm.eecs.qmul.ac.uk/people/adams/chordrec/

f0.fold (Fredrik Olofsson)
http://www.fredrikolofsson.com/pages/code-max.html

ftm, ftm.copy, ftm.mess, ftm.object,
gbr:fft, gbr.slice~, gbr.wind=, gbr.yin,
mnm.delta, mnm.moments, mnm.onepole,
FTM-Gabor library (Norbert Schnell et al.)
http://ftm.ircam.fr/index.php/Download

fiddle~ (Millar Puckette et al.)
http://vud.org/max/

---

[2] www.specknet.org

fog~ (Michael Clarke and Xavier Rodet)
http://eprints.hud.ac.uk/2331/

gf (Frederic Bevilacqua et al.)
http://forumnet.ircam.fr/shop/en/forumnet/59-mu.html

M4L.gain1~, M4L.delay~ (abstractions)
https://cycling74.com
multiconvolve~ (Alex Harker and Pierre Alexandre Tremblay)
http://www.thehiss.org/

imubu, mubu, mubu.granular~, mubu.knn, mubu.process, mubu.track,
readaptation of the abstraction mubu-mfcc-matching
pipo~ (IRCAM IMTR)
http://forumnet.ircam.fr/shop/en/forumnet/59-mu.html

roughness (John MacCallum)
readaptation of the abstraction rzcalib (Michael Zbyszbynski)
http://www.cnmat.berkeley.edu/MAX

sadam.stat (Ádám Siska)
http://www.sadam.hu/en/software

supervp.trans~ (IRCAM Analysis/Synthesis Team)
readaptation of SuperVP.HarmTransVoice
http://forumnet.ircam.fr/product/supervp-max-en/

zsa.flux~ (zsa.easy_flux) (Mikhail Malt, Emmanuel Jourdan)
readaptation of the abstraction zsa.consonant tracking
http://www.e--j.com/index.php/download-zsa/

K-Message_2
MAX/Msp 6.1 or *K_2-INDIAN* standalone application

LIST OF EXTERNALS AND ABSTRACTIONS

ambiencode~, ambidecode~, ambimonitor (Jan Schacher)
http://trondlossius.no/articles/743-ambisonics-externals-for-maxmsp-and-pd

bonk~ (Millar Puckette et al.)
http://vud.org/max/

chroma~ (Adam Stark)
http://c4dm.eecs.qmul.ac.uk/people/adams/chordrec/

dot.smooth, dot.std (Joseph Malloch et al.)
http://idmil.org/software/digital_orchestra_toolbox

ej.line (Emmanuel Jourdan)
http://www.e--j.com

f0.fold, f0.round (Fredrik Olofsson)
http://www.fredrikolofsson.com/pages/code-max.html

fiddle~ (Millar Puckette et al.)
http://vud.org/max/

ftm, ftm.copy, ftm.list, ftm.mess, ftm.object,
gbr.bands, gbr:fft, gbr.resample, gbr.slice~, gbr.wind=, gbr.yin,
mnm.list2row, mnm.moments, mnm.onepole, mnm.winfilter
FTM-Gabor library (Norbert Schnell et al.)
http://ftm.ircam.fr/index.php/Download

fiddle~ (Millar Puckette et al.)
http://vud.org/max/

imubu, mubu, mubu.concat~, mubu.granular~, mubu.knn, mubu.process, mubu.record, mubu.re-cord~,mubu.track, pipo~
readaptation of the abstraction mubu-mfcc-matching (IRCAM IMTR)
http://forumnet.ircam.fr/shop/en/forumnet/59-mu.html

roughness (John MacCallum)
http://www.cnmat.berkeley.edu/MAX
K-Message_3
MAX/Msp 6.1 or *K_3-ODRADEK* standalone application

LIST OF EXTERNALS AND ABSTRACTIONS

chebyshape~ (Alex Harker)
http://www.alexanderjharker.co.uk/Software.html

ej.line (Emmanuel Jourdan)
http://www.e--j.com

f0.fold (Fredrik Olofsson)
http://www.fredrikolofsson.com/pages/code-max.html

ftm, ftm.list, ftm.mess, ftm.object,
gbr:fft, gbr.harm, gbr.slice~, gbr.wind=, gbr.yin,
mnm.alphafilter, mnm.list2row, mnm.list2vec, mnm.onepole, mnm.winfilter
FTM-Gabor library (Norbert Schnell et al.)
http://ftm.ircam.fr/index.php/Download

fiddle~ (Millar Puckette et al.)
http://vud.org/max/

ircamverb~ (IRCAM Espaces Nouveaux)
http://forumnet.ircam.fr/product/spat-en

list-interpolate, resonators~, res-transform, sinusoids~, (Adrian Freed)
delta (Matt Wright, Michael Zbyszynski)
roughness (John MacCallum)
http://cnmat.berkeley.edu/downloads

sigmund~ (Millar Puckette et al.)
http://vud.org/max/

yin~ (Norbert Schnell)
http://imtr.ircam.fr/imtr/Max/MSP_externals

K-Message_4
MAX/Msp 6.1 or *K_4-TREES* standalone application

LIST OF EXTERNALS AND ABSTRACTIONS

dag.statistic (Pierre Guillot)
http://www-irma.u-strasbg.fr/~guillot/

ej.line (Emmanuel Jourdan)
http://www.e--j.com

f0.distance, f0.round (Fredrik Olofsson)
http://www.fredrikolofsson.com/pages/code-max.html

ftm, ftm.list, ftm.object,
gbr:fft,, gbr.slice~, gbr.wind=, gbr.yin,
mnm.alphafilter, mnm.delta, mnm.list2col, mnm.list2row, mnm.list2vec, mnm.moments, mnm.one-pole, mnm.winfilter,
FMAT and Gabor library (Norbert Schnell et al.)
http://ftm.ircam.fr/index.php/Download

multiconvolve~ (Alex Harker and Pierre Alexandre Tremblay)
http://www.thehiss.org/

OSC-route (Matt Wright)
http://www.cnmat.berkeley.edu/MAX

pipo (IRCAM IMTR)
http://forumnet.ircam.fr/shop/en/forumnet/59-mu.html

quat2car (freeware)
http://www.mat.ucsb.edu/~wakefield/soft/quat_release.zip

spat.oper, spat.spat~ (IRCAM Espaces Nouveaux)
http://forumnet.ircam.fr/product/spat-en

INDEX

LIST OF FIGURES

Awakening

Interactive harp quartet

Dedicated to the Adria Harp Quartet
First performance FORFEST,
Kromeritz (Czech Republic)
June 23rd 2014
Duration 10'

Video instructions at: https://www.dropbox.com/s/gcv3jjseuzetfu2/Awakening-instructions.mp4?dl=0
Studio recording at: https://soundcloud.com/nicola-baroni/awakening
Video recording at: https://youtu.be/gasFAG5QilY

PRESENTATION

CONCEPT

The idea of shaping music as if it were an organic form whose different articulations interleaves and grow similar to a living entity could be viewed as a post-romantic heritage. On the other hand this concept was traditionally related to the development of a drama, where the actions of imaginary or abstract characters are codified within a score.
These structural relationships should be eventually felt as evolving sounds recalling one another in the time domains of performance and attentive listening.

The interactive quartet Awakening is conceived as a concrete living organism, where there are no special focus points on its history and its future, and in fact no scores are fixed.
The living interaction is made of sounds, actions, functions and symbols seeking for balance and actual boundaries with respect to their environment.
The performers are the actors of this search for an identity of the **living sound system, which is driven by the music-social intentions of the ensemble.**

PRELIMINARY NOTE

Each harpist, specified as Harp_1, _2, _3 and _4, has a specific role inside the interaction. The detail of the following presentation is essential for the musician dealing with the overall setup, installation and concert location. This responsibility can be assumed by the composer, by an external sound engineer, or else by one or more members of the ensemble.
Technical notes are given at page 24.

The conceptual involvement of Harp_1 and _2 requires the knowledge of this presentation, which could be in part skipped by Harp_3 and _4, going directly to the general and individual performance notes.

INSTRUMENTS

The harps are amplified and live processed. The position on stage requires Harp_1 and _2 to be **placed at a certain distance** from Harp_3 and _4 (4 meters approximately) in order to avoid the sound interference of the microphones coming from the opposite couples of players.

Three harps are required, since Harp_2 only interacts with the resonances of the neighbouring instrument (Harp_1).

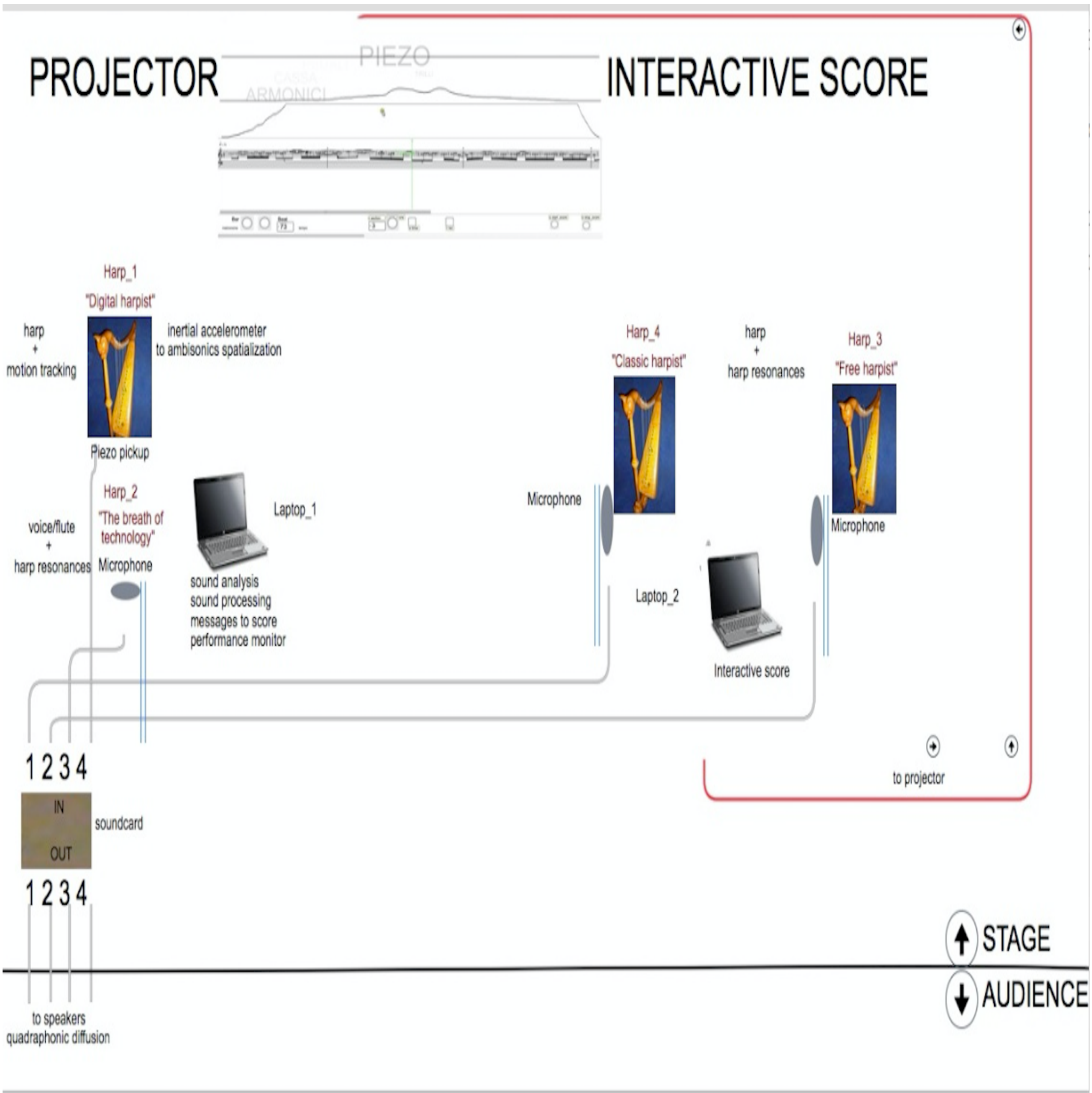


Fig.A_1 Arrangement on stage

COMPOSITION

ACTIONS

The piece is conceived as a harp quartet, but "Harp_2" doesn't need to be a harpist (in a sense she is more a composer rather than an instrumentalist) even if she interacts with the harp.
The composition could be seen as a harp trio plus flutist/vocalist.

Harp_1 ("Digital Harpist") plays**:**
-**single notes** in order to digitally select the sound effects of the live electronics.
-**soft passages** allowing for electronic depth to the sound, shaping electro-acoustic nuances.
-an IMU **sensor worn on the left hand** through which the electronic sounds are spatialised.
Harp_2 ("The Breath of Technology") never truly plays the harp:
-**initially she scans the harp resonances,** shifting the microphone near their nodes on the surface of the instrument body, producing modulated audio-feedback.
-during the following sections she **performs voiced/noisy sounds with her voice or any wind instrument** (with the exclusion of reed instruments), in order to shape the electronic timbres.
Harp_3 ("Free Harpist"):
receives an **animated graphic score** interactively upon which to improvise.
Harp_4 ("Classic Harpist"):
receives **interactive scores in pentagram** and common notation to sight-read.

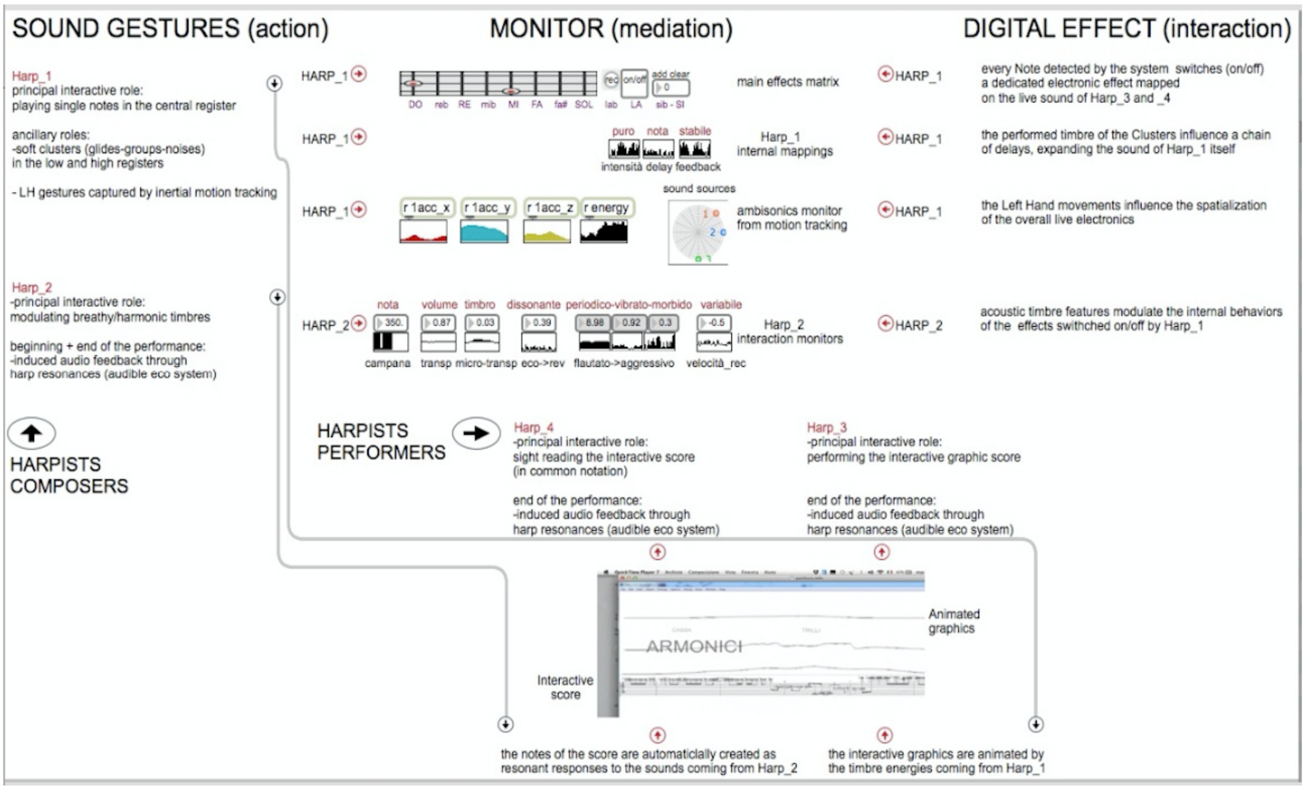


Fig.A_2 Schema of the interactions. On the left the actions performed by Harp_1 and _2 (composer-harpists).
The central part resumes the monitor interfaces and functions as they appear on the harp laptop screens.
On the right an essential description of the digital interactions connected to the relative actions.
The bottom part shows roles and scores of Harp_3 and _4 (performer harpists).

SCORES

Harp_1 and _2 share the graphic interface contained in Laptop_1.

The laptop has to be positioned in a music-stand fashion in order to be visualised by both players.

The upper part of the screen (monitors and annotations) only regards Harp_2.

The middle part of the graphic interface shows the actions performed by Harp_1: the actions called "points" (single notes) are especially in evidence as on/off functions relevant to both players.

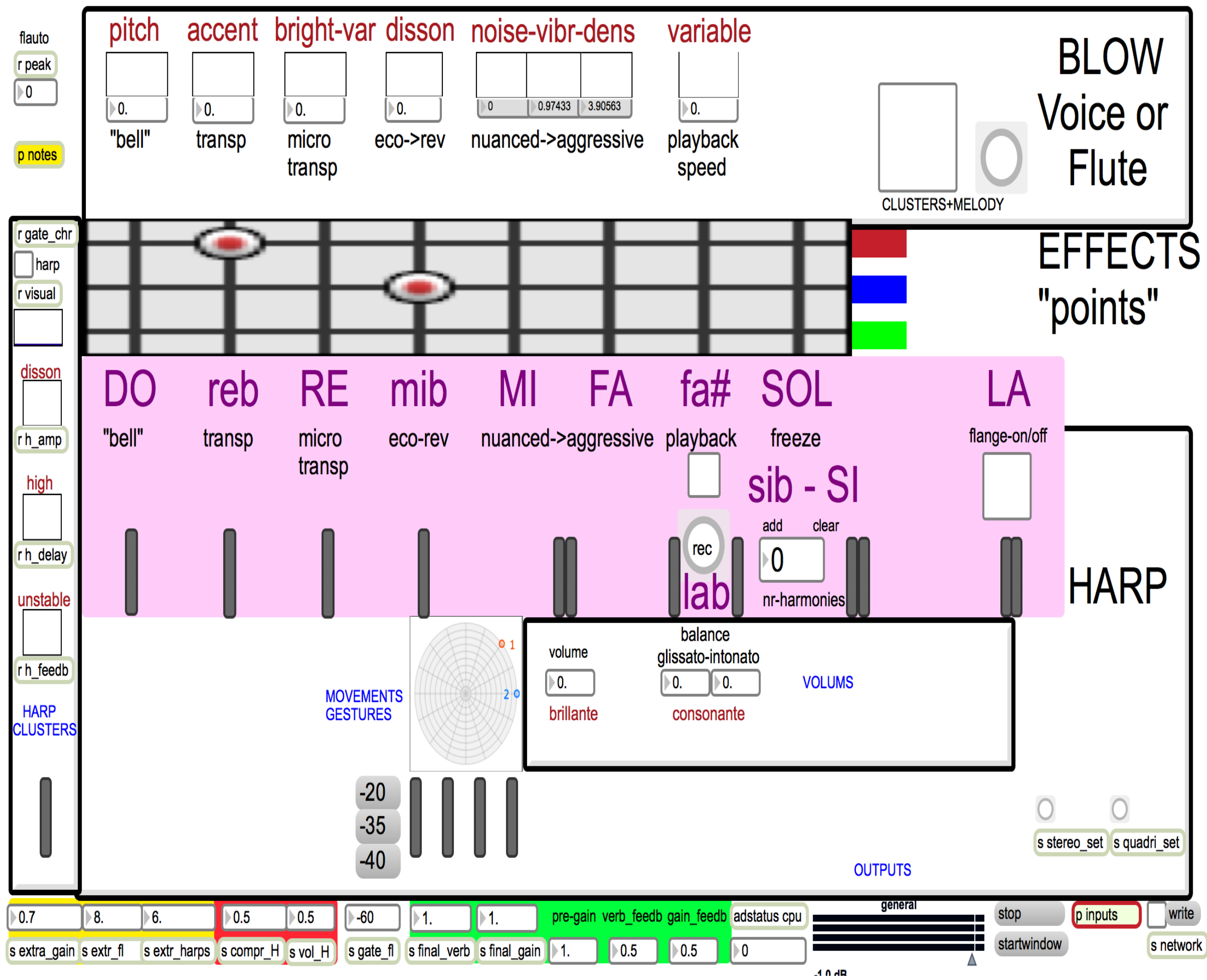


Fig.A_3 Screen interface as it appears on Laptop_1 (interactive monitor for Harp_1 and _2).
The upper part regards Harp_2 (voice/flute): it monitors the timbre analysis of the "blows".
Just below is the matrix called "effects", the mid-low part ("arpa") is the interface of Harp_1.
At the bottom all the settings.

Harp_3 and _4 share the interactive screen of Laptop_2
(receiving messages from Laptop_1).
This laptop too has to be positioned and well visualised by the both players.
The upper part contains the graphic-verbal animated score for Harp_3.
The middle-lower portion contains a pentagram for Harp_4.

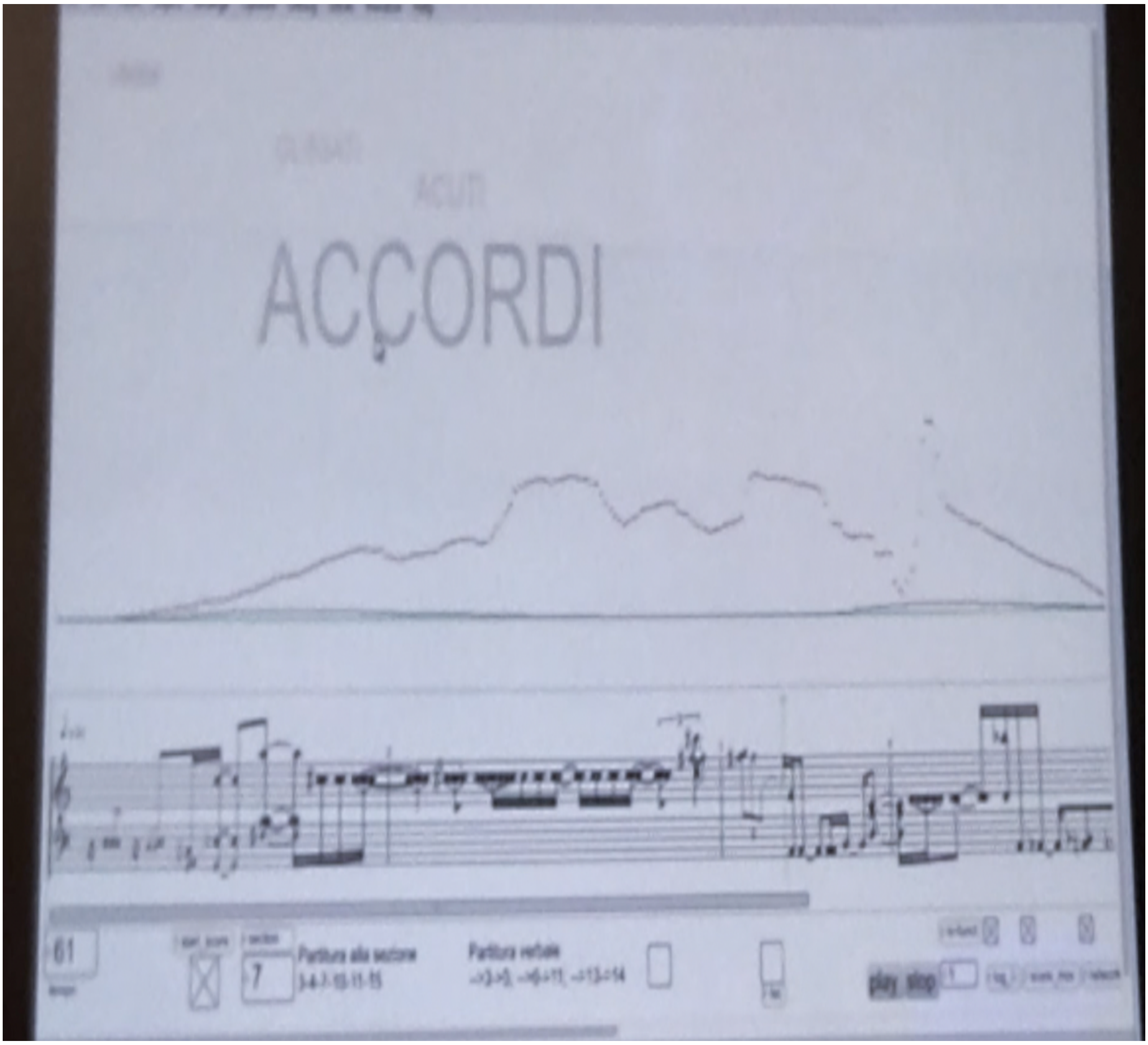


Fig.A_4 Screen of Laptop_2. At the top the verbal-graphic animated score for Harp_3, just below the interactive score for Harp_4. At the bottom variable BPM, number-section advance, various settings.

The lower part of both screens shows preliminary settings.

TIME DESIGN

Harp_1 and _2 (“Harpist-composers”) improvise, but strictly interacting with the software functions and monitors. Harp_3 and _4 (“Harpist-performers”) perform the interactive scores.

A complex net of synchronised changes are automated inside the software.

These hidden agencies, coordinated with an internal timeline, show the performers the essential time-event-signals and interactive trajectories.

The composition, as if it were a sound installation, maintains an internal consistency upon which the performers build their own strategies of interaction.

The designed time segmentation of the music (**10’** as a default, but changeable inside the internal settings) produces **two complementary states**.

TIME-SPACE DEVELOPMENT

<u>**Beginning and conclusion** (“peripheral body of interaction”).</u>

Audible eco-system.

The performers reveal the natural resonances of the harps through microphone-scanning.

The induced audio-feedback between instruments, technical equipment and room creates ghost-pitches showing that the audible space doesn’t correspond to the visual boundaries between stage and audience.

<u>**Central part** (“central body of interaction”).</u>

Social-digital composition.

The initial audio-feedback ostensibly grows and interleaves in a collective composition digitally mediated. The ensemble splits itself into two complementary entities of composers and performers. The combined musical actions of two harpists (Harp_1 and _2) generate and control the live electronics fed by the sound of the other two harpists (Harp_3 and _4).

In addition the sounds of the two harpist-composers are “interpreted” by the software and are sent as interactive scores to the couple of sight reading harpist-performers.

AUTOMATED PERFORMANCE

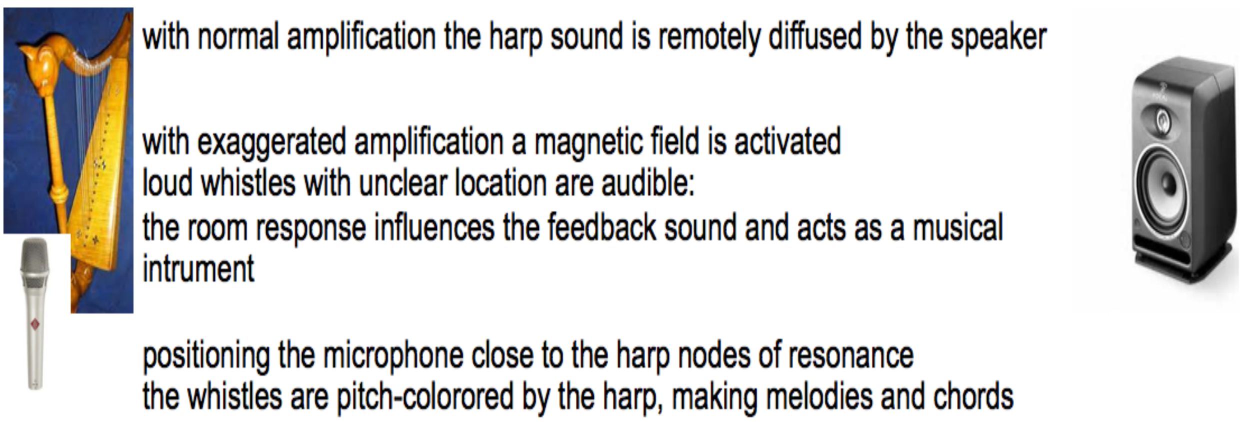


Fig.A_5 Performing the acoustic feedback

Beginning-conclusion.

The transitions between the two states of performance (the Audible eco-system and the Digital-social interaction) are technically realised through cross-fading amplitude gains of the input microphones.

The audio-feedback is obtained by a chain of variable exaggerated gains operating upon the single microphones (and compressed in order keep the whistling sounds inside a meaningful not disturbing range).

This extra-gain is synchronised with a message telling the interested performer to stand up, take off the microphone from the stand and start moving it around the harp. **By approaching with the microphone the main nodes of resonance inside the body of the instrument, the natural resonances of the harp are revealed, pitch-colouring the audio-feedback.** When the central digital interaction starts, the gains automatically return to their normal levels.

Central part

During the central digital interaction the software mediates the human actions through sound analysis: it recognises and monitors features and patterns of the acoustic sounds of Harp_1 and _2.

These **two harpist-composers,** reading the monitor-analysis of their own sounds, are allowed to interact with the live electronics machine. In this way **they choose and influence the types and nuances of the sound treatments upon the live sound of Harp_3 and _4,** gaining the power to shape the overall performance.

In addition, by "listening" to the sounds of Harp_1 and _2, the software transforms their sounds into messages and symbols, sent as animated scores to Harp_3 and _4:
a symbolic resonance of the sounds invented by Harp_1 and _2.

The composer tradition to codify on paper a successful improvisation is rendered in real-time on stage, allowing for a social creative interaction.

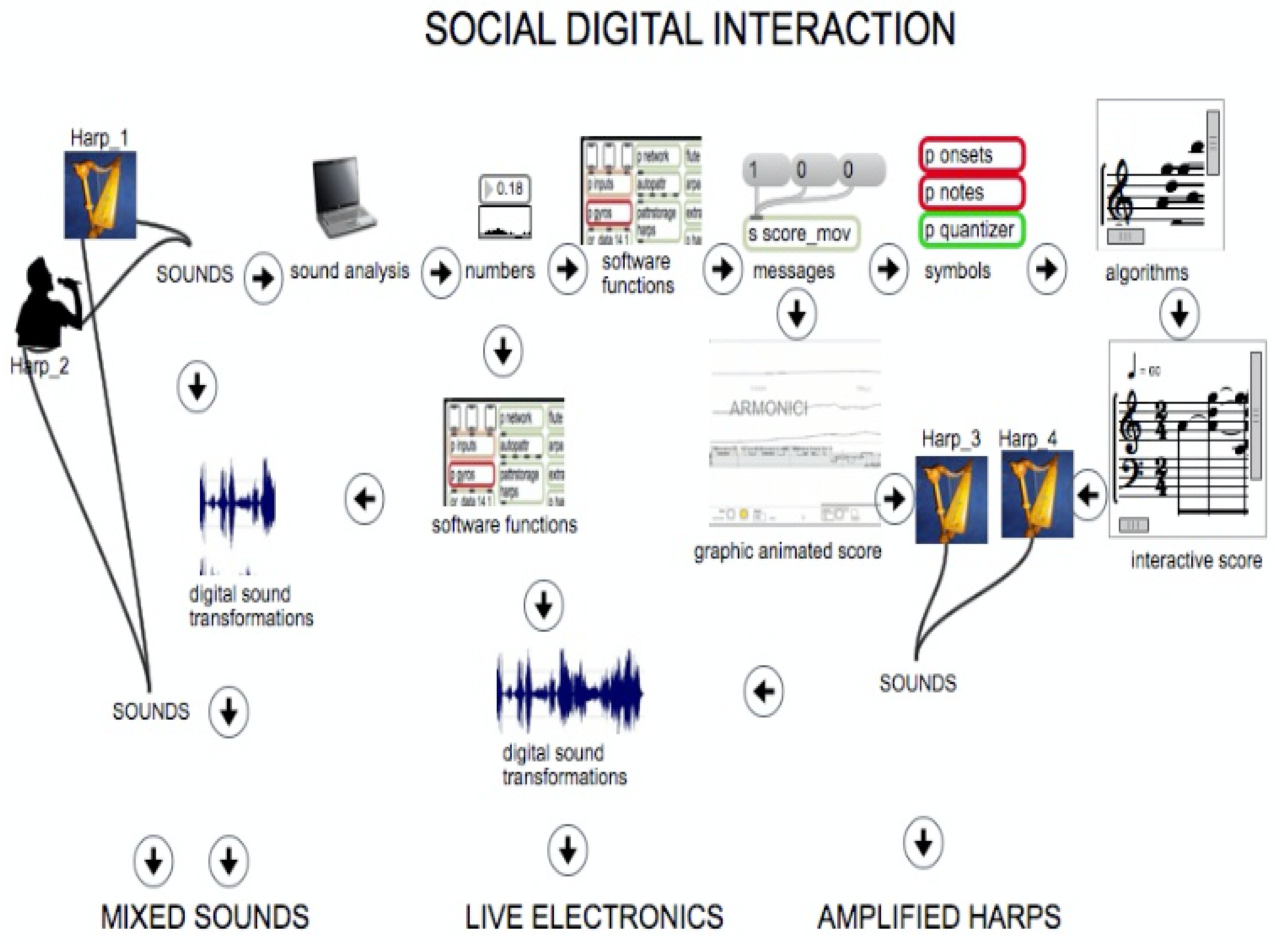


Fig.A_6 From sound to interactive functions, to scores, to digital processing, to socially mediated music

AWAKENING

Awakening is the process through which the subtle energies of life, present inside our body, empowers and harmonises our physical, mental and emotional dimensions through the spiritual practice of Yoga (whose meaning is union). The opening comparison of this harp quartet with a living organism is justified by its physical origin inside sound gestures and natural resonances. The performance arises from the extra-energy of the environmental audio-feedback. On the other hand the mental-symbolic dimension of the scores is treated as a dynamic part of a collective search for balance.

The non obvious boundaries of the interaction are performed through circles of opposites.

-Sound as it is perceived vs. Sound as it is computed through models of analysis
-Physical agency (sound gestures) vs. Symbolic resonance (scores)
-Musical gesture (instrumental note/timbre) vs. Electro-acoustic sound
-Technology vs. Environment
-Improvisation vs. Composition in real-time
-Concert-based music vs. Sound installation

TIME SEGMENTATION

TIMELINE
(automatic)

0'00"	Harp_2 harp resonances	microphone scanning	extra gain for Harp_2 microphone	
1'00"	first messages sent from Harp_2 to Harp_4	1st pentagram score	Harp_1 enables the effects playing notes	RESONANCES
2'00"	Harp_2 stops scanning the harp and performs (voice/flute/wind)			
2'00" -> 7'00"		complete digital interaction	Live electronics and score messages from Harp_1 and _2 to Harp_3 and _4	DIGITAL INTERACTION
7'00"	Harp_3 and Harp_4 start scanning harp resonances	mix of resonances and digital effects	extra gain fade-in for Harp_3 and _4, digital effects still enabled	
8'00"	Harp_2 joins _3 and _4 scanning resonances Harp_1 stops playing, stands up only spatializing	ensemble of resonances no more digital effects	all gains very high resonances are still moved in space by Harp_1	RESONANCES
9'00"		from sound to empty gestures	overall gain fade out	
10'00"		end		SILENCE

Fig.A_7 The piece starts with pure harp resonances, and gradually fades in the central digital interaction. From minute 7', at different times, the performers receive from their laptops a signal indicating the reprise of the resonance-scanning activity.

0''00" -> 1'00" Harp_2 starts to scan the harp resonances with the microphone; the other harpists are silent, with the microphones muted.

1'00" -> 2'00" Harp_4 receives a first score; when she starts playing, this is the signal to **begin the interaction of Harp_1;** when Harp_3 receives the first score and starts playing, **Harp_2 positions the microphone in the stand and proceeds with the central part of the interaction**[3].

2'00" -> 7'00" Central body of the digital interaction: **Harp_1 and _2 drive the composition in real-time, Harp_3 and _4 are receiving the scores.**

7'00" -> 10'0" Progression of fading out, gradual transition from the digital interaction to the **ensemble scanning of the harp resonances. Harp_3 starts,** then Harp _4, and finally Harp_2.

The action of leaving the previous position and grabbing the microphone for the scanning process is signalled by messages inside the laptop interface.
When everybody is scanning, Harp_1 stops playing and limits the activity only to spatialisation, until all the microphones fade out to silence.
The interaction finishes after a short time of silent gestures.

[3] The scores are received at fixed times, routed through an automatic timeline

GENERAL PERFORMANCE NOTES

PERFORMER ROLES

The production of the audible eco-system (harp resonances) involves Harp_2, _3 and _4 (see following performance notes).

The central digital interaction requires an amount of conceptual involvement by Harp_1 and _2 (the "Harpist-composers"): it justifies the dense detail of the following individual explanations.

The verbal notes for Harp_3 and _4 will be much lighter, since a great deal of the performance instructions is embedded inside their actual interactive scores: in this sense their performance styles are essentially those of classical players involved in contemporary music and graphic-score interpretation.

REHEARSALS

Some preliminary section rehearsals by Harp_1 and _2 are suggested before meeting the whole ensemble.

A previous individual training of Harp_1 and Harp_2 with the system is recommended (these "harpist-composers" should have an overall knowledge of the above presentation).

Load the patch "Awakening" in Laptop_1

1) Pressing the Spacebar the full rehearsal and performance starts (and Laptop_2, if connected by Ethernet, will react in its settings-mode).

2) When the piece is finished press Enter (close and reopen the patches before a new take).

3) Press the keyboard key A for "Section rehearsal", key B for "Harp_1 training", key C for "Harp_2 training", in the case of a study session.

4) During a full rehearsal, you can press the keyboard 2 for "Start from min2" or key 7 for "Start from min7", if you want to rehearse only a part of the composition.

HARP RESONANCES

A too high amplitude of a microphone can instantiate a magnetic field involving proximate loudspeakers, and creating an audio-feedback effect. As a result some standing waves (whose frequency depends on distance, angle, room response and equipment specs) form a generally disappointing group of fixed whistles. This effect is exploited in a controlled fashion, through a chain of variable extra-amplitude and compressors: positioning the microphone close to special nodes of the harp surface (or inside the holes of its body), specific harp modes of resonance start to influence the pitch and the amplitude of the audio-feedback. This effect, when hybridised by digital processing, was called audible eco-system[4], since it involves the natural interferences of technology and environment, in our case with the contribution of the resonant body of the harp. During the normal setup your microphone is positioned on its stand and the sound gain is at a neutral level. When you are requested to produce the eco-system, the software automatically raises the input amplitude of your mike, and you should be able to feel a sort of sound-magnetic field.

After the start signal, grab the microphone in your hands, approach it to the harp, and perform creatively following these general suggestions.

1) **Find the most interesting pitched nodes of resonance of your harp,** generally the result is more effective near to the curved shapes of the body (see video instructions).
2) **By positioning the mike closed and towards the base,** near the lower strings, and **very slowly moving it** towards the middle part of the strings and/or towards the low-middle pitch register of the instrument, some chords can be produced.
3) By **scanning with the microphone the holes** in the back part of the column, or inside the pedal holes, you can gain powerful sounds, but there is a possibility of exaggerated and distorted effects, here the performance has to be extremely careful.
4) You are advised not to hold the microphone too far from the harp, otherwise the effect could interfere with the noisy components of the environment and fall out of control.
5) It is important to **intuitively find the true boundary of the magnetic field**: if the mike is removed too quickly from the harp proximity, the wave could disappear, but moving it one millimetre too close the sound could be distorted: find a good feeling and balance in your gestures.
6) The audio-feedback standing wave takes time to emerge and stabilise: sometimes you have to wait for it, with the mike still and close to the chosen nodal point (maybe you have to wait longer than you could expect). When the whistle begins, it is better to immediately distance it by about 1 cm. in order to avoid an uncontrolled sharpening of the effect: the movements around the sound boundaries should be characterised by **specific patterns of acceleration/ deceleration,** you can "tune" your gestures by listening after some rehearsals.
7) When you decide to reach a different node (searching for a different pitch), **move the mike slowly** and keep it inside the boundary of resonance (a correct distance, which you feel by careful listening and soft airy gestures), otherwise the resonance disappears and you miss the opportunity to shift the pitch.

---

[4] Agostino Di Scipio, Contemporary Music Review, 33:1, 2014.

DIGITAL INTERACTION_INDIVIDUAL NOTES

HARP_1

The contribution of Harp_1 is crucial in designing the macro-form of the music.
During the time of the performance Harp_1 chooses which effects are acting and in which sequence. The density of the electronics (the kinds and the number of effects working in parallel) are extremely important for shaping the music well in terms of variety, tension and interest.

Harp_1 is a hyper-harp: the way she makes music is sensed by the software (through sound analysis), and directly affects the live electronics.
In addition one accelerometer is fastened to the left hand in order to drive the spatialisation.

Vocabulary

1) POINTS (single detached notes);
2) CLUSTERS (soft glides and note-groups);
3) GESTURES (rotational movements in the air with the left hand wearing an accelerometer)

-1) Points: every note clearly detected by the system has the role to open and close a single attached effect of the live electronics (transforming the sound of Harp_3 and _4).
-2) Clusters: improvised patterns of soft and continuous timbre commentaries performed in contrasting pitch registers: they diffuse electronic sound-copies of what Harp_1 is playing (*delays* effect)
-3) **Gestures:** orientation and speed of the left hand affect the **final spatialisation.**

Time

0’00” -> 1’00” No sound, only spatialisation through **Left Hand rotations**

1’00” (Harp_4 starts playing)

1’30” The “Points-matrix” is enabled:
play *Points*, not yet *Clusters*

2’00” -> 7’00” (Harp_2 take place in front of the microphone): **full interaction.**

7’00 -> 8’00” (Harp_3 and _4 start scanning the resonances):
play *Points*, no more *Clusters*.

8’00 -> end (everybody is scanning the resonances),
stand up, stop playing, only spatialisation through Left Hand rotations.

Points

The central part of Laptop_1 is the graphic monitor of the sound actions called *Points*.
You can see on the screen many virtual buttons (red points and crossed buttons mean that the effect is turned on).

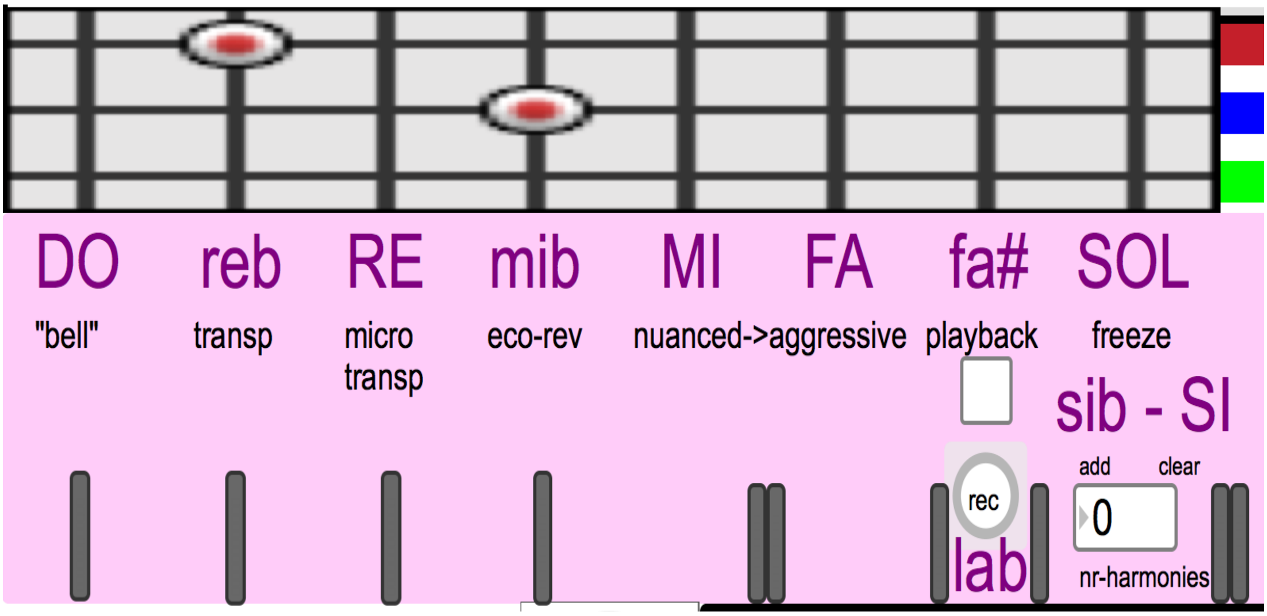


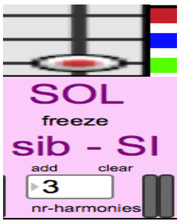
Fig.A_8 The “Points-matrix”: the effects-console of Harp_1

-Any note you perform, if played alone and detached, can be clearly detected by the system, which activates a related sound effect.
-The notes are intended as pitch classes, therefore tracked independently by their octave: generally they have the function to open or close one effect.
-When you play a note the effect is opened, on repeating the same note the effect is closed (the note B is the only exception).
-It is possible to open many effects together in order to increase the density of the live electronics; when all the effects are closed, only the acoustic sound of the harps will be heard.
-The notes are better detected if they are **in the mid register:** avoid high and low pitches if you need a precise control.
- The name of each note is present on the screen near to the on/off monitor and the name of the related sound transformation (which affects the sound of Harp_3 and _4).

Even if the machine note detection is quite responsive and accurate, it can happen that some unwanted notes ("false positives") are captured by the system (especially in the middle part of the performance, when many notes are performed by the other players!), in this case probably some efforts will be needed in closing unwanted effects.
A sort of tolerance towards this independent behaviour of the machine makes the interaction more interesting, obviously if the false positives are not in excess. In this sense the computer is more a "composer assistant in real time" rather than a strict instrument.
It is extremely important that Harp_1 reaches a clear perception of the difference between every sound effect, as shown by the video instructions.

List of the connections

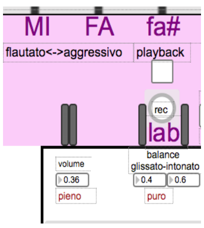
Note C	ring modulation	bell-like effect
Note C sharp	transposition	pitch glides, inside the range of a major third
Note D	micro-transposition	microtonal glides and beats
Note E flat	delays	effect of multiplying the most recent sounds
Note E	spectral decomposition 1	split the sound in its noisy vs. pure components
Note F	spectral decomposition 2	similar, but more harmonic effect
Note F sharp	playback	playback of a live recorded fragment (A flat -> record)
Note G	spectrum-freeze	enables freezing the sound (as it is at that moment)
Note A flat	recording	records the last 2 and ½" of sound (F sharp -> playback)
Note A	flanger	extreme artificial vibrato modulation (electric-guitar effect)
Note B flat	add-harmony	adds one layer of freezing, a new fixed harmony
Note B	clear harmony	clear the all freezes harmonies



On playing G the freeze is only enabled.
After enabling, play B flat when you want make a sound, every new B flat adds one more sound creating a fixed harmony.
Play B when you want to silence the harmonies (a small number tells you how many harmonies are playing).

Fig.A_9 Freeze

A few more interactions (less important to be fine-controlled)
Notice that Harp_1 only activates the effects, which are instead internally modulated by Harp_2. The only exception is the Flanger (activated by the note A), which is modulated by you: take it easy and be intuitive!
But you may notice that:
-the brightness of your sound adds artificial pitched-colour to the flanging,
-when your sound is very resonant, it increases the presence of the effect,
-your high pitches increase the flanger vibrato-reactivity,
-impulsive quick movements of the left hand dramatically increase the reverb of the effect.



The effects called "spectral decomposition", activated by E and F note detection, can sound extremely harsh (noisy) or very subtle (pan-flute-like) depending on the performance of Harp_2. You can influence the volume of these effects (if you feel the need to better balance these sounds):

Fig.A_10 Volumes

-Low volume <- soft/touching sounds in the middle of the string, or leaving the harp free to resonate.

-High volume <- aggressive/brilliant sounds.

You can also influence the playback module (effected by the F sharp): the more your sound is consonant ("puro"), the less the playback will be transposed (probably the *Clusters*, since dissonance will produce many pitch transpositions in the playback).

It is not necessary to pay close attention to the fact that your sound creates the graphic score of Harp_3, just note that:

- the more numerous the effects opened by your notes (the *Points*), the greater the quantity of overlapping instructions to Harp_3 (no *Points* opened, no verbal instructions to Harp_3).

-the energy of your sounds impact the dynamic animation of the score.

Clusters

Harp_1 alternates the single-note performance with some improvised passages, characterised by timbre density, very soft intensity, blurred pitch contents, and very low, or by contrast, very high pitch registers (they shouldn't affect the note detection):

-soft glides inside narrow-band pitch contours,

-trills,

-soft scale-like passages with grace notes,

-slow nail vertical scratches,

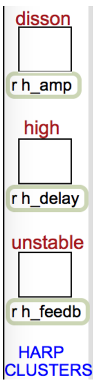
-any other sound characterised by softness and timbre density.

***Clusters* transform only your sound,** through a chain of delays adding depth to your amplification.

Clusters* are never to be performed during the *Harp-resonances (beginning-end of the piece).

An increasing requirement of *Clusters* is signalled by recurrent yellow flashes in the upper right part of the screen, which suggests also Harp_2 to increase melodic variety.

Fig.A_11 Increasing Clusters



The choice of producing *Clusters* is left to your feeling of adding "fatness" to your amplification.

This added fatness/depth to your sound is obtained by a delay-system (you will hear many echoes of your sound). You can influence the echoes in this way, just playing the harp:

-high pitches -> distant echoes (low pitches -> close echoes, similar to a reverb)

-dissonant/rough sounds (opposite to sound "puro" -> more amplitude

-unstable timbre -> increasing of the effect (feedback)

Noisy or dissonant passages and groupings should increase the overall echo density.

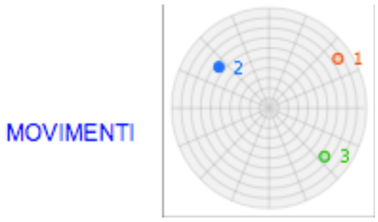
Fig.A_12 Delays

But the way a machine detects timbre is not exactly the same as that of our ears, therefore some previous study and experiments should be individually done in order to reach a fine-tuned control of the effect[5].

Gestures

A three axis accelerometer is fastened to your left hand[6].
The direction and the velocity of your movement in the air are tracked, in order to move the electronic sound sources around the space of the audience.

During the beginning and the end of the piece you can focus only on spatialisation, but when you are concentrated on the harp sounds, even your involuntary hand movements are still tracked and spatialised, it is a good idea to give some attention to this during the pauses of your sound, while it resonates.



Inside the spatial monitor (called "movements") the three sound sources are coloured, and their colour corresponds to the colours besides the main graphic called "effects" (the effects appearing in the first column are marked as red, in the second column as blue, in the third as green, and they correspond to the digital sound effects described above).

Fig.A_13 Spatial interface

The first part of the performance involves only one sound (the sounds of resonance extracted by Harp_2) therefore only one coloured source will appear in the spatial monitor.

An intuitive approach to this kind of interaction is advised, but remember that your hand can have three straight positions corresponding to the high, horizontal and lateral axis, which displace the three sound sources in the space positions shown here on the left. Any intermediate position of the hand will move the sound sources accordingly.
The overall velocity of the hand affects the velocity of shifting of the electronic sounds. In addition the hand velocity strongly increases the reverb of the *flanger* effect, when it is active.

These three methods of performance show an unconventional, gestural and highly conceptual way to play the harp. Maybe not many notes are performed, but each sound is charged with a strong compositional influence, and intriguing gestural aspect.
Sometimes you will be less focused on the "logic and beauty" of the music coming from your harp, and much more on the sensitivity towards the interaction.

[5] Stable/unstable timbre is technically detected as "spectral flux": sharp attacks, noise and pitch variability will show more unstable values. Dissonance is computed through "roughness" (timbre dissonance): melodic/harmonic dissonance, scraping sounds, but also very low resonant notes create the sensation of timbre dissonance.

[6] A simplified tracking could be exploited by a mobile or an iPod tied around the right forearm.

HARP_2

<u>Modes of performance</u>

1) 0’00” -> 2’00” Resonances (on Harp_1)

2) 2’00” -> 8’00” Breaths/Voices/Blows – Digital Interaction (on your microphone)

3) 8’00 ->10’00” Resonances (on Harp_1 again)

Shift between “resonances” and “blows” without any hurry or strict sense of time.

Your resonances are **the opening event of the music, the first sound will not appear immediately,** wait patiently for it and then start to very gently modulate and harmonise it.

Approximately you go in front of your microphone when Harp_3 starts playing, and you return to scan the harp resonances after both Harp_3 and _4 have begun the activity in the last part of the music.

These **two opposite performance modes** have in common an airy and wireless relation with the sounds of technology, in both cases the pitches emerge as byproducts of scratch and noise. Resonances are sounds of the environment, in the mid part of the performance the “resonance” becomes more conceptual, since your voice (or flute) timbre has the power to electronically transform the sound of the harps: in other words it is a hyper-instrument.

“Resonances” are explained above, **“Digital Interaction”** on the next page.

Your sounds are also feeding the pentagram score of Harp_4 during time-defined moments of the performance.

Fig.A_14 Melody enhancer

The yellow button flashes during the times of the score-feeding of Harp_1: if you wish, you can be more active and harmonic during these moments, in this way putting some melody inside the score.

Digital Interaction

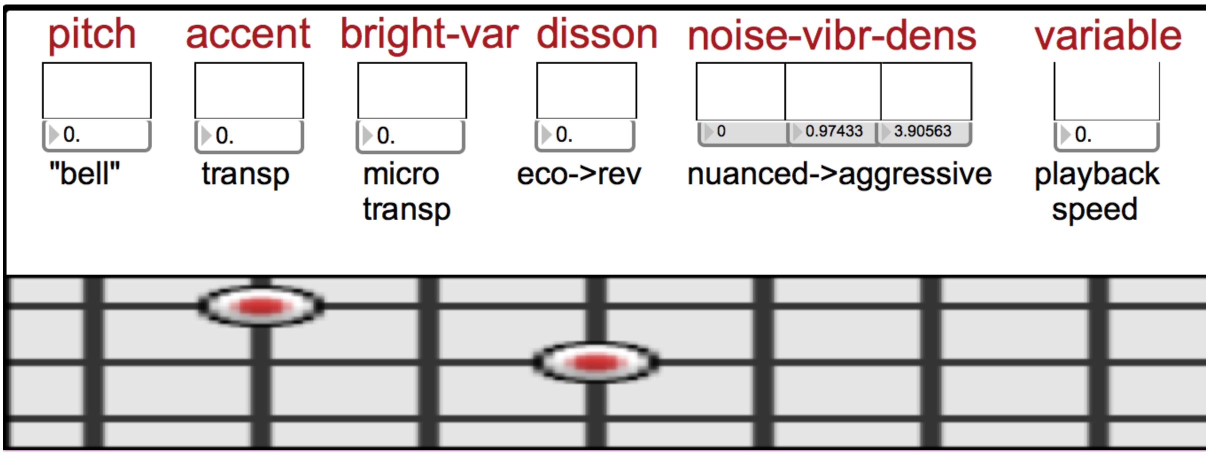


Fig.A_15 Hyper-instrument console

During the Digital Interaction you have the power **to modulate the electronic sounds coming from Harp_3 and _4. Your timbre micro-shapes directly affect the live electronics.**
In the upper part of the laptop-screen you can monitor your timbre shapes, which share the same curves affecting the electronic effects.

These modulations operate only inside the currently active effects, if more effects are opened in parallel your timbre will be transforming many different effects at the same time.
The effects are opened by Harp_1 and you can see which ones are working by looking at the matrix called "effects" below your monitors (red points mean open effects).

Sound analysis is active only when the intensity of your sound is not too low.

Description of the input sounds
The music is improvised, but the acoustic sound is only a partial focus, since **any sound inflection is finalised to shape the live electronics of the harps.**
The performance is conceived for voice or/and any kind of flute.
Your music shifts between sound/noise, pitch/breath, voiced/unvoiced.

Schema of the effects

Played feature	Transforming technology	Heard effect upon the amplified harps		
-1) PITCH	-> ring-modulation	(large bell	-> medium bell	-> small bell)
-2) VOLUME	-> melodic glissando	(sitar	-> harp	-> sitar)
-3) BRIGHTNESS	-> beats	(normal	-> dissonant	-> detuned)
-4) DISSONANCE	-> delays	(eco	-> multiplication	-> resonance)
-5-6)PERIODICITY+DENSITY	->spectral-decomposition	(pan-flute	-> artificial harp	->aggressive)
-7) VARIABILITY	-> playback-rate	(accordion	-> normal speed	->fast harp)

Explanation of the effects

-1) Pitch to ring modulation

-ring modulation detunes the spectrum of the harps through a sound frequency that modulates them

-the result is **a hybrid bell-like sound**

-the machine detects your pitch in real-time and continuously tunes it to the modulating frequency

-you have control over the hybridising frequency, affecting the sensation of width of the imaged harp-bell (low pitch = large bell).

-2) **“Volume” to melodic glissando**

-variable pitch transpositions are applied to the harps (within a major 3rd range)

-the result is a **continuous glide** up and down **(sitar-like effect)**

-the machine doesn’t exactly detect your sound amplitude (“Volume” is here only a conventional name), instead it detects how much your crescendo/decrescendo is intensifying or relaxing. Notice that the resulting value is not the intensity of your de/crescendo, but how much it “accelerates”: in this way your “effort” is active, rather than your sound intensity

-if your crescendo is increasing in a linear proportion (or the decrescendo linearly decreasing) the harp sounds will be in tune, if you impulsively accentuate your crescendo (or refrain the decrescendo) the harps make an upward glissando, if you release the push of your crescendo (or immediately drop with decrescendo) the harp make a downward glissando (sitar-like effect).

-3) **Brightness to beats/detuning**

-microtonal pitch transpositions are applied to the harps

-extremely subtle glides give the impression of a rough beating timbre, if they increase beyond the range of (approximately) 1-2 eighths of a tone, they are audible as detuned sounds

-brightness is enhanced by the high-frequency components of a sound and it is connected with the impression of its “brilliancy”: a noisy or hybrid sound is extremely bright, a tense timbre is brighter than a relaxed or resonant one. This system detects the variation in brightness: if you start a soft sound and increase its tension, you should gain a positive value; the transition from a voiced sound to a breathy/noisy one also returns a positive value, and the opposite

-you can detune the harp sounds by navigating between contrasting timbres, or keep them tuned by holding onto the same kind of sonority in terms of its brightness.

-4) **Dissonance** to *delays*

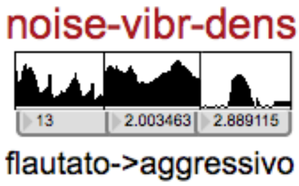
-artificial echoes (more or less repeating themselves) are applied to the harps -

1 distant echo is 1 repetition of the sound, more repetitions at a short time distance (i.e. half of quarters of a second) result in a dense overlapping sound texture, numerous echo repetitions in the range of 20/50 milliseconds create a sensation similar to reverb

- roughness is a method of computing how “dissonant” the timbre is. Effects involving pitched noise (such as jet whistles, rumbles) or small spectral shifts (i.e. exaggerated vibrato, or detuned low pitches) sound more “dissonant” than pure noise, pure harmonic tones are not at all dissonant, but they could increase their dissonance in the case of quick melodic passages

-The more you are “pure” and the more 1 single detached echo is discernible; dissonant sounds multiply and approach echoes in time, pitched noises (very rough) simulate reverb.

-5-6) **Periodicity/density** to spectral decomposition



-these effects called "spectral decomposition" (more confidentially "pan-flute effect") perform a splitting process between the sinusoidal (harmonic) and the noisy (high frequency) components of the harp sound

Fig.16 The "pan-flute effect"

-in this way it is possible to output only the sinusoidal part of the sound **("pan-flute effect"),** only the noisy part ("aggressive" effect) or some mixes of the two. Take into account that the reconstruction of the sound can be reduced to its most prominent components (resulting in an effect perceivable as "artificial"), or expanded to a broad palette of partial components (allowing from "realistic" to "hyper-real or exaggerated effects)

–your interaction mixes periodic vs. noisy sounds, static vs. vibrato-like sounds, light vs. dense timbre

–density and noisiness make the electronics aggressive, lightness (and pure high pitches) create the "pan-flute" effect (enhanced when the sound is pure and periodic), trills, vibrato and breaths enhance the artificiality of the effect.

7) Spectral flux to **playback speed**

-short chunks (2 ½ ") of harp sound are live recorded and played back as loops at variable speeds

-high speed increases the density of the loop, low speed stretches the sound giving more focus to the timbre, negative speed reverses the sound which resembles an accordion rather than a harp

-the spectral flux detects how variable the sound spectrum is (i.e impulsive attacks, noisy contents, complex-discontinuous timbres)

-therefore **through high timbre variability you increase the velocity of the harp playback, but through a very static sound the accordion-effect is discernible.**

<u>Timbre analysis remarks</u>

You will easily notice that the mapping-effects connected with pitch and "volume" are more natural as controllers of the electronic sounds, but the other timbre mappings can be quite complex and elusive.

Timbre is almost impossible to be fully defined by numbers. Machine sound analysis is often modelled upon the patterns of human perception, but the two "languages" are not the same. Timbre qualities are generally codified in our brain as music concepts (i.e. bright, expressive, nasal etc.) or as instrumental techniques (i.e. vibrato, flageolet etc.).

The physical qualities of sound vibration, detected in your monitor by the analysis machine, are only traces of your timbre, a sort of interactive score, upon which to find creative and meaningful solutions for shaping the sounds of the electronic harps.

Towards a vocabulary

Harp_2 shapes the electronics through 8 sound descriptors (3 of which are variable quantities). Below is a short vocabulary of instrumental techniques apparently influencing the 4 fixed descriptors: Dissonance, Noisiness, Vibrato, Density. As observed above, there is no straight correspondence between one technique and a reciprocal analysis feature, only an influence happening under different sound conditions.

Dissonance
High value: Singing into the flute (detuned), jet whistle, breathy attack
Mid value: Breathy-sound, chromatic quick passage, deep low pitch

Noisiness
High value: Breath
Mid value: Breathy attack, trill, multiphonic

Vibrato
High value: Trill
Mid value: Vibrato, flatterzeug, flageolet, breath

Density
High value: Low tense pitch,
Mid value: Pitched noise, multiphonics, crescendo

HARP_3

1) 0’00” -> 2’00” Silence

2) 2’00” -> 7’00” Sound gestures (Improvised harp effects)

3) 7’00 ->10’00” Resonances (see section above)

You receive a graphic-verbal animated score.
You are the last performer starting to play: when the screen is empty it means silence.
The performance happens when one or more verbal labels appear indicating sound effects upon which to freely improvise:
-trills,
-arpeggios,
-nails (vertical scratch),
-pedals (sounds of just the pedals in this case),
-harmonics,
-claps (hand percussion on the instrument body),
-glides,
- high-pitches (extremely high passages).

The width and the position of the labels (sometimes moving) suggest modes of performance. Sometimes the labels are numerous (their number is related to the overall density of the electronics), in this case the performance has to be more intense until agitation, or even emotional explosion.
On the contrary one or two single labels, their smaller dimensions, and slow/absent movements suggest a reduced energy.
Some moving waves appear on the screen intersecting the written labels: feel and invent the appropriate sounds.

The time occurrence of the animation is fixed, not the contents since they are shaped by the sound of Harp_1.

When the background becomes black it is the signal to stand up, grab the microphone from the stand and start to scan the resonances: the other players eventually will be joining you in the same activity.

At the very end, fading out the sound, maintain the movement for a while, as an empty gesture.

HARP_4

1) 0’00” -> 1’00” Silence

2) 1’00” -> 7’30” Phrases (sight reading the interactive score)

3) 7’30 ->10’00” Resonances (see section above)

The score appears at fixed times (as indicated in the bottom part of the screen).
A couple of times the note sequences are the exact repetition of the previous one.

When the score appears you have 30" to mentally read it, after that, a green pointer starts to shift from left to right and you follow its position by playing.

Grey notes are to be played softer.

Don't accentuate the rhythmic values; the flowing time relationships are often underlined by grace notes and sequences of re-bounced notes.

Play with intensity.

Your score is a symbolic resonance of the sounds coming from Harp_2.

When the background becomes black, take the time to finish your score sequence: Harp_3 will be already beginning to scan the harp resonances. Without any hurry join her in the same activity.

At the very end, fading out the sound, keep the movement for a while, as an empty gesture.

TECHNICAL NOTES

HARDWARE EQUIPMENT AND SETUP
-2 laptops positioned in front of the two couples of performers, connected by one Ethernet cable (1000Mbit/s, 3 meters long at least).
-Laptop_1 is concerned with interaction and sound processes, it must be a Mac.
2,4 Ghz double processor, 4 GB RAM, as minimum requirement, more power is advised.
Laptop_2 receives data without processing audio, and sends the screen (scores) to a projector: it can be Mac or Windows.
-Sound card at least 4 inputs (3 microphone inputs + 1 line input) and 4 outputs, connected to laptop_1. Optional mixer.
-Quadraphonic PA
-2 small audio monitors positioned on stage, near to the opposite couples of performers, in order to increase and modulate the audio-feedback
-1 triaxial accelerometer for Harp_1 (mobile accelerometers could be a reduced option).
-Projector for video streaming of the animated scores of laptop_2

MICROPHONES (minimal requirements):
-1 specifically designed harp-pickup (or a piezoelectric pickup positioned inside the back column facing the string joints) for Harp_1: the pickup should be positioned in the middle part of the soundboard in order to offer a middle-register sweet-spot
-1 condenser microphone for Harp_2
-2 high quality dynamic, or directional condenser microphones for Harp_3 and _4 (one for each harp).

MOTION TRACKING
Inertial Motion Tracking is tested with the Orients_15 System, developed by the *Centre for Speckled Computing of the University of Edinburgh*, [7] running through the orientMac application. This application and the related Readme.txt document are contained in the main folder of this software.
The system needs a native Bluetooth 4 Mac version as minimal requirement.

A different Motion Tracking system is allowed by substituting the abstracion "or_data" with a different OSC udpreceive module, which must contain proper scaling and normalisation.
Details are given inside the module "or_data" and in the Readme text file.

---

[7] www.specknet.org

AUDIO SETTINGS

The option to output portions of direct amplified sound from the instruments (through audio card or mixer) is to be carefully balanced before the concert depending on the audio-feedback response.

Sound setting before the concert is crucial, and the dedicated software section is visible in Laptop_1

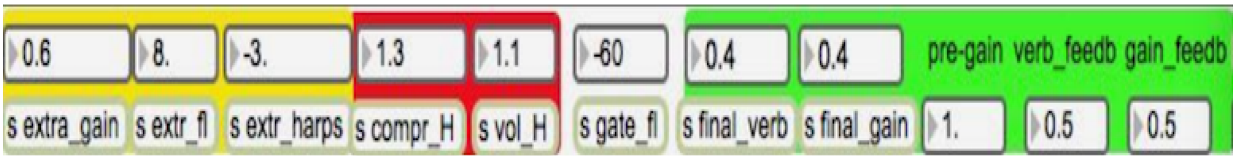


Fig.A_17 Setting section in Laptop_1

<u>Feedback extra-gains</u>

-"s extra_gain" enhances the global feedback from 0.5 upwards

-"s extra_fl" and "s extra_harps" sets the extra gain in Db

(separately for Harp_2 and Harp_3 _4)

<u>Harp inputs</u>

Sometimes the levels of the live processed instruments (Harp_3 and _4) are not sufficiently high.

Pre-DSP software gains are necessary: they affect both harps

-"s vol_H" sets the initial input amplitude (pre high-pass filtering)

-"s compr_H" sets the final input amplitude (post high-pass and pre-DSP)

<u>Threshold of analysis</u>

-"s gain_fl" set the minimum signal level in Db, sent to the analysis module, in order to allow just the analysis of instrumental sounds, cutting the environmental noise

<u>Final mix</u>

-"pre-gain" sets the final amplitude of the processed harps (Harp_1 excluded)

-"gain_feedb" sets the final amplitude of the audio feedback

- "verb_feedb" sets the final amplitude of the reverb applied on audio feedback

-"s final_gain" sets the final amplitude of the overall electronics

-"s final_verb" sets the final amplitude of the overall reverb

Dry and reverbed outputs are independent signals mixed up.

After the last saved setting, press "write" (right bottom of the patch)

SOFTWARE

The interaction is designed in MAX/Msp (6.1.10).
Laptop_1 exploits some externals specific for Mac, Laptop_2 can be Mac or Windows.
Every laptop exploits a different patch, talking through Ethernet.

Requirements: MAX/Msp 6.1, or *Awakening,* plus *Awakscore* standalone applications.
Python plus the dedicated python folder installed in Laptop_1 (or otherwise a different Motion Tracking system, not excluding a simple mobile setup).

In case of a different MT system, replace the "rec_orient" abstraction and "p gyros" patcher with a fitting module. In case of mobile MT the "mobile_data" abstraction is given inside the main folder. See the Readme.txt, for details on Motion Tracking installations.

LIST OF EXTERNALS AND ABSTRACTIONS
LAPTOP_1-Awakening

ambiencode~, ambidecode~, ambimonitor (Jan Schacher)
http://trondlossius.no/articles/743-ambisonics-externals-for-maxmsp-and-pd

chroma~ (Adam Stark)
http://c4dm.eecs.qmul.ac.uk/people/adams/chordrec/

contrast-enhancement (Michael Edwards)

dot.smooth, dot.std (Joseph Malloch et al.)
http://idmil.org/software/digital_orchestra_toolbox

ej.line (Emmanuel Jourdan)
http://www.e--j.com

fiddle~ (Millar Puckette et al.)
http://vud.org/max/

ftm, ftm.copy, ftm.list2col, ftm.mess, ftm.object,
gbr:fft, gbr.slice~, gbr.wind=, gbr.yin,
mnm.delta, mnm.moments, mnm.onepole
FMAT and Gabor library (Norbert Schnell et al.)
http://ftm.ircam.fr/index.php/Download

jfc-spectral-tutorial3, melody2harmony (Jean Francois Charles)
https://cycling74.com/toolbox/live-spectral-processing-patches-for-expo-74-nyc-2011/#.Vh0sE2A-BE4

multiconvolve~ (Alex Harker and Pierre Alexandre Tremblay)
http://www.thehiss.org/

newverb~ (freedistribution)

OSC-route (Matt Wright)
roughness (John MacCallum)
http://www.cnmat.berkeley.edu/MAX

SpT.analsynth, SpT.makeharm (abstractions)
Spectral Toolbox (William A. Sethares et.al)
http://www.dynamictonality.com/spectools.htm

zsa.easy_flux (Mikhail Malt, Emmanuel Jourdan)
http://www.e--j.com/index.php/download-zsa/

LAPTOP_2-Awakscore

bach.roll, bach.score, bach.transcribe (Andrea Agostini, Daniele Ghisi)
http://www.bachproject.net

o.route (Adrian Freed)
http://cnmat.berkeley.edu/downloads

INDEX

LIST OF FIGURES

Les Demoiselles D'Avignon

Interactive Quartet

First performance Reid Hall, Edinburgh, February 1st 2015
by Dimitris Papageorgiou, Emma Lloyd, Clea Friend, Pete Furniss
Duration 11', Dedicated to the Bologna Cello Project

Fig.D_1 The painting

Live recordings at:
https://youtu.be/Tj1VujA90QM
https://www.youtube.com/watch?v=AD0fknwQjRw&feature=youtu.be

PRESENTATION

MODEL
Le Demoiselles d'Avignon is an interactive quartet for bowed-string instruments.
The quotation of Pablo Picasso's painting refers to the reconstruction of a reality where different points of observation coexist, also because of the deformations of the space due to the implicit action of the physical bodies.
The sculpted representation of the female figures (recalling African styles) resists the classic concept of an objective visual-perceptual organisation. The portrait is not yet Cubist, but clearly anticipates a new spatial order, towards a plurality of dimensions and categories inside one single collapsing surface.

FRAMEWORKS
The musical interaction of the quartet is obtained through five laptops in network: one for each musician, with the addition of one more generating the video in real-time.
The whole set of connections between the gestures and the digital interactions of each single player creates the sound development and the aim of the work. The time-space (the musical form) of the work is not imposed a priori, it emerges as a shared activity from the different points of view of each musician acting as an augmented-instrument performer.
In this work the augmented-cellos are based upon the real-time analysis of the sound as it combines with the bow gestures performed on-stage.

The musicians read the flows of analysis data, performing them as musical functions.
The software mappings are designed in order to build musical structures and to influence the other players (processes, messages and scores), charging the habitual chamber music gestures with interactive extra-meanings.

The conscious feedback between the physical performance, its analytical monitored knowledge, and its compositional use in real-time places the human agents in the conditions to collectively define shared spaces of action, mediation and exchange.
The current digital means allow actions and symbols to be unified in the same environment: in this sense physical actions, scores and messages can be part of a complex digital instrument allowing real-time composition.

The system is conceived in order to recognise music expression by means of spectral sound analysis, note detection and motion tracking (the latter organised for the description and computation of some classical bowing styles).
The aim is to augment the traditional chamber music communication through a texture of functional remote influences and a net of formal mediations between the performers.

NOTES
The work makes use of 5 MAX/Msp applications (one for every laptop).
Each system comprises music processing, scores and monitors, and calibration settings.

An external coordinator of the interaction is suggested, if possible a sound engineer. Due to the interactive character of the composition, the musicians need detailed explanations of their system.
The scores are embedded in the real-time software and cannot be printed.

The musicians are here defined as Cello_1, _2, _3 and _4. The work can be performed by any type of bowed-string ensemble, whether classical or experimental. The performers exploit a small motion tracking sensor (Inertial Motion Unit, IMU) tracing their principal bowing styles *Balzato, Tremolo, Staccato* and some bow dynamics. Cello_4 instead interacts only through sound: if a different ensemble is used, "Cello_4" need not be a string instrument, any other monodic instrument is allowed.

This document consists of:
-presentation
-interaction explanations
-general and individual performance notes
-setting details for the coordinator of the performance
-tech and audio specs

The performers should be aware of the following interaction notes before reading the performance details. An explanatory video support for each performer is included.

INTERACTION

ROLES
Each musician has the responsibility to:
-invent and perform his/her chamber music
-interact with his/her specific digitally-augmented cello
-generate through music gestures messages, scores and sound processing upon the other players
-influence, through the same music gestures, some global shapes of the overall music event.

The improvisation is thus shared, controlled and functional.
All the visual cues are received by the performers on the screen of their individual laptops, positioned in front of them in a “music-stand” fashion.
The final behaviour of the composition is in part pre-designed in the software and in part interactively created by the gestures of the musicians on stage.

These interactive global aspects are the following:

-Cello_1 generates the background colour screen of all the Apps, whose significance regards some modalities of the overall performance, but above all an indication about the densities of playing.
-Cello_2 sends an animated action score to the other musicians, and makes choices upon the video.
-Cello_3 spatialises the electronic sounds produced by the ensemble, and in addition live-selects, records, diffuses and processes sounds played on stage.
-Cello_4 sends a variable chord, as a shared tonal centre.

Other shapes can be preconfigured by the ensemble, a video is processed in real-time responding to the bowing styles and dynamics of the performers.
A full interactive score in pentagram form is received by Cello_4.

AUGMENTED INSTRUMENTS
The sensing system is based on motion tracking and audio analysis, the devices exploited as sensing inputs are small inertial motion units (IMU) positioned under the frog of the bows, and contact microphones on the bridge of the cellos. Each musician performs autonomously a totally different augmented instrument in terms of sensing input, mapping space, kind of output and interactive role. Each musician contributes to the consistency of the overall result through global controls and remote dialogues: the same sound-gestural means (audio analysis and gesture computing-recognition) finalised to global interactions are driven by each musician towards an individual electroacoustic sound palette.

Fig.D_2 The wireless IMU sensor under the bow frog

-Instrument_1 (Cello_1; Spectral): generates interactions by means of bowing-styles captured by the IMU. The sound output spectrally transforms its acoustic cello sound (freeze of the spectrum, dynamic equalisation, transposition-decomposition of the sinusoidal/noisy partials).
Through bowing-styles it sends variable background colours to the other players (colours are intended as an interactive graphic score).

-Instrument_2 (Cello_2; Artificial): generates interactions by means of a hybrid gestural sensing system (bowing-styles captured by the IMU combined with spectral sound analysis). As output it creates sounds of synthesis (physical models, additive synthesis, frequency modulation synthesis). It sends graphic interactive scores to the other players.

-Instrument_3 (Cello_3; Sampler): generates interactions by means of bowing-styles captured by the IMU. Selects prerecorded files, and record-renders live fragments played by the other musicians, applying transpositions, fragmentations and overlapping on the output materials.
It spatialises the sounds coming from the ensemble of augmented instruments.

-Instrument_4 (Cello_4; Harmoniser): generates interactions by means of the sound expressiveness of the cello performance captured by means of sound analysis computed at a note-level.
The sound output is made of "canonic" transpositions of the input sound (four-voice harmoniser).
It sends variable chords to the other players (shared tonal centre) and receives an interactive score in full common notation (built by the bowing styles of Cello_2).

SENSING SYSTEM
The digitally augmented instruments (hyper-instruments) are based on a motion tracking system aiming to offer the musicians means to interact with the digital composition through the same gestures normally functional to the acoustic outcome: therefore without disturbing the classical (or experimental) techniques.

Cello _1, _2 and _3 mainly interact through motion tracking, Cello_4 only through sound (timbre analysis, note detection and expressiveness pattern recognition).

The former three musicians receive and monitor interpreted bowing styles computing through the interpretation of:
-Angle/Orientation of the bow movements on the Horizontal axis
(from the low to the high string)
-Angle/Orientation of the bow movements on the Vertical axis
(from "full-hair" bow position to "hair plus wood")
-Global bow Energy ("*velocity*")
-Energy of *rotation* (with respect to the instrument strings)
-*Tremolo* intensity
-*Balzato* intensity
(Energy of orthogonal movement towards the string: *Ricochet* or *Spiccato*)
-*Staccato* intensity (*Martelé*, massive "alla corda" style)

The intensity of a bowing style is here intended as a sum of the global amplitude and velocity of the pattern.
Motion tracking applies to performing bowing styles, as like to silent bow movements in the air.

These seven continuous parameters are integrated with three types of impulsive bow motion recognitions (functional to triggering and on/off interactions):
-impulsive *rotations* of the bow
-impulsive Accelerations of the bow
-hybrid system of bow position recognition with respect to the strings

Below is a graphic summary of the principal gestures recognised and computed by the system. The description of the audio-analysis parameters will be reserved to the individual notes for Cello_4.

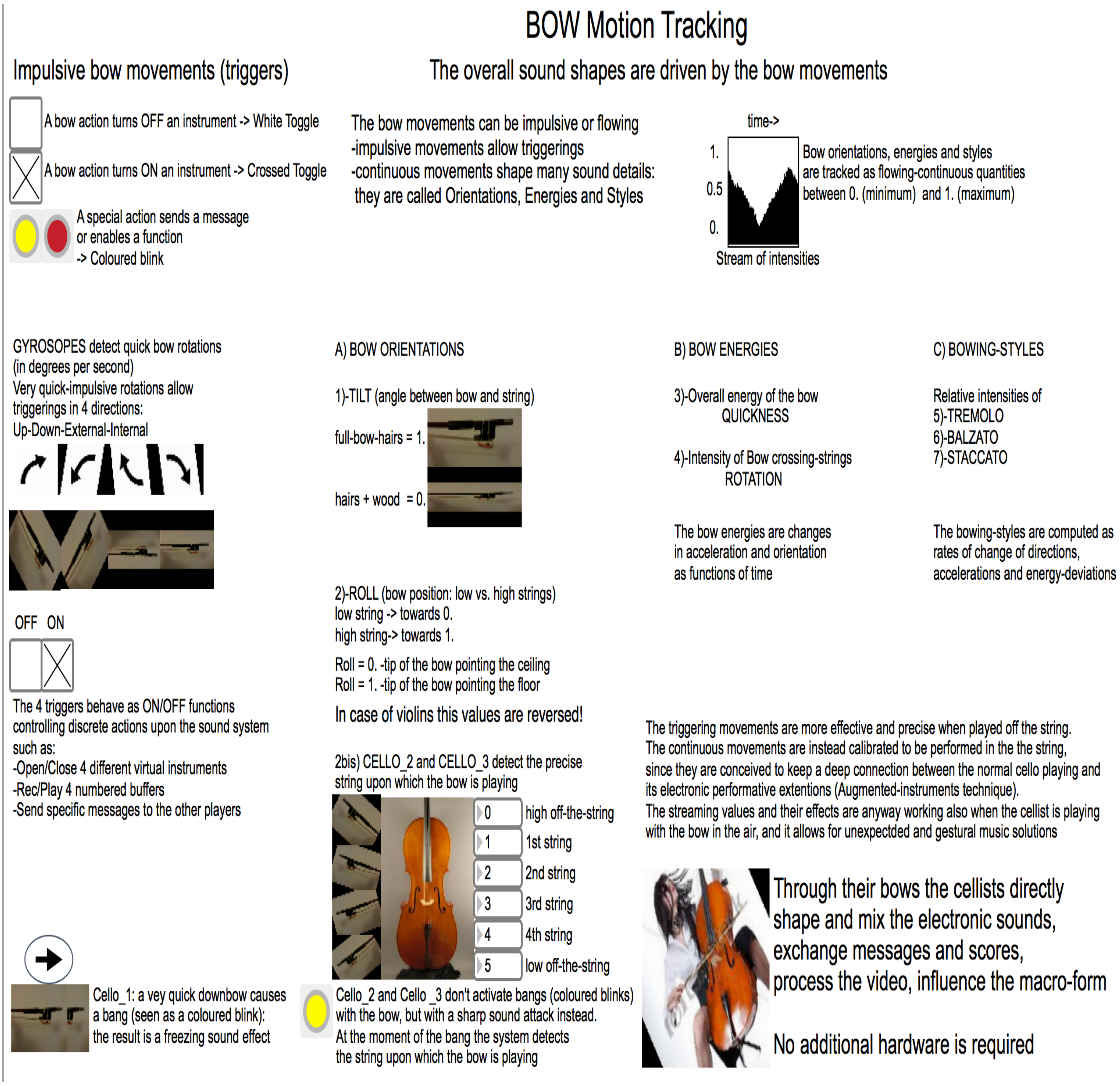


Fig.D_3 Motion Tracking functions

COMPOSED INTERACTIONS
The augmented instruments have preferential trajectories of dialogue.

-Cello_1 and Cello_3 drive their electroacoustic processes through bowing styles, but the intensities of some styles (*Tremolo, Staccato, Balzato*) are computed either individually or as a reciprocal gradient of similarity between the two performers.
In this way the two musicians (contrasting or imitating each other) strongly influence the sampling processing coming from the electronic sound of Cello_3.

-Cello_2 and Cello_4 drive together a crossed system highly reliant on pitches and notes produced in real-time. Cello_2, through the bowing-styles T*remolo, Staccato, Balzato*, generates pitch and rhythm in one of its virtual instruments, but the same module also generates the polyphony (density, rhythm and pitch transposition) of Cello_4, whose augmented instrument is a four-voice harmoniser; in addition the same module of Cello_2 generates the notes received by Cello_4 in its interactive pentagram.
Part of the sound synthesis of Cello_2, the electronic polyphony of Cello_4, and its score are therefore strictly correlated in terms of rhythm and intervals since they are generated by the same gestures, produced by Cello_2.
On the other hand Cello_4 has the power to activate and mute the four virtual instruments of Cello_2 by means of the melodic intervals of its performance.
Cello_4, through its musical expressivity, can also influence the resonance, intensities and shapes of Cello_2's electronic sounds.

As described above, all four musicians have a role in affecting the global development of the composition:

-Shared tonal centre (interactive variable chord) sent by Cello_4
-Spatialisation driven by Cello_3
-Action score sent by Cello_2
-Background colour (as a graphic animated score) sent by Cello_1

<u>Tonal centre</u>
Cello_4 controls the shared tonal centre through an algorithm defining his/her last most often performed notes.

<u>Spatialisation</u>
Cello_4 has an autonomous fixed quadraphonic output system .

The other three musicians output their sound in stereo; their stereos are individually spatialised by the bowing styles of Cello_3 (see Cello_3 individual notes).
The overall spatialisation can be octo or quadraphonic.

Action score

Through a conventional bow gesture Cello_2 interrupts for a brief period any current activity of Cello_1, _2 and _3. An interactive image appears on their screen in synch which has to be performed by everybody with intensity and impulse.

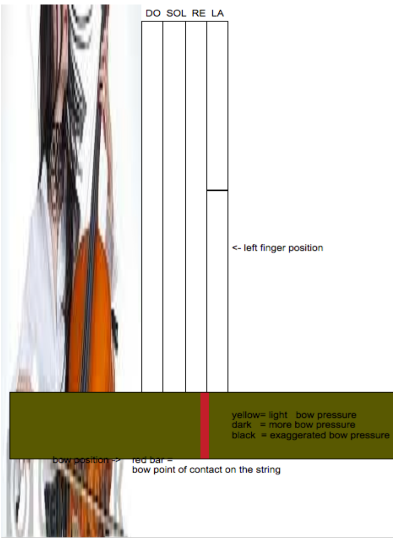


Fig.D_4 Action score

The image consists in a stylised cellist where:
-A quick moving small segment shows the left hand position on the fingerboard and the four strings
- A coloured bar represents the bow:
black = more bow pressure on the string,
Yellow = light pressure,
Bar movements up and down =
bow from sul-tasto towards near the-bridge,
Red pointer = point of contact of the bow upon the string (between frog and point)

The movements of the score are generated by the real-time sound analysis of each cellist.

Background colours

The background colour of each laptop has a crucial impact on the macro-form.
Each musician receives the same colour sequence at the same time, but with different gradations of brightness. At the beginning all the musicians will receive a black background (with the exception of Cello_1, who receives a white background).

Black = Silence; White = play a solo**.**
The overall length of the work is 10 minutes, preceded by 30” of solo Cello_1.
These default time lengths can be modified before the performance inside the settings of the Cello_1 App (see setting section below).
During the initial solo, some bowing styles of Cello_1 are associated with colours.

After these 30” the ensemble interaction starts, since the musicians receive the colours created by Cello_1: the background colour is a trace indicating how to play.
During the ensemble interaction the temporal development of the colours changes 20 times slower than the original bow gestures of Cello_1, generating them.
The initial 30” are therefore the seed of a macro-formal message, and Cello_1 is aware of that during his/her solo (see individual instructions).

The musical meaning of the colours should be a shared ensemble decision made in advance and regarding character, intensities, mood and techniques of the performance
(but a loose improvised interpretation of the colours could also be appropriate).
The only fixed interpretation regards the meaning of the parameter of brightness vs. darkness.

Bright = increase in the active generation of original musical materials.
Intermediate = short music commentary, accompaniment, dialogue, digital interaction.
Dark = decrease in originality and limiting to the sound gestures only affecting the interaction towards the other musicians and the overall music shapes.

After a few rehearsals the musicians easily learn how different these two detached performance styles are: the first flowing and expressive, the latter discrete, atomised and functional.
The decreasing gradients of activity (solo, dialogue, accompaniment, commentary, single gesture, silence) imply the increase of functional and structuring "compositional" detached sound gestures, and two distinct performance modes emerge:

-1) fluid, improvisatory, individualistic

-2) objective, detached, compositional, influencing the external communications and the sounds of the other people.

The composer has however predefined some internal envelopes of brightness, preserving the colour but differently time-shaping the individual quantity of light for each performer.

All the musicians will therefore be receiving different tonalities of brightness: in this way Cello_1 will be very active at the beginning, Cello_4 predominant towards the end of the piece, Cello_2 and Cello_3 will be performing with some peaks of foreground action in some intermediate points of the performance.

CIRCUIT

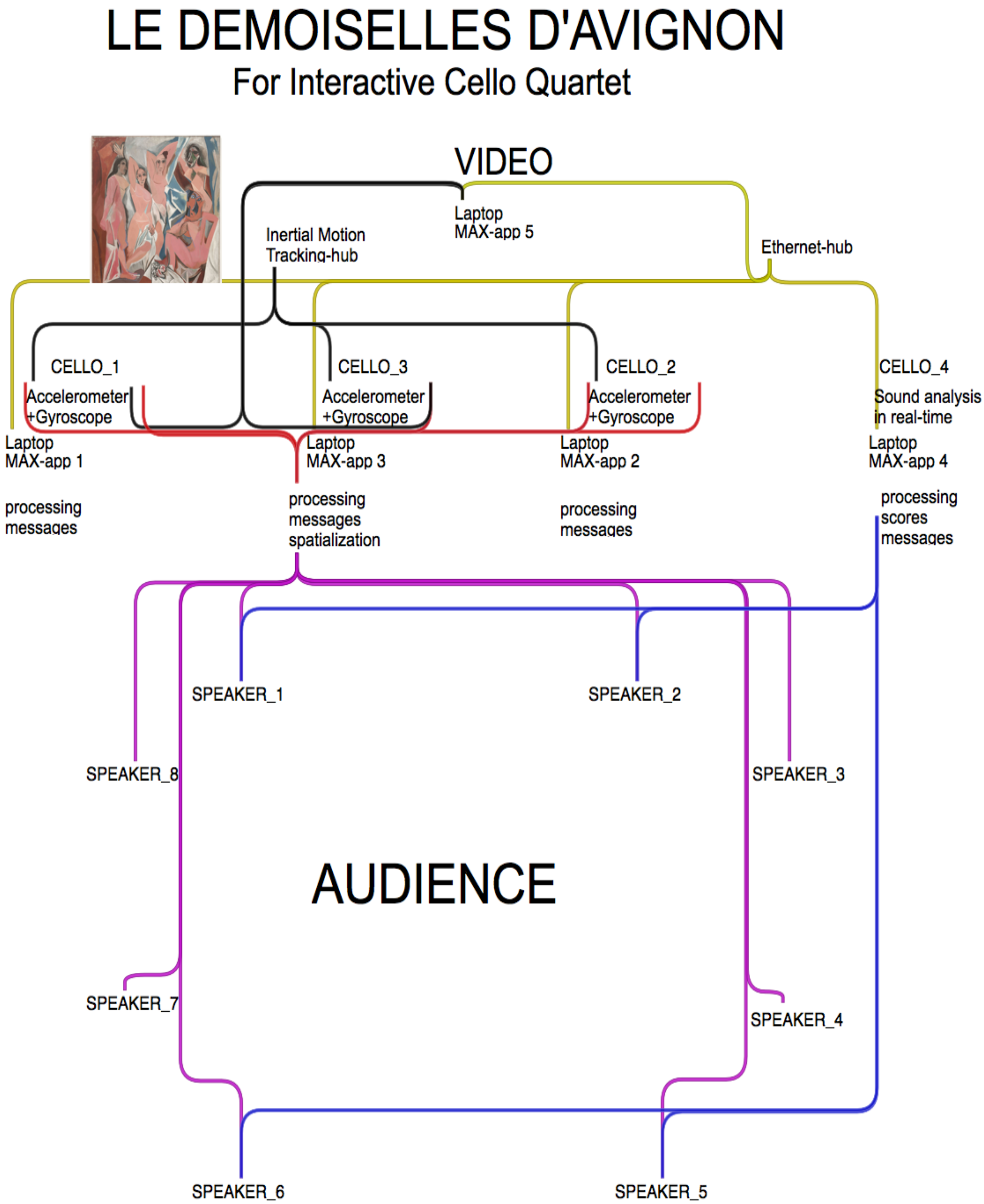


Fig.D_5 The circuit

GENERAL INSTRUCTIONS FOR THE WHOLE ENSEMBLE

The laptop screen is at the same time a monitor and an interactive score, upon which to model the ensemble improvisation, the reciprocal influences and the technical control.
Each musician is provided with a laptop (containing one individual MAX-Application), one sound card, and at least one microphone (see the final section "hardware equipment").
The laptops are linked via Ethernet.
The performance notes don't include any scores, since the composition is an ensemble interaction, and behaves much more as a collective instrument requiring explanatory details rather than notational instructions. Before starting the performance, a general review of the settings is necessary. The settings are contained inside each App, sometimes accessible as hidden modules by double-clicking the corresponding label.

SETTINGS
Each App contains three setting sections:

1) *Setting*: this section is positioned in the upper-left part of the screen.
   The written labels inside the red and yellow borders can be opened by double-clicking on them (each yellow or red bordered label can be opened with a double-click).
   These interfaces are called: *"p network", "p audio-settings", "nb.bowings*".
2) *Input/Output*: sound monitors and number boxes (filled with default values).
   These numbers set the input and output gains normalised between 0 and 1.
   By typing or dragging the decimal numbers it is possible to modify the gains.
3) *Calibration*: number-boxes (monitors and settings).
   Calibration can be manual or automatic.

A few parameters need to be checked inside these modules before every performance.
-the motion tracking monitors have to show flowing data
-check that the right sound card is active (double-click "p audio-settings")
-the input/output gains should be appropriate
-in case of lack of motion tracking control, a new calibration needs to be performed
See video description.

PERFORMANCE: START!
After organising the settings (the first time it will be a rather complex procedure), the calibrations should be remembered by the Applications, and only a brief checkup is recommended before every new performance (above all the sound card check inside "audio-settings").
The performance starts when Cello_4 presses "Spacebar" on his/her laptop. At this moment Cello_1 receives two off-beat flashes, and then immediately starts the opening solo.
During the solo the background colour of Cello_1 is white, while it is black for the other musicians. After the time of the solo (30" by default) all the laptop backgrounds start to shift across different colours, and then the ensemble performance starts to evolve. At the end, all the laptops will be black again and the ensemble silent: Cello_4, being the last one to receive a steady black background, turns off the system by pressing "Enter"

CELLO_1. SPECTRAL

Video performance instructions at: https://www.dropbox.com/s/4suc3k9ecm9xcfj/cello1-instructions.mp4?dl=0

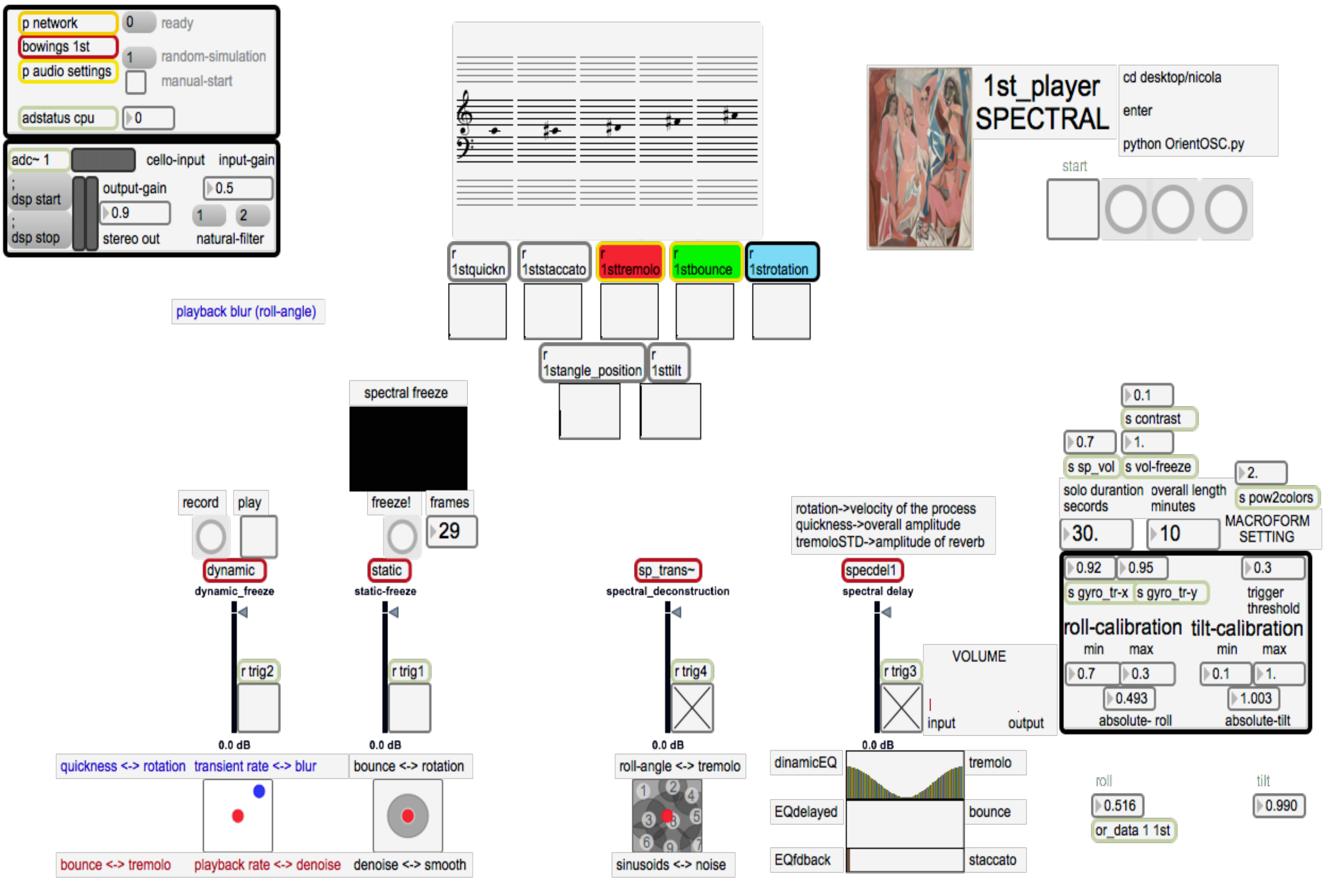


Fig.1-C_1 Cello_1 application

ELECTRONIC SOUNDS AND INTERACTIVE ROLE OF CELLO_1

Cello_1 is the instrument that explores most deeply the cello timbre. This feature is underlined by the foreground role in the initial part of the composition, where the main sound qualities are introduced, and upon which the other players will act by development and contrast.

The electronic sound of Cello_1 involves spectral modulations of the live performed cello, therefore not evolving by contrast, but instead deepening and interleaving the cello acoustics.

Performance could be shaped through:

-a frequent use of bow-wood sonorities: this bow *rotation* amplifies the direct cello sound, meanwhile attenuating the electronics amplitude, in a dry-wet fashion.

Performing with “full hair” on the strings instead increases the electronics presence.

- scraping, noisy and on-the-bridge sonorities induce broad and rich spectral responses, a fuller and more common cello sound will produce more static responses from the electronics, energetic bowing styles, sometimes also performed in-the-air, can help to mix exasperated cello sounds with more dynamic electronics interactions. Timbre is globally oriented to a clear cohesion and intimacy between cello and electronics.

The composition opens with a solo, immediately starting after two off-beat flashes on the screen.

The solo is improvised but it should be prepared in advance taking care of the following responsibilities towards the ensemble:
-exposition role of the sounds (obviously1or 2 virtual instruments are to be immediately chosen and opened by bow triggers)
-development of a tonal centre (freely following the chord sequence written on the screen, which during the solo is fixed with the pitches C, C-sharp, D-sharp, F-sharp, A-sharp)
- choice of a clear sequence of T*remolo* and B*alzato* bowing styles with precise dynamics of *rotational* energy across the strings: as described below, the evolution of the overall background colour macro-form received by the whole ensemble throughout the performance depends on these bowing styles alternating during the initial solo.
The opening solo will be created in order to musically mix these three obligations. The solo is signalled by the white background colour: when some colours start to appear the ensemble music begins. These instructions take for granted that the section "composed interactions" on pp. 4-5 is fully known. The overall time-envelopes of brightness/darkness show the tendency for Cello_1 to fade out from an active foreground role at the beginning towards a final stillness. Bright colours mean production of flowing and original music materials, intermediate colours mean gestural and more detached sound commentaries, performed with full attention towards the ensemble. The darker the colour the more the performance will be involved to focus only on the dialogue with Cello_3 and on its output (similarity vs. diversity in the intensities of T*remolo, Staccato* and B*alzato* between Cello_1 and _3 strongly affects the output sound of Cello_3).

FEATURES AND INTERACTIONS
From the very beginning the performance evolves progressively through these focal sections:
1) Solo, building a macro-form (white background)
2) Active flowing sound interactions (bright backgrounds)
3) Short commentaries and dialogues with Cello_3 through bowing styles (dark backgrounds)
4) Silence (black background)

-1) The solo sets a sound exposition and a melodic-tonal centre. This exposition has to be integrated with a clear sequence and mix of the two bowing styles *Tremolo* and bouncing, performed with different intensities of *rotation* across the strings. The intensities of *Tremolo*, bouncing and bow-*rotation* are recorded by the system, transformed into colour messages, and sent to the backgrounds of all the laptops when the solo is concluded. *Tremolo* generates Red intensity, Bounce *(Balzato*) generates Green intensity, bow-*rotation* generates Blue intensity. Mixed bowing styles generate mixed colours, a single bowing styles generates a pure tonality. Bow stillness creates darkness, and bow hyperactivity brightness. These values are recorded only during the time of the solo, at the precise moment that the solo finishes the system doesn't record anymore, instead it starts to output the background colours for everyone (this is the signal that the ensemble part is beginning).
The output time of the colours is time-stretched and lasts until the end of the work. If the solo lasts 30" and the work 10', it means that the initial bowing styles will produce a flow of colours 20 times slower, affecting the subsequent macro-form messages as a seed (i.e. the background colour happening after two minutes of ensemble performance, is generated and corresponds to the bow movements performed after six seconds of solo).

-2) The more active and flowing-creative sound interaction will happen during the solo and during the first part of the performance (the brightness of the background colour telling how active to be).The sound interaction is afforded by bow-impulsive triggers opening and closing the virtual instruments (see the last section below on virtual instruments and the video example).
The internal response of the virtual instruments is played through the bowing movements, by internal mappings that can be visually followed from the laptop screen. The mappings avoid linear parametric approaches thus permitting a global and musical interplay allowed by the complex behaviour of the modules employed (see foot notes for more info) and by mappings oriented to navigation instead of punctual control. The aim is to treat the electronic sound as if it were a "normal" musical instrument whose responses can be logical but highly complex and non-obvious: they have to be mastered through practice and knowledge of the specific character of each virtual instrument. The electronics can be attenuated, and the cello more amplified, when the bow plays with less hair and more wood (tilt towards 0.), producing a slightly scrappy sound: but the same effect happens also if the bow moves in the air with the same tilt value.

-3) As the background darkens the performance starts to reduce to short detached sounds and the bow gestures are no longer oriented to produce a flowing sound but instead to mainly interfere with the sound of Cello_3, by means of reciprocal bow movements. The similarity or contrast of bowing styles *Tremolo, bounce* and *Staccato*) between Cello_1 and _3 strongly affects the sound output of Cello_3, mainly involved in transforming sound files. Cello_1 takes no notice of this collateral effect when focusing on making his/her own music, but as the protagonist role reduces, the aim of interference and bow dialogue starts to be significant.
This bow dialogue is detected as the difference between the bowing intensities of the two performers in relation to S*taccato, Tremolo* and *Balzato*:
-similar *Staccato* (irrespective of being intense, lazy or absent) -> more dense-overlapping sound material from the sound files output of Cello_3
-contrasting *Staccato* (i.e. one performer plays *Staccato*, the other one *Legato*) -> short-intermittent output from the sound files of Cello_3
-similar intensities of *Tremolo* -> the files from Cello_3 are low transposed (and different intensities transpose higher)
-similar intensities of *Balzato* -> the direct sound of Cello_3 is low transposed (and different intensities transpose higher)

-4) Silence when the background is black (the second part of the performance progressively fades out, leaving final prominence to the Cello_4)

-5) Cello_2 sometimes sends an action score, which unexpectedly appears as a window on the screen. The score arrives synchronously to Cello_3 and Cello _2 itself. During these briefs periods stop any previous music activity, and perform the gestural suggestions collectively, with intensity (see above "composed interaction").

Fig.2-C_1 Action score

THE FOUR VIRTUAL INSTRUMENTS

The instruments are open and closed by the four *quick-impulsive triggering rotations* Up, Down, Internal, External, better responding as in-the-air-bowings. If the virtual instruments are closed, no sound at all will be output.

It is possible to keep open more than one instrument mixing the resulting sounds as an example one *freeze* added to one of the *real-time instruments* could result in a dynamic live effect upon a groove.

The internal nuances of each instrument are consequences of the bowing styles live performed, therefore a detailed description of the virtual-instruments internals appears necessary.

<u>Sound characters</u>

The couple of *freezes* shown in the left part of the screen, when active (in the position ON), live-record a tiny portion of input sound just at the moment of the *quick-impulsive down-bow* (the trigger is underlined by the yellow flash). The sonogram builds up the sound representation of the recorded cello input: the more the sound captured is strong and brilliant, the more the sonogram is dark and shaped, and the sound output powerful. A good synchronisation is necessary between the *down-bow impulse* (to be performed on the string or otherwise in the air) and the cello sound the player decides to be captured.

The *freeze* process captures the sound in both the modules at the same time (if they are open in the position ON). Any *freezes* overwrite the previous sound captured, but the sound inside the module still produces sound after having closed the effect, until a new *down-bow impulse* is performed cancelling the recording.

-*Static-freeze* records a very short chunk of sound, whose length is determined by the tilt position of the bow during the *down-bow impulse* (with *tilt* near zero the recorded chunk will be extremely short): the length of the freezing sound is given in number of frames inside the nearby number box.

-*Dynamic-freeze* instead records 2.5” of sound, allowing for a broader interaction whose nuances upon the freezing sound are controlled by many bow gestures together in combination.

The other two instruments, the *real-time instruments,* instead process the live sound directly.

-The third instrument, called *spectral deconstruction*, operates a detachment between the sinusoidal and the noisy components of the instrumental input. When sinusoidal components are enhanced, the effect produces a sort of “Flute of Pan” transformation: few or many sinusoids can contribute depending upon the bow controls of the effect. The noise-component enhancement instead pushes the sound to be aggressive and very responsive: sound can also be transposed and differently modelled. Inside the *spectral deconstruction effect* the final result is highly dependent on the input in the sense of its flat, light, rich or dense timbre qualities.

-Dynamic equaliser (*spectral delay*) is a deep and selective equaliser in 64 bands operating on the cello input. It is designed in order to shift between fixed-EQ states and very dynamic changes sounding as a sort of cascade-EQ. The single bands are prone to delays and feedback in order to mix their individual different persistence.

All the effects are shaped and controlled in their time behaviours by the bowing styles.
The cellist therefore performs a double action upon the acoustic instrument and upon the electronics whose shapes are influenced and mastered by the bow gestures.

<u>Internal nuances and controls</u>
The controls schematically summarised below are visually represented in the *virtual-instrument* monitors of the App, and should be aurally-visually explored.

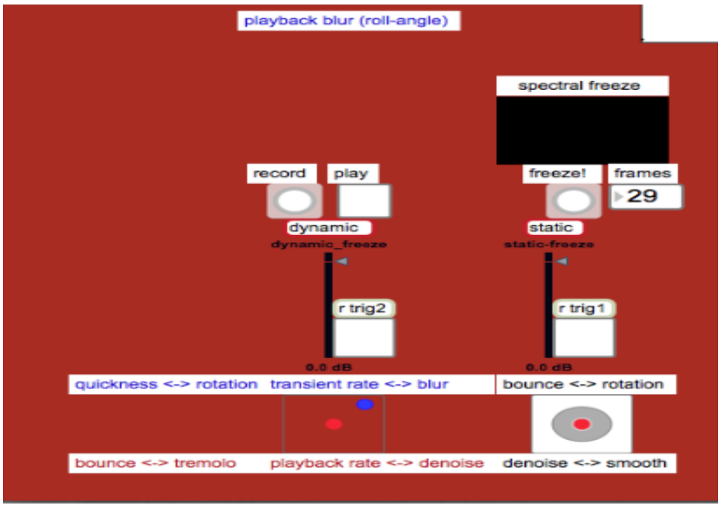


Fig.3-C_1 Action score Freezing spectrum instruments

1) *Dynamic-Freeze*
The sound captured and freezing is dynamically shaped in this way:
-playing low strings the portion of sound output is quite thin , rolling towards higher strings the portion of sound performed is larger, and the output result will sound more blurred and "confused", as shown by the blue zone inside the sonogram.
-the intensity of bouncing (B*alzato*) affects the playback velocity of reproduction of the freezing sound (few-bouncings -> static sound; intense bouncing -> quick playback;
no bouncing> reverse playback).
-the more intense the *Tremolo*, the more artificial and light is the output: the *denoise* effect proportionally selects the most prominent sinusoidal parts of the captured sound.
-the bow Energies of *velocity* and *rotation* help to define clear and quick transients, otherwise blurred and slowed down when the bow is slow and moving on the same string.

Two small red and blue balls move inside the visual control space as bow monitors, even if the sonogram returns a more consistent visualisation of the sound processes in action, caused by the bow interactions.

2) *Static-Freeze*
-an intensively bouncing (B*alzato*) bow increases the *denoise* effect
- an intense *rotational* bow activity increases the *smooth* effect, making the sound static and dense. These sound effects are again monitored through a small red ball moving inside the control space, the largeness of the grey circle shows the time length of the tiny *freeze,* even if the aural response and the sonogram diagram should be enough.

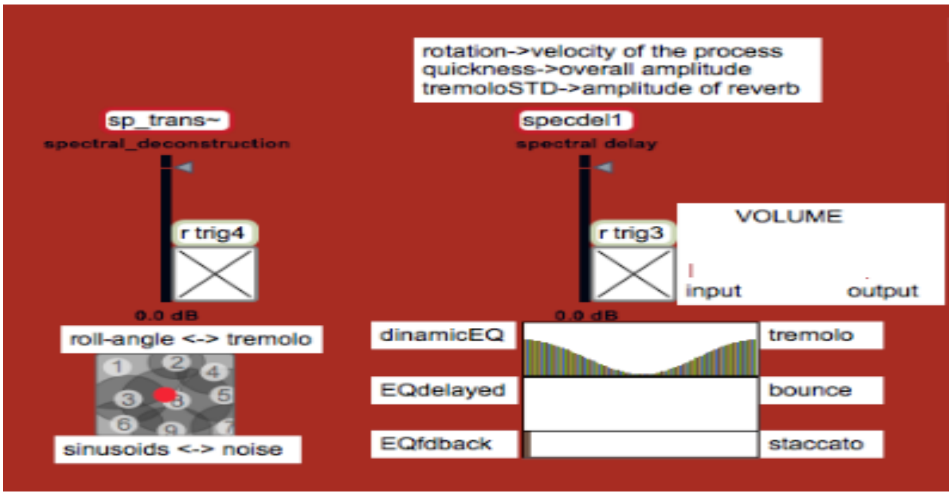


Fig.4-C_1 Real-time spectral instruments (dynamicEQ)

3) *Spectral_deconstruction*
-low vs. high strings bow-position moves the red ball high vs. low,
-*Tremolo* intensity moves it left and right.
It is a visual cue allowing to navigate inside a non-obvious control space, intersecting different nodes mapped to specific sound effects of density, transposition, sinusoid extraction, noisiness.

4) *Spectral delay* (dynamic equalizer)
-the intensity *of Tremolo* shuffles the resonance bands of the spectrum moving from high to low (graphically from right to left) in a wave fashion: it is represented in the *dynamicEQ* upper monitor.- by varying the intensities of bow-bouncing, the delay effect operates upon some detected spectral bands: *EQdelayed* middle monitor.
-*Staccato* increases the "feedback" (the tendency of the effect to persist): *EQfdback* lower monitor
-the intensity of *rotation* across the strings makes the equalisation shifts much quicker and dynamic, whereas playing on one same string makes the equalisation fixed and still, as underlined by the monitor shifts.
-bow *velocity* (*quickness*) and the *Tremolo* irregularity increase the volume and the reverb of the effect, as shown by the input and output volume-monitors.

Obviously this detailed support has to be globally experienced inside the aural/visual concrete interaction in order to be effective.

CELLO_2. ARTIFICIAL

Video performance instructions at: https://www.dropbox.com/s/789z2g5lhwccvda/cello2-instructions.mp4?dl=0

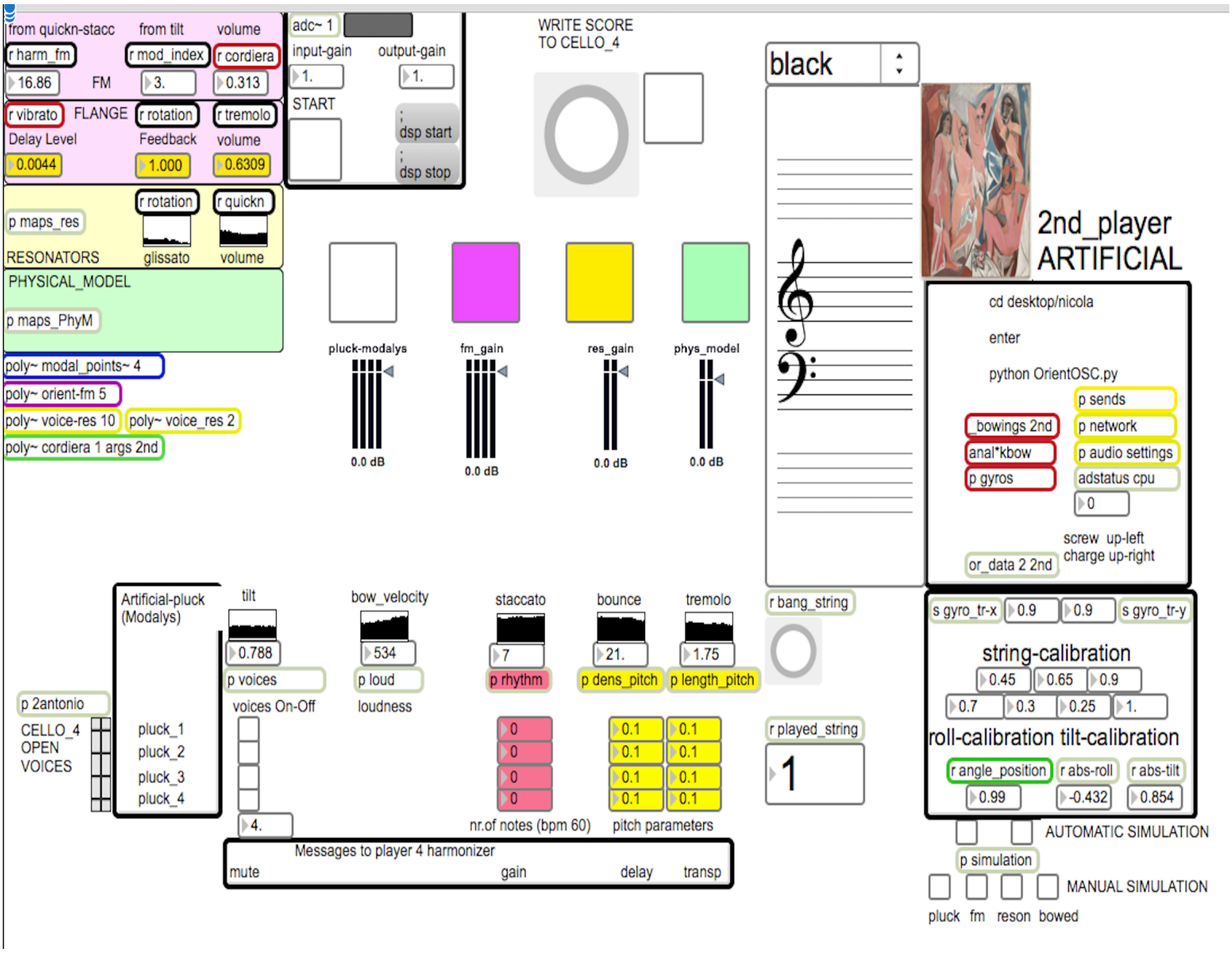


Fig.1-C_2 Cello_2 application

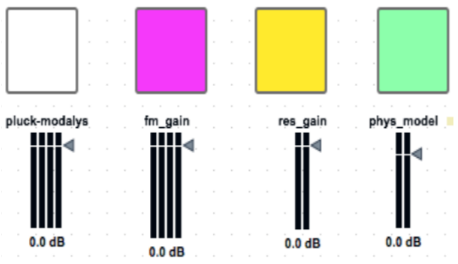
ELECTRONIC SOUNDS AND INTERACTIVE ROLE OF CELLO_2

This system is very gestural, and it generates synthetic sounds. Unlike the other musicians, the electronics act here as a contrast with respect to the cello sound, and the results will be far from obvious. The cello sound, though, is crucial for influencing the artificial sounds, which are mainly generated by the bow movements (on the string as well as in the air).

You can find a good control of the electronics by mixing bowing styles and sounds creatively. Whilst the computer interprets your musical gestures and transforms them into sounds of synthesis, it sends you visual monitors of your movements and of the sounds you are producing. In this way you receive clear feedback about how to invent and organise your performance.

Your electronic sounds are not totally foreseen, and in order to get interesting results you'll have to practise, listen and act intuitively. Notice that the acoustic cello sound sums up the electronic sound, in a sense you are playing two different instruments in coordination and at the same time.

Received messages
A variable chord (created by Cello_4 and sent to all the players) appears on the screen: freely improvise upon this tonal centre.



The electronic sounds are created through four virtual instruments, represented by differently coloured buttons located in the central part of your screen: when the button is crossed the instrument is open and you will see below it green movements representing the amount of sound produced.

Fig.2-C_2 Four virtual instruments

But you don't decide when to open and close these instruments (the choice comes from Cello_4). You can only modulate the sounds internally to the effects when they are opened.
The task is not simply to modulate the electronic sounds of your individual augmented cello: you have at your disposal further techniques interacting with the other musicians, in particular with Cello_4 (whose electronic instrument multiplies and transposes in a "canonic" fashion his/her sound).

Messages to Cello_4
-your bowing styles (*Tremolo, Balzato, Staccato*) determine the kinds of harmonisation upon Cello_4
-you decide how many "voices" are making up the Cello_4 "counterpoint"
-Cello_4 sometimes receives a pentagram score in real-time, whose notes are created by your bowing styles.

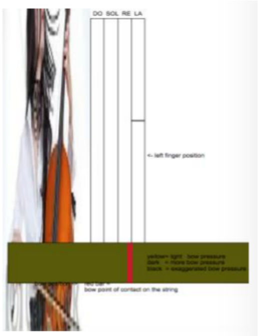
Messages to the ensemble
-when you perform a special bow gesture in the air, an interactive action score appears on the screens of Cello_1 and _3 (and yours too).
-some impulsive bow movements have the function to strongly modify the video.

Timings
As described above in the general instructions, the background colour of the screen has a precise meaning:

-Black (during Cello_1 solo): silence
-Dark (first part of the interaction): rarified sound commentaries, perform some gestures as messages to the ensemble.
-Bright (central part of the interaction): play more intensively; when the colour is white it signals the presence of your solo
-fading to Dark (second part of the interaction) play less intensively, but keep alive the gestures modifying Cello_4 electronics (you will notice that his/her is playing much more in the second part of the work).
-again Black (ending part): stillness

INTERACTIONS

Messages to the ensemble (first part of the interaction)



-*"quick-impulsive horizontal-bow"*.

An extremely impulsive and Horizontal (parallel to the floor) bow gesture immediately triggers an action score for Cello_1, _2 and _3: you will interrupt any current activities in order to play this animated graphic score together. The strength of your impulse has an impact on the length of this performative window, which it will be anyway short lasting.

The performance instructions of this score are explained above inside the general instructions (p. 7).

Fig.3-C_2 Action score

Don't launch this effect too many times. It will be especially suitable for offering immediate vitality and contrast to the performance: find the right moment, and notice that the effect is active after the initial solo of Cello_1, and it will be disabled in the final part.

-*"quick-impulsive triggering rotations"*.

Four quick impulsive *rotations* of the bow in the air (up-down-external-internal) modify the state of the video:

Internal = Black

External = Colored

Up = visible score

Down = full video

Fig.4-C_2 Message to video

This interaction is active in the first part of the work, after the first receiving of the score by Cello_4 the process will be automatic, and after that you'll be able to concentrate better on the musical aspects.

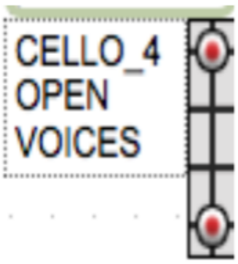
MESSAGES TO CELLO_4 (mainly in the last part of the interaction)
Electronic sounds
You decide how many voices "harmonise" Cello_4 (and you can change their number).

Each of your four strings is connected with one of the four voices of Cello_4.

When you produce a sufficiently clear sound attack, you'll be able to see inside your screen a yellow flash (named "bangstring"): at this point the system attempts to predict which of your strings you are currently playing; as a consequence the corresponding voice will be opened inside the electronic polyphony of Cello_4. If you put your bow on a string and you pass from the position "full-hair" to the position "hair plus wood", you will close the corresponding voice.

Fig.5-C_2 String recognition

These string positions are recognised by the system both if the bow is upon the string and if it is flying in the air.



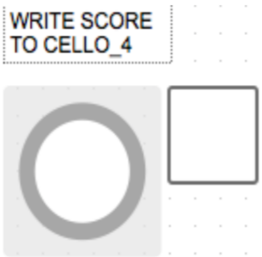
In the bottom-left part of your screen you can find a small monitor showing how many voices are active in the polyphonic system of Cello_4.
Four red buttons = all voices active; no red button = silence.
In this way you can model the density of the electronics of your colleague.

Fig.6-C_2 To Cello_4 polyphony

You can also model the quality of the last opened voice (without excessive worries about the details, the global controls are):
-the intensity of *Staccato* increases the amplitude of that "voice",
-the intensity of *Balzato* transposes it higher (and less or no *Balzato* = lower)
-the intensity of *Tremolo* increases the Delay (intense *Tremolo* = distant repetition until 5" less or no *Tremolo* = close repetition until 1/5 of a second)

It is worth noting that an identical system controls one of your virtual instruments, as will be described later

Score



A red flash in the upper part of the screen signals that the Cello_4 score is building up as a consequence of your bowing styles (it will happen much more frequently in the second part of the performance). A cross inside the white square tells that the process is working, until the cross disappears.

Fig.7-C_2 To Cello_4 score

The Cello_4 score is notated in 4/4 tempo. How to influence the interactive score:

-*Legato* produces long notes (2/4, 3/4, 4/4)
-*Staccato*: the more intense the *Staccato* is, the more quick and irregular the score rhythms will be
-*Balzato*: no *Balzato* = low notes; the intensity of *Balzato* increases the change of pitch register until very high notes in the treble clef
-*Tremolo*: when intense and irregular it increases the variability of the melodic contour.

THE ARTIFICIAL SOUNDS: VIRTUAL MUSIC INSTRUMENTS
After the details about the influences of Cello_2 upon the ensemble, this section describes the internal sound interactions of Cello_2 as an individual augmented instrument. These aspects will be more present in the central part of the performance, and its density will be tuned to the background brightness of the laptop screen.

The musical gestures (sounds and bowing styles) modulate the effects of the Virtual Instruments, only when they are opened (by Cello_4): if several instruments are opened together, the same musical gestures act in parallel, if the all instruments are closed no sound will be audible, except the amplified acoustic cello.

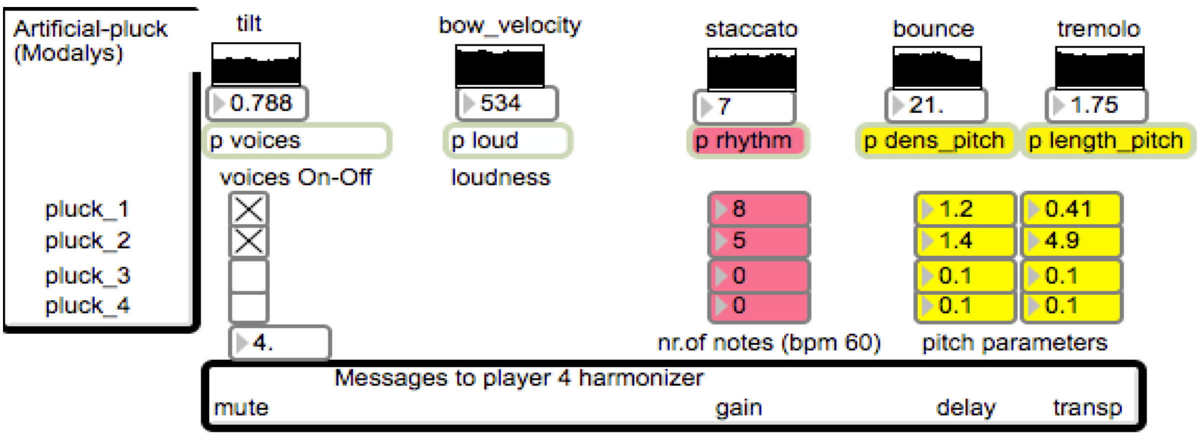


Fig.8-C_2 The instrument “Mandolins”

-White instrument “Mandolins”
The sound is produced by physical models synthesis, simulating an artificial plucked string. The system is the same as the virtual engine affecting the Cello_4 “polyphony”, and obviously the same gestures affecting the “mandolins” have a parallel influx upon the Cello_4 electronics.

Each cello string is connected to a different virtual mandolin, the actions upon the mandolins work only when the effect is active (white button crossed).
The visual monitor is in the central-bottom part of the screen.

It is the only instrument working through a explicit and visible connection between the bow gestures and the electronic sounds.

Functions:
A clear sound attack produces the yellow flash “bangstring”, signalling that the system tries to detect which string you are currently performing.

The corresponding mandolin starts to play and you can modulate its notes (if other mandolins are active in this moment, they keep steady notes and rhythms as a “bordone”).

In the monitor “voices On-Off” you can see which mandolins are currently playing (crossed or uncrossed buttons); the numbers in the red and yellow boxes are flowing only in correspondence with the currently selected “soloist” mandolin.

You modify the notes of the “soloist” mandolin with the same procedures above described:

-*Staccato* intensity -> quicker rhythms; *Legato* -> slower rhythms -
Tremolo intensity -> the mandolin note shifts down in small intervals
-*Balzato* intensity -> the mandolin note shifts down in larger intervals
If the bow stays still, it shifts the notes very high and at a very slow rhythm.

When a new string is selected (through the “bangstring” process), the last note values of the previous “mandolin” remain unchanged. For this reason it is suggested to cross from one “mandolin” to a new one in a very dynamic fashion, in order to avoid that the last note pattern will stay fixed on high notes because of unconscious intermediate bow rests.

The overall *velocity* of the bow increases the mandolin volume, and the cello timbre has a slight influence on the mandolin timbre.

When you decide to silence one mandolin, place the bow in position “full hair” on the corresponding string, and shift it to the position “hair plus wood” on the same string (the process is only gestural, you can perform it silently without playing).

Violet instrument: “Electric guitar”.

The sound is produced by frequency modulation synthesis (FM), with added flanger and reverb. In this case the cello sound is extremely important as a source of the modulation.

The five carrier frequencies of the FM are the same as your main cello sound partials (sounds on the bridge or very noisy sounds produce high pitch variability, a more conventional cello sound retunes the sounds of synthesis together).

The overall amplitude of the effect is regulated by your cello amplitude.

Cello_4 can increase the timbral density of your effect through his/her expressiveness.

This instrument is complex and it has to be governed more with practice and listening rather than with theories, but it is useful to know that:

-*Tremolo* intensity increases the volume of the flanger (a sort of “Hendrix” effect) if Cello_4 in this moment plays more “espressivo”.

-Playing cello without changing string with the bow, the flanger starts to be massively coloured, but in presence of intensive bow *rotations* across different strings, the flanger effect decreases, and the overall sound colour changes (only the FM remaining active).

The FM is mainly modelled by bow *velocity*, bow tilt (“full hair” vs. “hair plus wood”) and different gradations of *Staccato* vs. *Legato* bowing.

In terms of FM synthesis the result will be:

Slow bow -> much more harmonic sound,

Fast bow -> sound dense and intermingled in timbre;

“Full hair” -> aggressive sound

“Hair plus wood” -> simpler and resonant sound,

Legato -> consonant timbre

Staccato intensity-> inharmonic timbre,

Balzato intensity -> increasing the reverb/resonance of the sound

Therefore a very slow-legato-wood playing style will allow a sort of “spiritual” sound effect (enhanced if the bow is left still in the air with the cello resonating). Conversely energetic bowing styles afford different contrasting effects, all raising artificial copies of the cello sound.

Notice that if you wish to completely silence the effect you need to stop the string with your hand, otherwise the effect will maintain the cello string resonances.

Yellow instrument: “Glissati”

Additive synthesis: also in this case the partials of the cello sound feed the artificial one (resonators), but here there is no audible resemblance between the acoustic and electronic sound.

The timbre oscillates between pitched glides, whistles and light/foggy small bells.

This instrument interaction is also impossible to be described in detail because the musical gestures interlace in a complex fashion; also in this case an “espressivo” performance by Cello_4 contributes to the overall volume and resonance of the effect.

Low notes (especially if dark in timbre i.e. sul-tasto, resonant pizzicatos etc.) make the artificial pitch glides slower and lower in tuning, high cello pitches (especially if *Balzato* in bowing styles) interrupt the continuity of the pitch glides. *Tremolo* intensity raises the volume and the presence of hidden resonating sonorities. Contrasting timbral differences are produced if the bow crosses the strings rapidly rather than playing on a same string.

The overall effect is quite interactive, the artificial sounds respond not synchronously to the cello, and the instrument requires some previous practice exploration.

Green instrument: "Resonant percussions"
It is a double system of physical models synthesis.

A) deformation of the cello sound,
B) resonant percussion (like a huge gong or a beaten piano stringboard),

-every energetic sound attack of the cello (monitored by the "bangstring" flash) produces
a percussive output

-a nervous and quick bow conduction builds up selective bands and contrasting spectral zones,
as a consequence extreme timbres and intonations arise when the percussion happens

-intensity of *Staccato* and bow-*rotation* amplify and characterise these nodes of resonance,
on the contrary legato styles on a same string soften the timbre and make it more changeable.

-playing with a small portion of hair and no *Balzato* increases the resonance of the percussion,
the opposite contributes to a less aggressive and detailed sound

- *Tremolo* intensity increases the amplitude of the deformed cello

The overall augmented cello has to be experimented with freedom and focus in order to memorise these new connections between bow gestures and artificial sounds. The only direct and explicit instrument is the first one, called "mandolins", the others are to be understood in an intuitive and instrument virtuosic fashion.

All the electronic nuances depend on the interrelations between the cello sound and the seven bow movement detectors, monitored inside the laptop screen. The intensities of these bow movements contribute together to the artificial sounds and they are organised as bowing styles *(Tremolo, Staccato, Balzato*), Energies (*velocity* and *rotation*), Orientations (Horizontal from the low to the high string, Vertical defining the bow inclination with respect to the string)

CELLO_3. SAMPLER

Video performance instructions at: https://www.dropbox.com/s/h0d0yi83x2pfkbe/cello3-instructions.mp4?dl=0

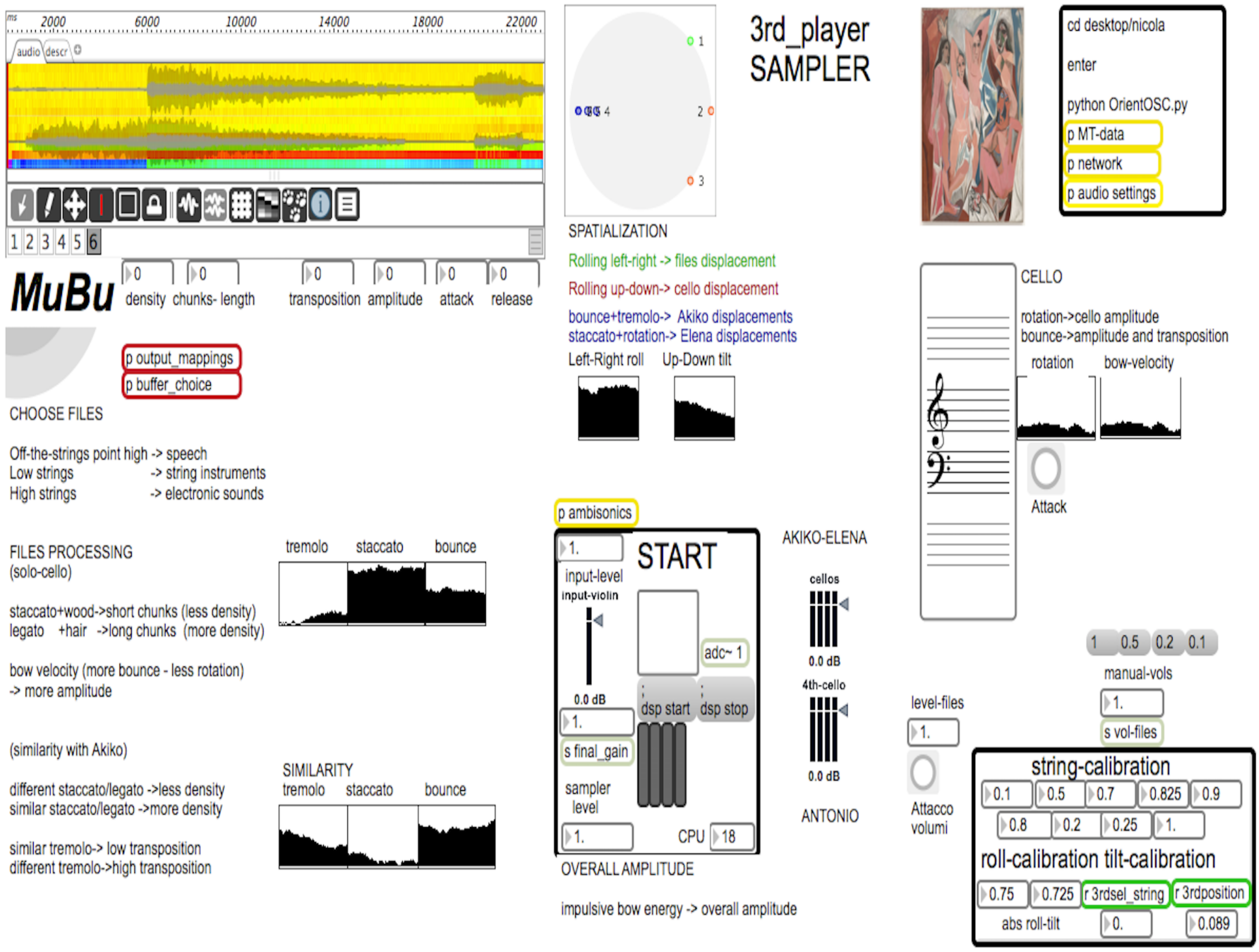


Fig.1-C_3 Cello_3 application

ELECTRONIC SOUNDS AND INTERACTIVE ROLE OF CELLO_3

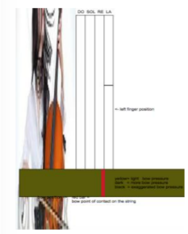
Cello_3 shares with Cello_2 a developed focus on gesture. The sound of the cello is autonomous from the electronics, which are produced by bowing styles.

The principal role of Cello_3 is to spatialise the sounds of the ensemble: this activity is a principal aim from the beginning (during the Cello_1 solo) until almost the end of the performance (when Cello_4 closes the whole work alone, being the only musician provided with an independent spatialisation).

Cello_3 electronic sounds will be in the foreground especially in the middle part of the performance (following the evolutions in the brightness of the laptop screen). The autonomous electronics of Cello_3 consist in selecting and manipulating prerecorded audio files. In the second part of the performance Cello_3 can record live short portions of the sounds produced on stage by single musicians, substituting in real-time the old files with some of the new ones.

The events created by Cello_3 (the audio files sonically transformed) have the function to create contrast and discontinuity, also in opposition to the unifying activity of spatialisation.

As below described, a preferential dialogue between Cello_3 and _1 regards contrast/imitation patterns in the production of the bowing styles *Tremolo, Balzato, Staccato*.

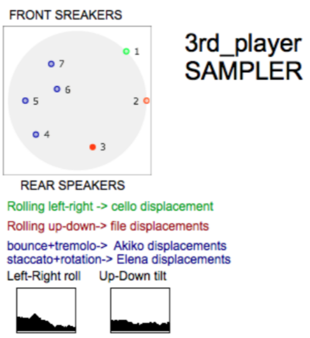


In addition, together with Cello_1 and _2, Cello_3 will be receiving an interactive action score sent by Cello_2. The score arrives as an improvised and unforeseen window inviting the players to interrupt all previous musical action for a short period. In presence of the action score all three musicians must perform the gestural indications provided (“Interactions”, p. 7) together and with intensity.

Fig.2-C_3 Action score

SPATIALISATION
The spatialisation is driven through the algorithm Ambisonics.
The sound movements are rotatory inside the audience space.
The upward part of the monitor shows the frontal speakers, the downward the rear.

Seven sources are spatialised:



-one copy of the player's own amplified cello sound (green source) shifted by the Horizontal bow Orientation (*rotations* between the high and low string of the cello)
-the stereo output of the Cello_3 sampling electronics (two red sources) driven by the Vertical bow Orientation (from “full hair” to “hair plus wood” positions)
-the double stereo of Cello_1 and _2 (four blue sources) respectively shifted by *Tremolo* and *Balzato* (Cello_1 stereo), *rotation* and *Staccato* (Cello_2 stereo).

Fig.3-C_3 Spatialisation

The overall bow *velocity* contributes to:
-accelerate the global sound shiftings
-increase the distance between the Cello_3 outputs (the red sources).

LIVE RECORDING
Through four *rotational* bow movements in the air (the up, down, internal, external *“quick-impulsive triggering rotations”*) you will get the recording on-the-fly respectively of Cello_1, Cello_2, Cello_3 (Cello) and Cello_3 (Electronics).

Fig.4-C_3 Red_Monitor

The live recording system is active and exploitable from minute 5 after the beginning: the recognition of the four triggering movements (crossed/uncrossed buttons), is visible inside the section "recording" shown in fig.4-C_3. Every new recorded file progressively substitutes the audios stored from the beginning, their waveforms are visible inside the "Mubu" interface (fig.5-C_3).
The procedure of file selection in order to output the sampled sounds remains unchanged and it works as follows:

SAMPLING

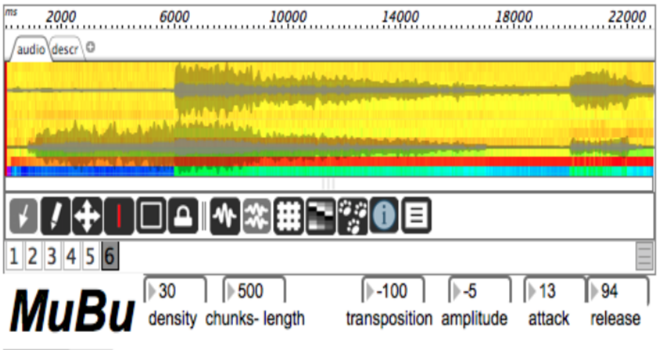


Fig.5-C_3 Sampling

Right from the beginning the system loads six short prerecorded sound fragments: you can select them in this way:

-You have at your disposal six different zones of bow inclination: 0 corresponds to "bow-point towards the floor and frog towards the ceiling"; 1-2-3-4 correspond to your four cello strings; 5 corresponds to "bow-point towards the ceiling and frog towards the floor".
-Each of these zones of bow inclination relate to the specific inclinations of your strings towards the floor (the zones are detected both if your bow is on the string and if it is flying in the air). A reference number ("sel_string") shows which zone you are currently occupying.

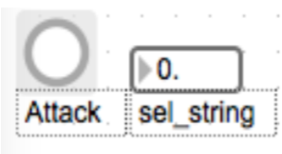


Fig.6-C_3 Choose-file

-In order to put in function the detection you must make a sound with a clear attack (maybe a left hand pizzicato would best fit, so you don't disturb the bow location): a yellow flash signals that the sound attack is detected and as a consequence the bow-zone number is activated. After one second the corresponding indexed file is selected and starts playing[8].

[8] This latency offers more stability to your musical choices and avoids unwanted file selections. Notice that every detected sound attack produces a new file selection. Therefore you have to play a sharp sound when you wish to change a sound file, otherwise during the course of the overall performance your sound style must be generally soft and smooth.If the machine starts to make autonomous decisions (maybe too many for your taste) don't be worried: interact with fantasy!

In other words each bow zone tags a different audio file stored in the system; the latency of the system and the need for a triggering sound attack prevent continuous and meaningless file selections, affording stability to the sampling interaction.
-the six files in numeric order contain: spoken voice, cello sounds, string quartet chords, electronic sounds, electrified piano, water mixed with sounds
-after having selected the file, you embed sound transformations upon it through a granular system which splices sound portions in lengths conceivable as "musical notes": the audio files will be kept more or less recognisable, at least in their timbral aspects.
-the methods of sound manipulations of these "sampled notes" are mainly controlled by your bowing styles, but in part influenced also by the Cello_1 bowing styles: attention and coordination in the reciprocal bowing styles are therefore a chamber music interactive duty.
-the sound manipulations of the files regard: volume, transposition (up and down) and density.
-the density is obtained through the durations and the frequency of occurrence of each fragment: very short fragments output at bigger time distances will produce some sort of rhythmic patterns, long fragments output at high speeds of occurrence will conversely produce overlapping until dense textures. The joint variation of these two parameters (length and frequency of fragments) will produce a high degree of variety in sound emissions.
-further parameters influence filtering and more timbre features of the sampled files
-an internal system of audio analysis allows the software to automatically select the file portions more similar in timbre to the cello sound you are currently performing: you can therefore have an impact upon the sounds you are sampling through your cello sound; the other methods of granular sampling are instead driven by your bowing styles.

CELLO
The amplified copy of the cello sound will be generally soft and it will sometimes be output. Some of your bowing styles increase its presence, some others produce slight gliding transpositions emerging as distant shadows alternating with your sampled audio files.

As with the other musicians, a variable chord is present on your screen: this shared tonal centre is a free point of reference for your improvisation.

BOWING STYLES
Each subtle change of your electronics depends on the set of seven bow detections, whose monitor is visible on your screen. It is pointless to control every single parameter individually without influencing the others, the bow actions will be the results of global activities focusing upon goal oriented interactions (as happens in every musical instrument).

Every single parameter has intensities between 0. and 1. (visually from white to black), the parameters detect:
-Bowing styles (intensities of *Tremolo, Staccato, Balzato*)
-Energies (*velocity* and *rotation*)
-Orientation (Vertical -> "full hair" vs. "hair plus wood", and horizontal -> from low to high string)

These seven parameters are common to the other players, but your system is provided with three more parameters: the difference in intensity of *Tremolo, Staccato* and *Balzato*, compared to Cello_1: the more your bowing styles are similar and the more the values of difference fall to zero, the more they are different (i.e. one is playing *Legato* while the other is playing *Staccato*, one player is playing *Balzato* and the other one not etc.). The difference value raises until 1. These values are here defined as “Similarity/TR”, “Similarity/ST”, “Similarity/BLZ”.

Below is a list of the bow parameters and their effect upon the electronics (notice that the parameters are affected through bowing styles performed upon the string, as well as in the air).

Amplified cello:
-Bow slow, with *rotations* between the strings-> increasing volume
-Intensity of *Balzato* -> transposition high
-Similarity/BLZ -> low glissato (high glissato if the value is opposite)

Sound files:
-Impulsive bow Acceleration Horizontal or Vertical (with no *rotation*!)
-> loud attack with slow fade out
-Intensity of *Balzato* -> contributes to increase the amplitude
-(*Legato*, Col-legno, Similarity/ST) -> indirect volume increase (more density of sounds)
-Intensity of *Staccato* -> shorter grain fragments
-Bow *Legato* -> longer fragments (more recognisable)
-Col legno -> more density of occurrence of the file grains
-“Full hair” -> rarified and intermittent occurrences of the file grains
-Similarity/ST -> more density of occurrence of the file grains
-Similarity/TR -> lower transposition of the file sound (higher if the value is opposite)
-*Velocity* and *rotation* -> contributes to a clear timbre (in terms of attack/release)
.
You can notice that some bow gestures overlap their functions, and it contributes to a better ductility of the system.

It could be helpful to summarise the most important interactions:

-*Velocity* impulse without any *rotations* = dramatic loud file impulse
-Intensity of *Balzato* = sustain in the file amplitude
-*Legato*, Col-legno = high density-manipulability of the file contents
-Intensity of *Staccato* = file fragmentation
-Slow *rotational* bowing = emergence of the cello
The dynamics of similarity/difference of the bowing styles compared to Cello_1 offer unforeseen variables and the opportunity for a chamber-digital interaction.
Further sound connections can be freely found and explored

CELLO_4. HARMONISER

Video performance instructions at: https://www.dropbox.com/s/l22t12bsv2tpwrd/cello4-instructions.mp4?dl=0

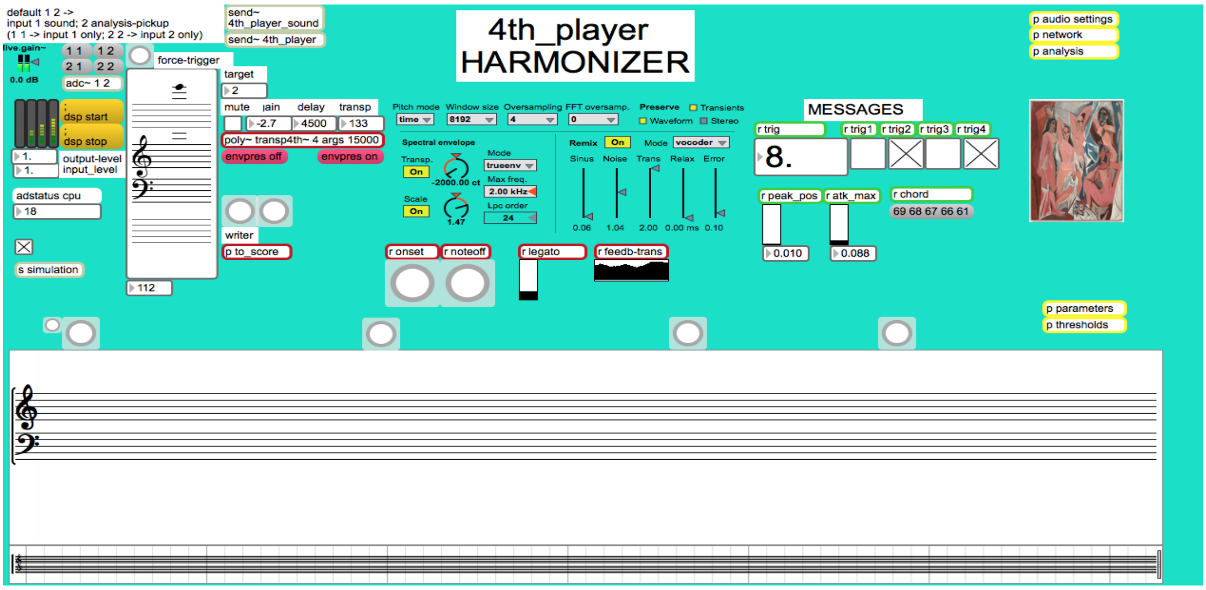


Fig.1-C_4 Cello_4 application

ELECTRONIC SOUNDS AND INTERACTIVE ROLE OF CELLO_4

You are the only musician not exploiting motion tracking. The kind of interaction is therefore different, not gestural, but based on communication with the other players through notes, timbre and music expression. The main part of your interactive system is organised in terms (almost traditional) of notes and models of expressivity.

Your performance will be split into two different modes:

A) interaction (with Cello_2),

B) free performance plus interactive score sight reading.

The mode A will be prevalent in the first part of the piece, the mode B in the second, but the mode A will be also present until the end. The density and the alternation between these two performance modes will be dependent on the colours and brightness of your screen. The brighter your screen (it will happen in the last part of the work), the more free and intense will be your music (mode B).

When the screen is dark you will be limiting the performance only to the functions of dialogue and control upon Cello_2 (mode A).

In performing mode A you decide which kind of sonorities are coming out the electronics of Cello_2. On the other hand an important part of your electronics is controlled by Cello_2. Your electronic sound is based on repetitions, accumulations and transpositions of the music as you perform and improvise it. The bowing styles of Cello_2 determine the “harmonisation” and time shifts of your multiplying electronic cello. Sometimes this harmoniser output could recall almost classical ideas of “canonic” polyphonies, which can be distorted, hidden or exasperated by your timbral choices executed during the performance. In fact your cello timbre affects the timbre of your electronic output.

START/STOP
You are responsible for the starting process of the interaction.
-The music starts for everybody when you press “Spacebar” from the laptop keyboard.
-The whole music ends when you press “Enter”, after having closed all the effects of Cello_2 and after a brief fading out musical pause.

INTERACTIONS
-After the start the initial part will be silent (your screen will be black)

-During the continuation (after the Cello_1 solo) your screen begins to be dark coloured and as soon as you see Cello_2 starting to play, you can progressively interact with him/her through brief events of detached notes (this kind of interaction is explained below)

-The intensity of your interaction can increase as your screen starts to be less dark

-A full and fluid performance is foreseen in the last part of the performance, when your screen will be bright, a final solo will happen at the end when your screen will be white

-Never forget to maintain a control upon the sounds of Cello_2.

The influence upon Cello_2 is crucial and consists in:

-Opening and closing his/her sound effects (more effects can be left open in parallel, increasing in this way the overall density of the sounds of Cello_2)
-Contributing to increase volume and resonance of the effects n. 2 and 3 of Cello_2.

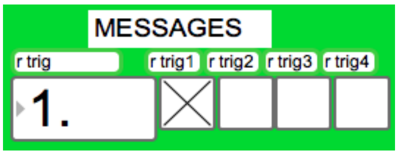


Fig.2-C_3 Interval detection and messages to Cello_2

The activation of the Cello_2 effects is actuated by a system of recognition of your note-intervals. The system responds only when your intervals are higher than one octave:

-The interval of a semitone controls the activation of the effect “Mandolins”

-The interval of a minor third controls the activation of the effect “Electric guitar”

-The interval of a tritone controls the activation of the effect “Glissati”

-The interval of a minor seventh controls the activation of the effect “Resonant percussion”.

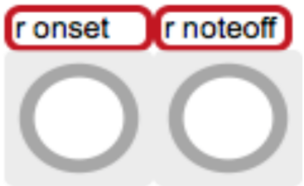
A rising interval opens the corresponding effect, a downward interval closes it.

On the screen the interval number is visible as it is recognised by the machine: the effective numbers are: 1, -1, 3, -3, 6, -6, 10, -10, meaning the upward and downward semitone, minor third, tritone, minor seventh.
At this point a cross appears, or disappears, inside a corresponding box (see fig. 2-C_3), the same cross appears inside the screen of Cello_2, signalling the opening or closing of the sound effect.

When your note is detected, if you perform them with more internal crescendos, the system recognises a higher amount of expressivity through the parameters called "peak_pos" and "atk_max".
In this way you can increase the volume and resonance of the effects of Cello_2

It will be useful to detail the system of note analysis and detection.

NOTE DETECTION AND EXPRESSIVENESS



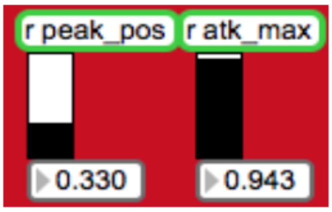
-1) In advance of the note-interval recognition the system must individuate the beginning and the end of the note ("onset" and "offset"): you can monitor it through a pair of yellow flashes signalling the on-set and the off-set (note-on and note-off).

Fig.3-C_4 Note-on/off detection

The system of analysis is able to recognise only one note at every take, and before a clear note release (signalled by a note-off) the machine can never detect a new interval: the release can be a subtle pause as well as a clear decrease in amplitude; two notes in "legato" style cannot be detected. In addition the double-stops are not understood by the system, which is monophonic. Some previous practice will be necessary in order to properly interact, due to these limitations of the system[9].
For this reason the performance style employed for the control upon Cello_2 must be based on single and slightly detached notes. As a contrast the style exploited for playing the solos will be free and fluid. The whole performance is based upon the contrast of these two different styles, which allows two consistently different sound responses from the electronics.

-2) after having time-defined the whole note (after each note-off), the system returns a simple estimate of a few parameters of expressiveness, computing whether the internal of that note contains a sound variable in intensity, provided with crescendos, or it is more or less sustained rather than decaying. Two small monitors in the lower part of your screen show these values (relative to the last performed note), which are mapped to the intensity and resonance of two electronic effects of Cello_2 ("glissati" and "electric guitar").

[9] Occasionally the machine can make mistakes in predicting the note interval, if this happens it will be simply necessary to perform new notes without breaking the continuity of the music. If too many mistakes occur, a new calibration needs to be done.



This pair of parameters, more sensitive to the evaluation of expressiveness, are “peak_pos” and “atk_max”, respectively indicating:
-where the peak of amplitude is located inside the note (beginning, middle, end)
-how strong the attack is with respect to the maximum peak of the note.

Fig.4-C_4 Expressiveness parameters

TIMBRE
Your electronic system is in turn strongly influenced by the bowing styles of Cello_2, who determines the density, transposition and time shifts of the electronic voices which harmonise your sounds (and as described in a following section, Cello_2 is also responsible, through bowing styles, for the notes filling your interactive score in real-time). You don’t control your own electronic harmony, but you have a crucial influence on the timbre of your electronic voices, controlling it by means of your own cello timbre.

-1) when the monitor “feedb-trans" rises (increasing its black portion), it signals the increase in the amount of transposed repetitions of your sound (increasing feedback) therefore your electronics can become huge; if you lower it, you dry the effect.

Fig.5-C_4 Timbre-expression parameters

In order to increase the feedback, you should produce resonant sounds (i.e. soft low pizzicato double-bass style, or extremely light sul-tasto bowings); bow techniques “on-the-bridge” as well as intense-compressed sound styles lower the feedback, reducing the amount of chained repetitions. This control determines the overall mass of your electronics, but you can gain detail on their timbre.

-2) the “legato” threshold (Fig.28) fixes your electronic timbre at an intermediate default level when you are playing “staccato”. But when you play “legato” (no significant pauses and spaces between your notes) you will be able to model your electronic timbre: at this point you will see some sliders moving, telling you how you are modifying the timbre. In this way the dryer sonorities used to interact with Cello_2 (mode A of performance) will not interfere with your electronic timbre, which can instead be modelled during the free part of your performance (mode B). You can visualise timbre shifts (as an aid to your listening) through three vertical sliders and two rotary knobs.

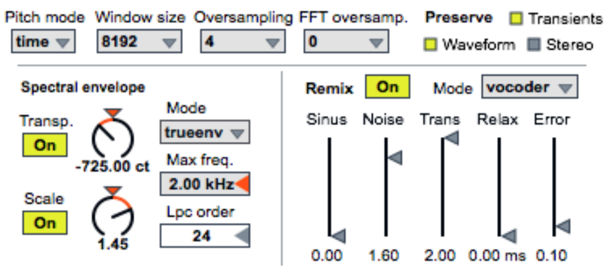


Fig.6-C_4 Tibre interactions

-3) -the two knobs “transp” and “scale” are sensitive to a dark-resonant cello timbre as opposed to a bright-high-compressed-intense one (i.e. resonant pizzicatos or very sul-tasto strokes vs. full tone, on-the-bridge; but also low notes vs. high notes): in other words detecting low vs. high frequency spectral contents. The two monitors will tend to move in opposite directions, but this timbre detection is quite complex and will require experimentation with listening to the timbral causes and effects (varying between deep, light, exaggerated output sounds).

-4) the three vertical sliders are sensitive to:
-extremely still and pure (in timbre, pitch and amplitude) cello sounds -> the parameter "sinus" increases producing a light-spiritual electronic sound
-highly variable cello amplitude -> the parameter "noise" increases producing a more aggressive electronic sound
- variable timbre (fast note changes, and/or quick shifts from ponticello to sul-tasto etc.) -> the parameter "transient" increases producing more clearly defined timbre edges.

Since instrumental timbre is a complex of interleaved phenomena and features, the affection of timbre parameters is a global task: try to experiment, focus and find your own style of performance in order to make a vocabulary of effective timbral influences.

During longer pauses, the sliders could react unexpectedly to the environmental sounds, producing highly deformed timbres: you can exploit this extreme effect. If you decide to include noisy cello sounds you can distort the electronics as well, and it could afford the creation of a wider electronic sound palette.

THE SCORE
The mode of performance B (second part of the piece) includes:
-continuation of mode A (interactions with Cello_2)
-free improvisation (density suggested by the brightness of the background color)
-timbral control upon the electronics (see previous section)
-reading the interactive score (density of score events also suggested by the screen brightness)

You decide when to receive a score. A strong impulsive sound attack (i.e. a Bartok-pizz, or a sharp *Staccato* at the frog) produces a yellow flash near the label “writer”: it activates the score writing process. Cello_2 creates your score through bowing styles (he/her is aware that you have called for your score).

Fig.7-C_4 Calling for the score

-Inside the bottom part of your screen the process of score building (20” long) is visible.
-The score immediately appears, it has to be sight performed, as a unique phrase you have to individuate its character and musical direction on-the-fly
-Tempo is always fixed as 4/4 at 60 BPM
-If it helps you can freely follow the yellow flashes as a visual metronome
-Tempo is not rigorous, but it must not be too enlarged (keep the musical direction)
-A new score can be called for only after the previous one has disappeared
-You are free to call for new scores at will
-Probably the score performance will keep the electronic timbre at its neutral-intermediate level
-Leave room for alternating score-readings with the other tasks of your mode B performance
-Sometimes an unwanted score could appear, a good calibration avoids misunderstandings.

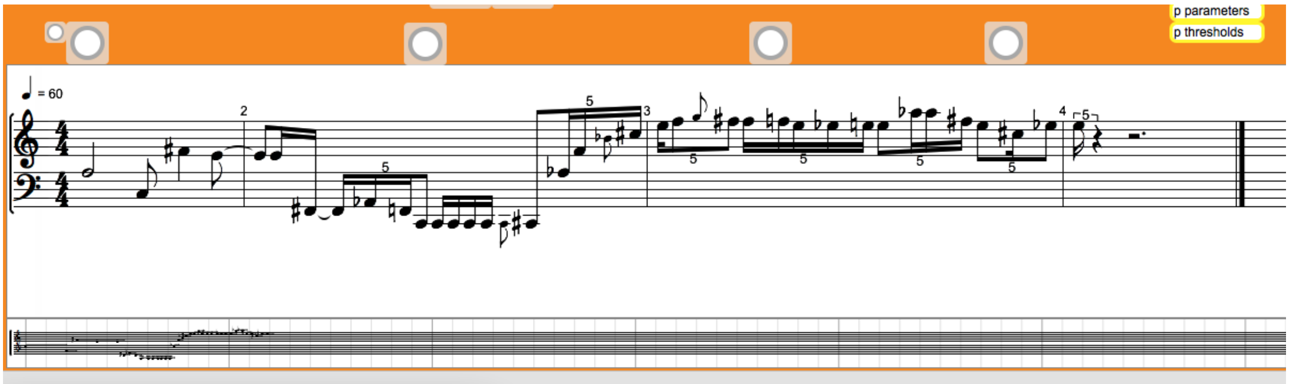
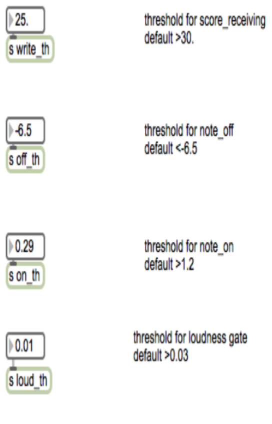


Fig.8-C_4 The score

CALIBRATION

Verifying the parameters of calibration is a task for the coordinator of the performance, but some crucial parameters can be easily rechecked inside the module “thresholds” (accessible by double-clicking its label).

The values are highly dependent on individual features, and calibration has to be rechecked when instrument, player or microphones are different.



1) The main parameter affects the “writer” threshold
(how much sound attack you need in order to call for the score)
-lower the number above the label “s write_th” if it requires too much effort
-increase the number if it is too sensitive and generates too many scores
-the minimum-maximum values of the “write threshold” should be between 15 and 35.
2) If too many note-ons are detected you can raise its threshold (or otherwise lower it if you need the opposite): the optimal range of “s on_th” is between 0.5 and 2.

Fig.9-C_4 Calibration parameters

After having changed the calibration number, press the label “write”.
The other calibrations are detailed below inside the technical section.

LAPTOP_5

Laptop_5 is the main hardware connecting the whole circuitry, and upon which the coordinator of the interaction mainly operates.
The MAX application contains:
-the OSC receiver of the Motion Tracking system
-the network module sending the sensor data to the other laptops through Ethernet
-the video processing driven by the three IMUs placed under the bows of the performers

The motion tracking module “rec_orients-D” is setup accordingly to the release 2015 of the Orients system. In case of a different motion tracking system the abstraction “rec_orients-D” has to be substituted with a new one fitting with the referenced motion tracking hardware.

The system receives accelerometer and gyroscopes in three dimension.
By default the system distributes also quaternions, in case they are not available, please tell the three performers exploiting motion tracking to press the “spacebar” before playing, in order to allow an alternative bow-tracking reading.

All the data has to be sent to the performers as already normalised between -1 and +1, in order to be properly read inside any individual applications. In case of different systems or releases, the default values inside the module “p normalise” must be manually changed accordingly to the minimum and maximum values sent by the inertial system.

The laptop_5 patch is designed with MAX 6.1. and Jitter. The only MAX external employed is “o.route” (see “software” section). The images are processed through Jitter, mixed inside the abstraction "final_cut" and rendered through the object *jit.window.*

The video is rendered through Jitter and it processes in real-time an image of Picasso’s painting *Les Demoiselles d’Avignon,* occasionally mixed with images of bows and music scores. The rendering is a process based automation whose engine is preprogrammed by the composer taking the bowing parameters of the performer as dynamic algorithmic parameters. The performers don’t need to be aware of the video processing. The video shifts between four different states: 1) black; 2) coloured; 3) score projection; 4) dynamic video.

In the first half of the performance the shifts between these states are controlled by Cello_2, in the second half they are automatic.

In states 1 and 2 no images are projected, state 3 shows the interactive score as it is received by Cello_4. State 4 is the complete video rendering.

SETTINGS

HARDWARE EQUIPMENT
Five laptops: each musician performs with an individual MAC, one more laptop is required (MAC or Windows) for video and Motion Tracking collecting/distribution.

The system is tested for MAC OS X 1.6 upwards, and built with MAX 6.1For the App Cello_2 the minimum hardware requirement is 2.4 GHz Intel Core 2 Duo, and the same minimum kind of processor is recommended also for laptop_5.
The remaining three applications don't show special CPU heaviness.

5 ethernet cables 1000 Mbit/s (3 meters length), 1 Ethernet Switch.

1 Master sound card 6 inputs, 8 outputs (or 4 outputs as a minimal option), possibly RME or MOTU+ 2 stereo sound cards (outputs plugged as inputs in the master card), + 1 Sound card 2 inputs and 4 outputs.

2 microphones (for Cello_1 and Cello_4) DPA, or condenser cardioids, or directional.2 directional microphones, or cardioid DPA, or contact (for Cello_2 and Cello_3), 1 pickup for the sound analysis of Cello_4 (showing input isolation; external microphones, or piezo-pickups should be avoided).
PA possibly octophonic.

Optionally mixer and more microphones (individual and/or panoramic) for the direct amplification of the instruments.

Cello_1, _2 and _3 augment their acoustic instruments by means of a small IMU (Inertial Motion Unity) developed by the Centre Speckled Computing at the University of Edinburgh.
The current setup is dependent on the current specs and its updates.
Any different Inertial Motion Unit needs the substitution of the abstraction "or_data" with a new fitting abstraction in Laptop_5, as described in the video instructions and in the Readme file.
IMUs must return accelerometer and gyroscope data in the 3 dimensions x-y-z, and possibly also quaternions.

REAL-TIME SENSING AND ANALYSIS
<u>Motion tracking</u>
Each performer (with the exception of Cello_4) positions the sensor under the frog of the bow with the help of tie sets (the power-chip pointing up). Motion tracking data come from laptop_5. When the network is working the performers will see the data flowing inside the monitors (with the bow Vertical the tilt numbers should be higher, and with the frog pointing to the floor the roll data should be lower: in case it doesn't happen the sensor position is to be reversed under the frog).
The module "bowings" contains the MT computations, and cannot be modified.

The wireless Orient Motion Tracking system reads Acceleration, Gyroscope and Quaternion in the three dimensions x, y, z: therefore we access angles and velocities of *rotation*, but no absolute positions. Each sensor sends data to a central router talking with laptop_5, which decodes the values through Python and sends them to the laptop_5 MAX Standalone through the OSC protocol. Data are then distributed in network through Ethernet.
Figure 4 at the beginning offers a general graphic explication of the bow-tracking functions enabled in the present composition. See the video instructions about calibration.
IMUs return raw data concerning bow Orientation ("angle positions" with respect to the floor), angular velocities (in degrees per second) and Acceleration. The system implemented by this composition develops methods of motion analysis in order to extract bow Orientations, Energies and Bowing-styles.

1) Orientation. At a first stage calibration and filtering allow the detection of Orientation in the two dimensions x and y (called here bow-roll and bow-tilt): mean and smooth Acceleration help to detect the bow angle-positions, taking the directions of the cello strings as a hypothetical fixed reference.
2) Energies. Derivatives and delta root mean squares computed on single and global data from accelerometers and gyroscopes allow the extraction of time information about the bow Energies.
3) Styles. Standard deviations and FFT are implemented in order to approximate the detection of specific qualities and intensities of the bowing styles *Tremolo, Balzato* and *Staccato*.
The system globally responds in synchronised and affordable ways. It is at an experimental stage and could be improved in the future.

<u>Sound analysis</u>
Sound analysis is performed by the MAX objects *gbr.yin, mnm.moments, sigmund~, analyzer~.*
Envelope-following and pitch-tracking are computed upon the overall signal and sometimes at the level of the principal spectral partials. Timbre features are extracted by means of periodicity detection, spectral centroid (and its gaussian distributions), and computing some derivatives and deviations upon the signal amplitude and the spectral centroid.
Sound analysis is performed as a sensing system inside the hybrid tracking system of Cello_2 and more in depth inside the sensing system of Cello_4.
The sensing system experimentally implemented in Cello_4 adds to the spectral features extraction, a combined system of note detection and expressiveness description (performed not completely in real time, but on-stage in the time of the performance).

Combining onset detection and pitch tracking the principal notes and intervals are defined on line.
At a note-level some parameters describe and quantify "legato", timbre-stability, and attack/continuation performance styles (some essential details are contained inside the Cello_4 performance instructions and in the calibration video).

SETUP

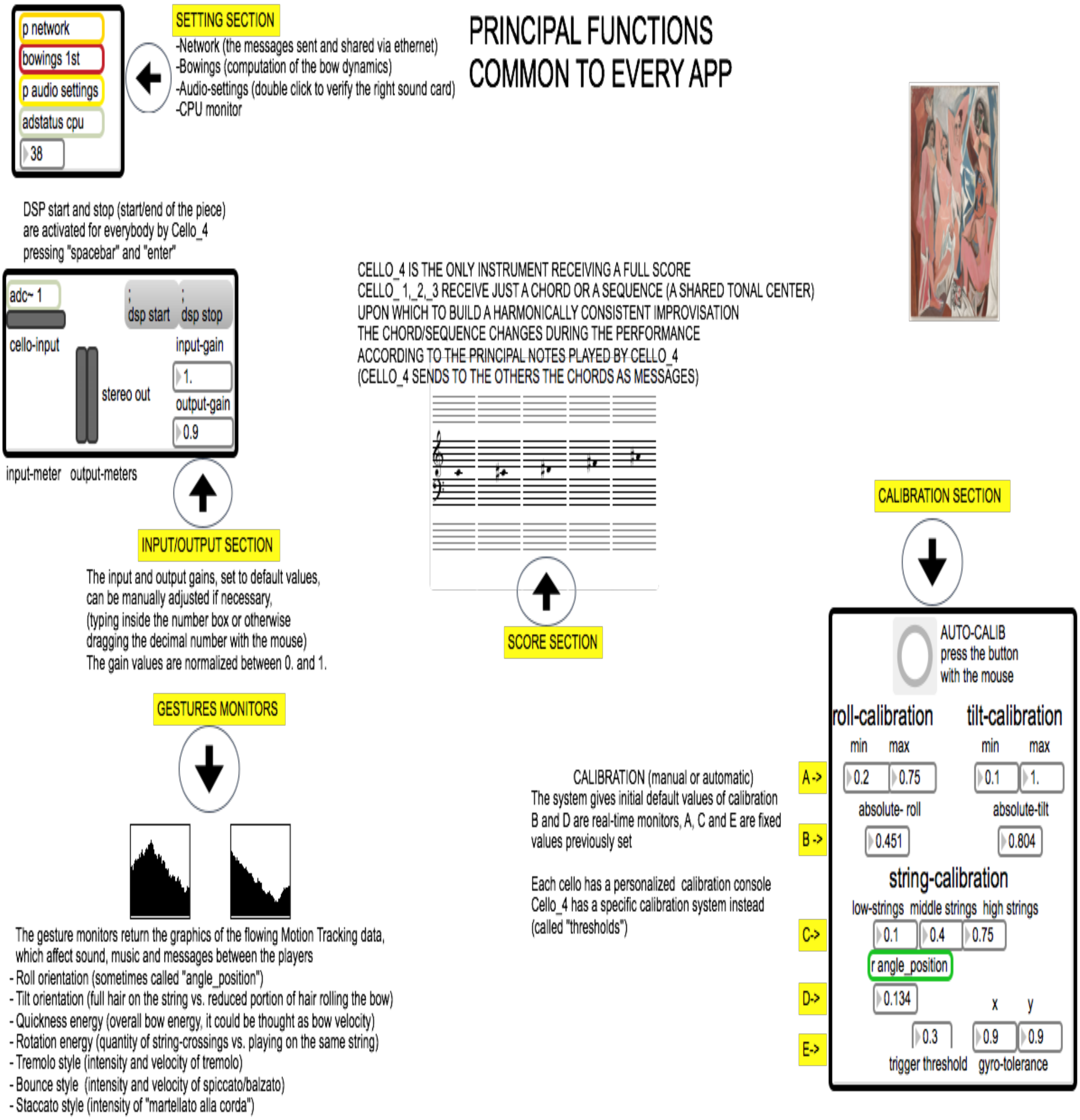


Fig.1-T Graphic interfaces common to any cello applications

<u>Audio settings</u>

Before any performance it is essential to verify the presence of the sound card.
Double-click the “audio-settings” icon in order to access the I/O module, if the sound card is not automatically loaded and written inside the yellow menus, it has to be set by dragging the two arrows in the right part of the yellow menus of input and output, as shown below in Fig. 2-T (the three menus should contain the labels “ Core Audio” in the upper menu, and the name of the sound card in the other ones).

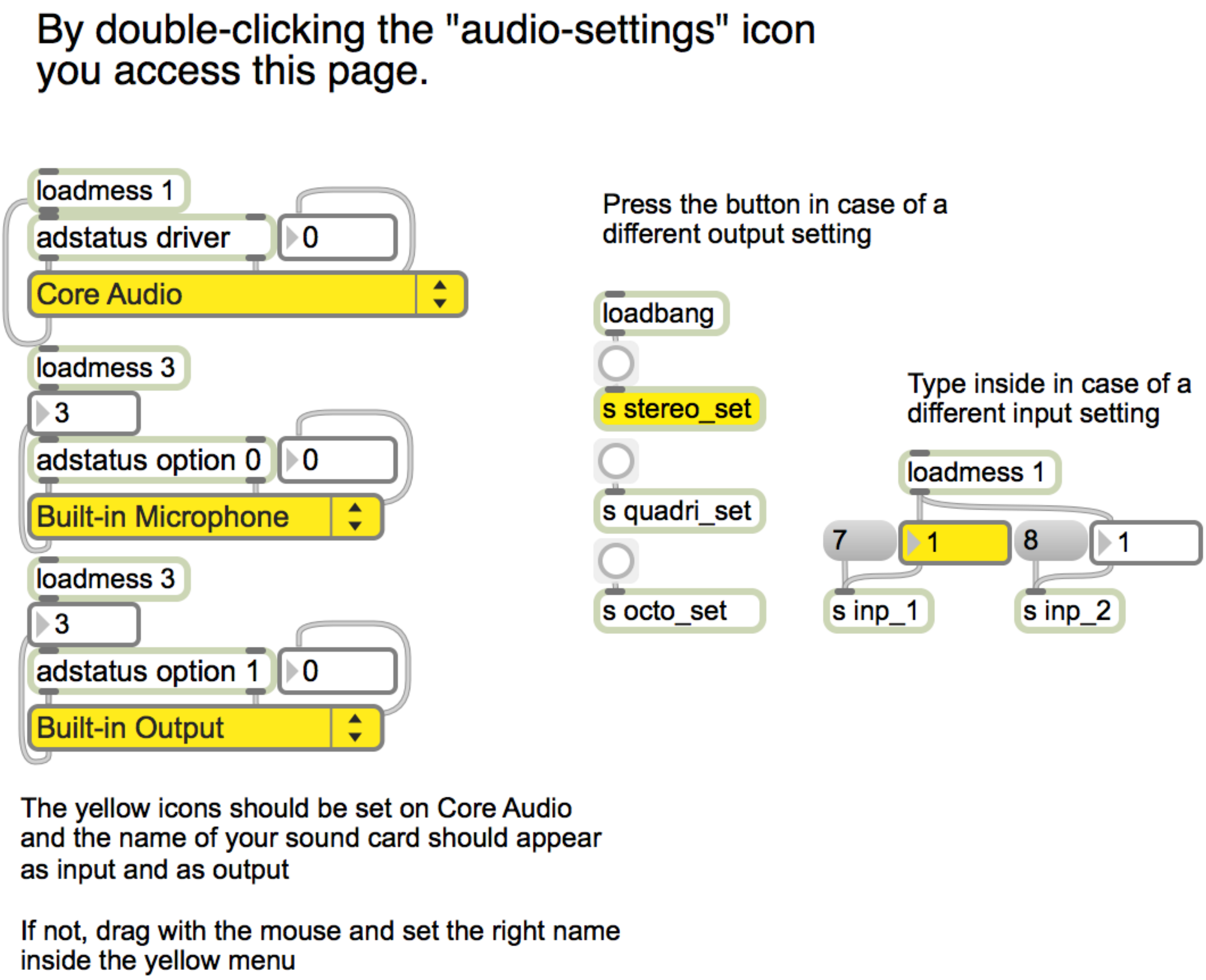


Fig.2-T Audio-settings and sound card

If it should be necessary to modify the input physical channel of the sound card, the option is given to type the number of the modified channel in the yellow number box above the message “s inp_1”. The default number of outputs can also be modified by pressing the corresponding button above the options “stereo_set”, “quadri_set, “octo_set”. The default output architecture previews the stereo outputs for Cello_1 and Cello_2, the quadraphonic output for Cello_4 and octophonic for Cello_3 (which drives the spatialization, receiving the stereos of Cello_1 and _2 as inputs).

Network settings

Instructions:

1) Connect the Ethernet cable from the laptop to the Ethernet Switch
2) Navigate /system preferences /network /ethernet, inside your laptop
3) The Ethernet icon must be green, select it by clicking with the mouse
4) Set the position as automatic
5) Configure the IPv4 as manual, and then type the address and subnet mask as shown below.

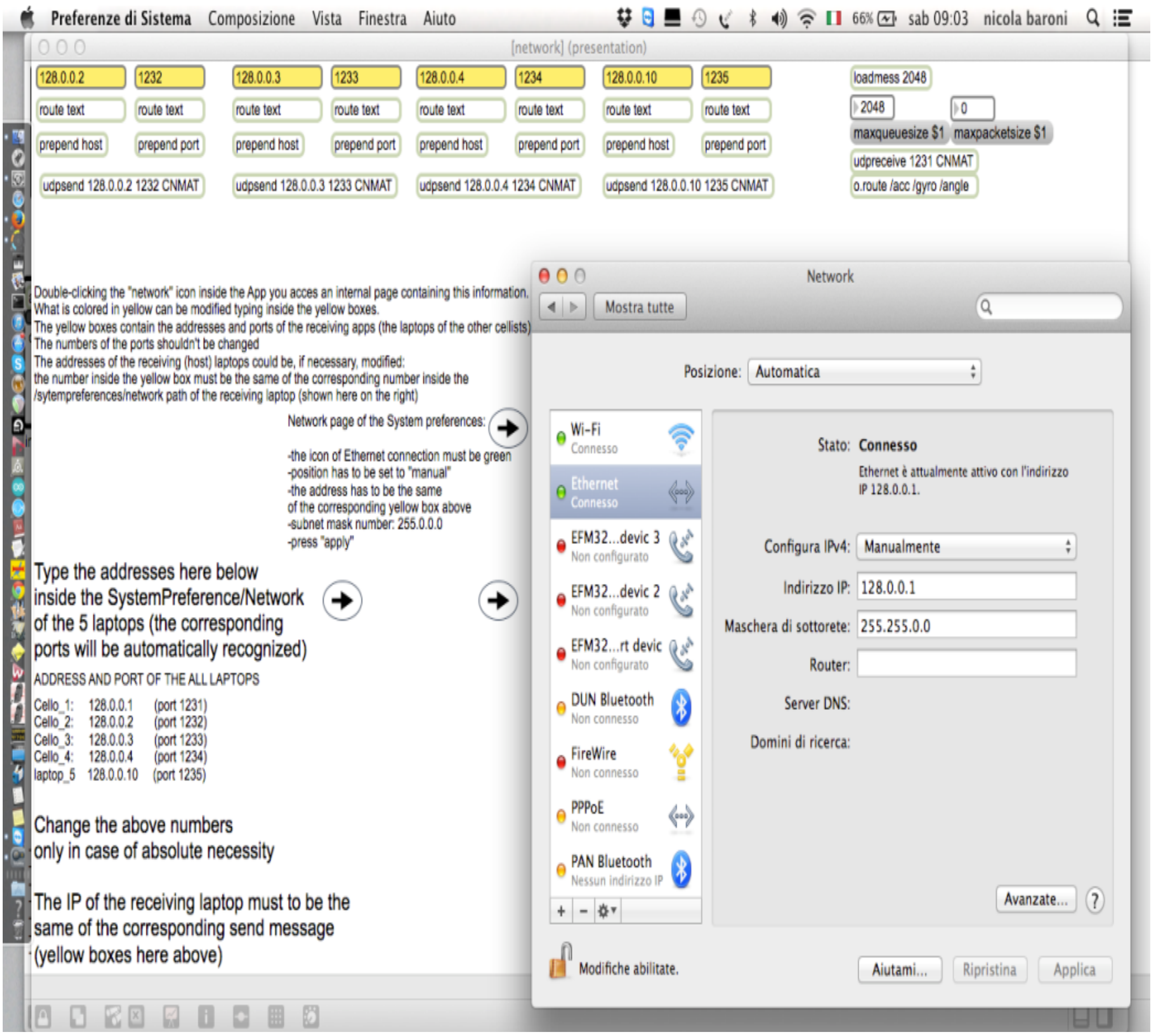


Fig.3-T The network

The default addresses of the laptops are:

Cello_1: 128.0.0.1

Cello_2: 128.0.0.2

Cello_3: 128.0.0.3

Cello_4: 128.0.0.4

Laptop_5: 128.0.0.10

All with subnet mask 255.255.0.0

By double-clicking the icon "p network", you can access the network module of the App: the addresses contained in the yellow boxes can be modified by typing inside (only in case of strict necessity!). The IP addresses and the port numbers obviously must be corresponding among the *"p network"* modules of all the applications, and also inside the system preferences network of each laptop, as shown in Fig.3-T.

Input_output

Each App provides the I/O section in the upper-left part of the screen: by default the input channel from each sound card is number 1 (adc~ 1 in the App), with the exception of Cello_4 which uses two microphones (by default: input 1 for the sound production and input 2 for the internal sound analysis).

As shown in Fig.1-T the I/O section contains visual sound-monitors and a couple of editable number-boxes for a possible modification of the input and output gains (amplitudes between 0. and 1.), in the case the sound card doesn't allow optimal balance and the default amplitudes don't fit.

Duration

The overall duration of the work (and also the length of the opening Cello_1 solo) can be differently set from the Cello_1 application.

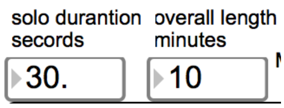


Fig.4-T Durations

CALIBRATION

The motion tracking calibration of Cello_1, _2 and _3 should be verified before every performance, the Application memorises the last calibration settings as default.

Cello_4 instead calibrates only the sound analysis data, which can be left unchanged after the first calibration, unless instrument, microphones or sound card are different.

Cello_4 calibration (onset/offset note detection, spectral description thresholds and parameters) will be described in the Cello_4 instructions.

The first time the calibration must be performed accurately (following the manual or the automatic modality); after that, before any following performances, a manual check should be sufficient.

The automatic calibration starts by pressing the *"auto-calib"* button and following the interactive instructions appearing on the screen.

If something fails during the process, it will suffice to press *"auto-calib"*, and start again from the beginning. Alternatively full manual calibration can be performed.

MOTION TRACKING

Motion tracking calibration is crucial in order to define the "*performance bowing space*" marking the boundaries of the bow positions.

Finding the minimum and maximum points of bow *rotation* in relation to the cello body is the requisite for a precise and meaningful bow interaction.Each value will be normalised within the extreme positions of 0. and 1., which represent the actual extreme points reached by the bow with respect to the cello strings during the performance.

The numbers referred by B and D (shown in yellow inside Fig. 8) are flowing quantities relative to the current Orientations of the bow: *"absolute-roll", "absolute-tilt", "angle_position".* The numbers referred by A and C will be set automatically (if auto-calibrated), otherwise the musician has to write them by typing inside the boxes or dragging the decimal portions with the mouse. The numbers referred by E are further thresholds to be eventually set. Default values are provided by the application, but notice that every further change is memorised when the App will be reopened.

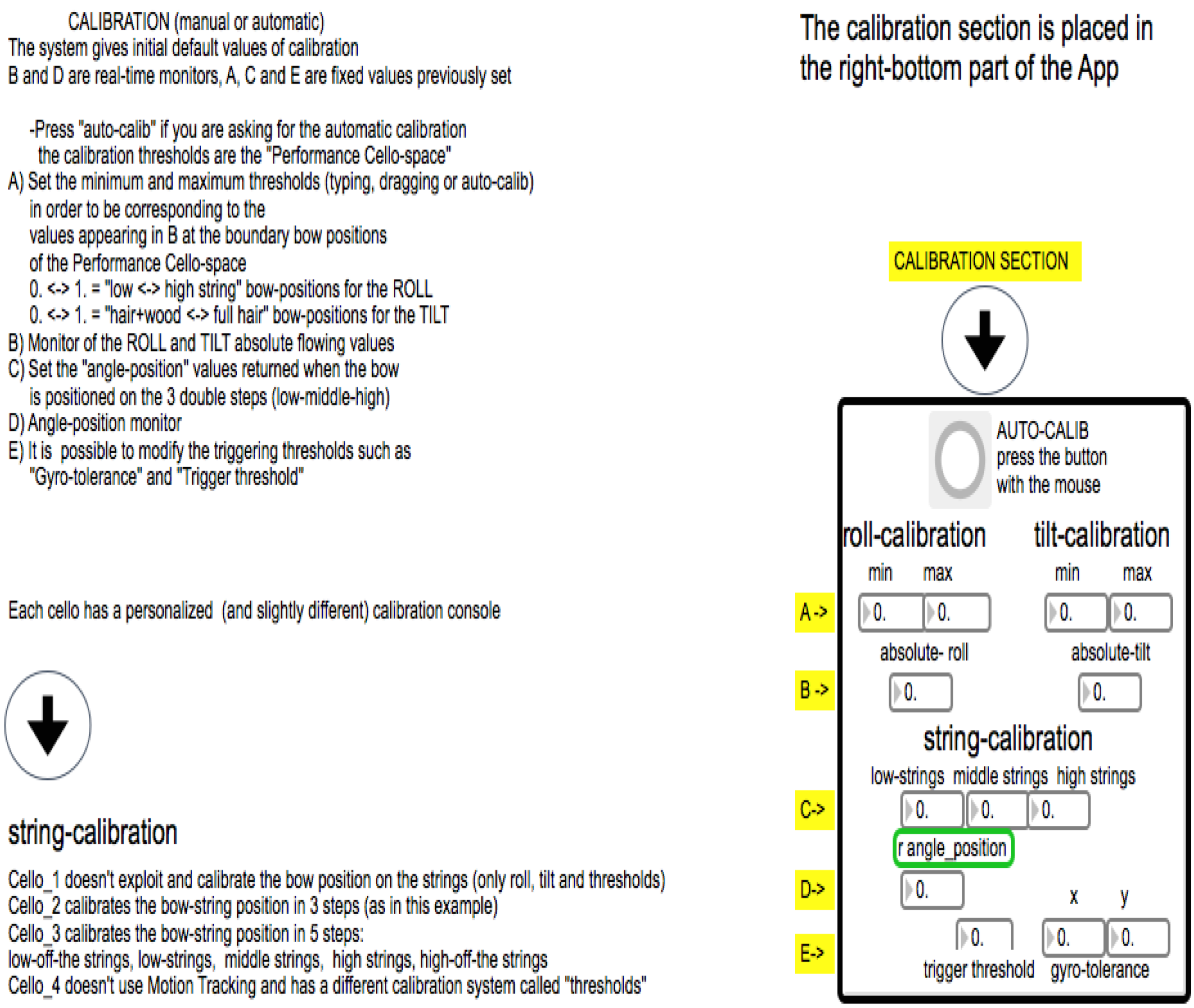


Fig.5-T Motion tracking calibration

Roll and tilt calibration

Absolute-roll and *absolute-tilt* are labels of the bow Orientation with respect to the x and y axis (taking the floor as a point of reference). But the performance point of reference is instead (from the point of view of the musician) the axis of the strings: we will therefore define *"roll"* as the changing value when the bow crosses the strings from the lower to the higher one, and *"tilt*" as the changing value when turning the bow (lying on the string) from "full-hair" position to "wood+hair" position. *Min/max roll-calibration* and *min/max tilt calibration* therefore define the extreme boundaries that will be reached during the performance.

It is useful though, during the *roll* calibration setup, to leave a little portion of room outside the extreme boundaries of contact between the external strings and the bow: some off-the-string downward and upward space, in order to allow some bow *rotations* in the air (especially for Cello_3).

If the musician is instead a violin or viola player, the *roll* values will obviously be reversed, but the low string and high string remain in any case the right points of reference, and the final result will be the same, and in any case *Rol*l calibration defines the bow boundaries of Orientation starting from the low string towards the high string (the boundaries are here intended as the most extreme bow-flexion points outside which the bow loses contact with the string, starting to "scrape" the body of the instrument).

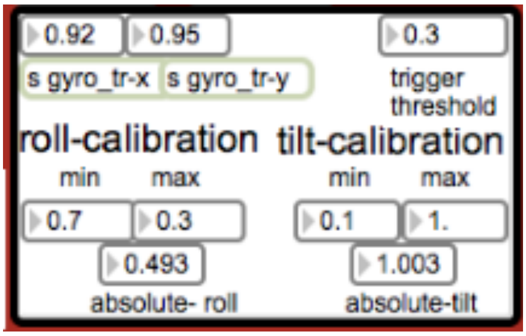


Fig.6-T Calibration box

General instructions

-Place the bow at the frog on the low string (C for the cello, G for the violin) in its maximum external flexion allowing not to loose the contact with the string.

Observe what is the mean flowing number appearing in the *absolute-roll* box, than transcribe it manually inside the *min roll-calibration* number box (typing or dragging with two decimal approximation).

-Place the bow at the frog on the high string (A for the cello, E for the violin) in its maximum external flexion allowing not to loose the contact with the string.

Repeat the same procedure transcribing the *absolute-roll* mean value observed, inside the *max roll-calibration* number box.

-Place the bow (in the middle) on the mid double strings as if playing with "full hair".

Transcribe the *absolute-tilt* mean flowing value appearing, inside the *max tilt-calibration* number box (the number should be very closed to 1.)

-Place the bow (in the middle) on the mid double strings again, as if playing with “wood+hair”. Transcribe the *absolute-tilt* mean flowing value appearing, inside the *min tilt-calibration* number box (the number will be closed to 0.)

If the numbers show to be reversed (i.e. the right outcome is high string ->1, low string ->0, hair->1 wood->0), it means that the sensor is probably placed not correctly under the frog of the bow, and it has to be put in the right position.

In this way the bow performance space will be filling the full range of values between 0. and 1.

Check the two number monitors under the calibration rectangle, or otherwise the main graphic monitors.

String calibration (for Cello_2 and _3 only)
After *roll* calibration the “*angle_position*” values will define the *rotational* space between the low and the high string (with a small added lateral space): this *roll* performance space is therefore normalised between 0. and 1.

Some interactions require the string currently playing to be identified. For this reason string calibration is required. This calibration is obtained by finding and fixing the “*angle_position*” values as a reference when the bow is successively placed (at frog position) upon the three double steps low, middle and high. This calibration in three steps is required for Cello_2. Cello_3 needs the string calibration in 5 steps, in order to also detect the low and high off-the-string positions.

During the performance this detection is reached after a perceptible latency, and only as a consequence of a clear sound attack, monitored with a flashing yellow bang: this procedure is due to the need to avoid unstable and too frequent unwanted change-string detections, and to extract only the most relevant changes of strings, monitored with a number tagged as “*choose_string*” (in this way the system suggests leaving room for significant musical passages played on the same string).

Triggerings calibration
The calibration section E offers the possibility to soften or increase thresholds involved in some triggering movements.

-“*gyro-tolerance”* regards quick *rotations* of the bow in the four principal directions Up, Down, Forward, Back.
Softening the threshold below the default 0.92 could help for a more natural style of playing, but risking at the same time to increase unwanted triggering because of a too tolerant threshold.
-“*trigger threshold”* is only for Cello_1 (“*quick-impulsive down-bows”)*
-“*sound-attack thresh*” defines the boundary of detection of the sound attack for the “currently played string” function of Cello_2 and _3.

Calibration allows a fine-tuned rendering of the bow controls over the electronics and the interactions. Bow movements are collected following three main typologies: Orientations (*roll* and *tilt*), Energies (*quickness* and *rotation*), Styles (*Tremolo, bounce* and S*taccato*). Triggering involve the detection of four types of "*fast-impulsive-rotations"* (Up, Down, Forward, Back), "*quick-impulsive down-bow"* detection (only for Cello_1), and the "*currently-played-string"* detection for Cello_2 and Cello_3.

AUDIO ANALYSIS (Cello_4 only)

<u>Note analysis</u>

The sound analysis modules involve timbre feature extractions, note detection and expressiveness[10] pattern recognition (as a submodule of the note detection).

-Timbre is continuously monitored through the "*gbr.yin*" external detecting fundamental frequency, overall amplitude, periodicity, spectral centroid, and spectral statistical distributions
-note detection is allowed by amplitude thresholds combined with transient deviation analysis in order to approach a substantially reliable onset/offset system synchronised with fundamental frequency detection
-estimations of "expressiveness" are computed inside the abstraction "expr_perf" which localises the amplitude peak position and its intensity compared to the attack inside each note detected, and computes standard deviation, mean and variance of the amplitude inside each note.

In this way it is possible to compute on the fly some consistent ratios between attack-sustain-decay of the performed notes. In addition every inter-onset-interval (IOI) is compared to the "note length" in order to extract a raw estimation of "legato" playing.
These data are returning immediately after each "note" is completed.
The "expressiveness" estimations inside the time and place of performance show evident limitations, though being interesting and affordable performance subsidiary controls.
On the other hand note detection has to be exploited with some cautions and in relation to special music contexts, as detailed inside the performance notes.

<u>Sound calibration</u>

Calibration is highly dependent on individual features, and must be setup again when instrument, player, microphones or sound card are changed. The system is provided with default values for cello playing. The most crucial calibration regards amplitude threshold and onset detection.

A deeper level of calibration involves offset detection and timbre "density".
When the performing instrument is not a cello a full re-calibration is mandatory.

Sound analysis calibration is accessible inside the "p thresholds" module of Cello_4.
Each label is provided with a number, which can be changed by typing or dragging.
After having changed the calibration numbers, press the label "write" and save.

---

[10] Canazza, DePoli, Drioli, Rodà,Vidolin, Proceedings of the IEEE, 92, 4, 2004

Instructions

Note detection needs to be carefully calibrated since it allows the performer to control global aspects of the interaction working on a net of on/off functions.
Timbre detection allows instead a more loose and continuous interactive interplay.

Any sound analysis doesn't happen when the signal is below the threshold "s loud-factor", set by default at -80 Db. You can raise it, if necessary.

A) Note detection parameters

-1. The attack threshold "writer" (see Cello_4 application) flashes when the cellist calls for a score when he/her sound surpasses the threshold through a sharp sound attack
-2. Note-on threshold. Note-on is detected as an increasing amplitude ratio respect the last 50 ms
-3. Note-off threshold. Note-off combines three different decay-tracking methods. Calibration can be set only upon one of them: the decay difference re-spect the last 100 ms. (in Db)
-4. Loudness gate disables the note-on detection when the cello amplitude is below its threshold, in order to avoid background noise detection.

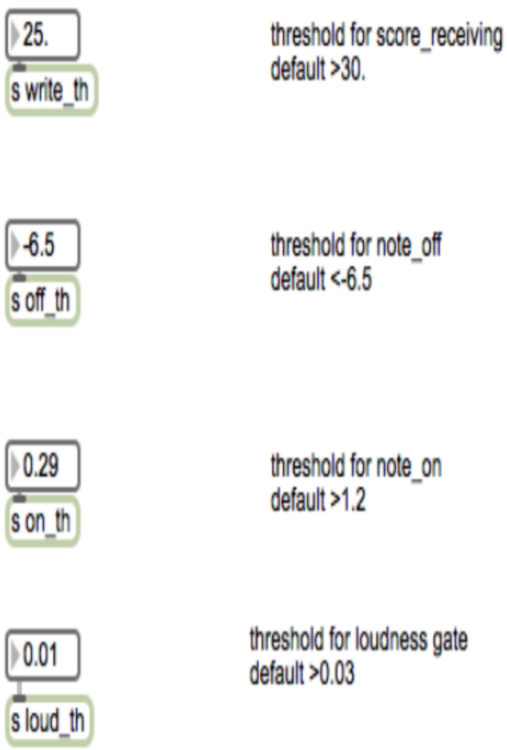


Fig.7-T Calibration parameters

1) score receiving (how much sound attack you need in order to call for the score
-lower the number above the label "s write_th" if it requires too much effort
-increase the number if it is too sensitive and generates too many scores
-the minimum-maximum values of the threshold should be between 15 and 35.
2) If too many note-ons are detected you can raise its threshold (or otherwise lower it if you need the opposite): the optimal range of "s on_th" is between 0.5 and 2.
3) Set an appropriate difference level in Db of "s off_th"
4) Raise the "s loud_th" if the background noise interferes, lower it when the note-on detection cannot be performed playing softly.

The amplitude monitoring is performed through the *peakamp~* MAX object

B) Timbre detection parameters

“Timbre” detection affects the interaction allowing the performer to modify the electronic timbre of his/her augmented instrument (harmoniser).

It needs to be calibrated in deep when the instrument assuming the role of Cello_4 is not a cello. In this case the values involved (amplitude, signal periodicity, spectral centroid, spectral kurtosis) could be dramatically out of range respect the default, needing different kinds of compression and scaling.

It could be assumed that for different cellists and cellos we don’t need a detailed timbre calibration, since the interaction can be learned by the performer through direct interaction.

The most effective timbre calibration, maybe useful also for a cellist, is contained in the “s pow_2feed” message. The referenced module computes the ratio between fundamental frequency and spectral centroid (sounds full of low components will output a value approaching 1., sounds full of high components will output values approaching 0.). The output, after being time-filtered, is directly mapped to the feedback of the harmoniser delay chains.
In this way the performer controls the sound density and quality of his/her augmented instrument.

This ratio can be powered by a coefficient (by default the power is 1, therefore the ratio is left unchanged). If you raise the power ratio inside the “s pow_2feed” module, the values of the feedback will be compressed downward, making it difficult to boost high qualities of delayed repetitions; conversely if you lower the power ratio between 0. and 1. the delay-feedback will be compressed upwards, more easily approaching the maximum value of 1.

All the other timbre calibrations coming from the input sound analysis, dynamically affect the sound parameters of the four voice harmoniser, namely the sinus, noise, formant and transient spectral components of the internal vocoder.

Detailed timbre calibration instructions are contained inside the Cello_4 application (“notes" patcher inside the “p threshold” module).

SOFTWARE

Inertial Motion Tracking is tested with the Orients_15 System, developed by the Centre for Speckled Computing of the University of Edinburgh, [11] running through the orientMac application. This application and the related Readme.txt document are contained in the main folder of this software. The system needs a native Bluetooth 4 Mac version as minimal requirement.
A different Motion Tracking system is allowed by substituting the abstracion "rec_orients-D" with a different OSC udpreceive module, which must contain proper scaling and normalisation.
Details are given inside the Readme text file.

The motion tracking data are collected in Laptop_5 through the UDP and OSC MAX objects.
These data are sent by the Ethernet network to the cello standalones inside the other laptops, where individual modules called "p network" route the messages, decoded inside the "bowings" individual abstractions. The processed data are sent to the main functions of the patches as controllers and interactive agents. All the patches and abstractions rely on the *"pattr"* system for calibration and automatic data recalling.

After processing inside the single cello-applications, the motion tracking data are sent back to Laptop_5 in order to generate the video in real-time.

CELLO_1.SPECTRAL
MAX/Msp 6.1 or *CELLO_1* standalone application

LIST OF EXTERNALS AND ABSTRACTIONS

analyzer~ (Tristan Jehan)
http://web.media.mit.edu/~tristan/maxmsp.html

contrast-enhancement (Michael Edwards)

dag.statistic (Pierre Guillot)
http://www-irma.u-strasbg.fr/~guillot/

dot.smooth, dot.std (Joseph Malloch et al.)
http://idmil.org/software/digital_orchestra_toolbox

ej.line (Emmanuel Jourdan)
http://www.e--j.com

---

[11] www.specknet.org

expo74 abstraction: readaptation of 04-transit-freeze, 09-adapt-pvoc (Jean Francois Charles)
https://cycling74.com/toolbox/live-spectral-processing-patches-for-expo-74-nyc-2011/#.Vh0sE2A-BE4

f0.distance, f0.round (Fredrik Olofsson)
http://www.fredrikolofsson.com/pages/code-max.html

ftm, ftm.list, ftm.object, ftm.reschedule,
gbr.bands, gbr:fft, gbr.resample, gbr.slice~, gbr.wind=, gbr.yin,
mnm.alphafilter, mnm.delta, mnm.list2col, mnm.list2row, mnm.list2vec, mnm.onepole, mnm.win-filter,
FTM-Gabor library (Norbert Schnell et al.)
http://ftm.ircam.fr/index.php/Download

jg.spectdelay~ (John Gibson)
http://pages.iu.edu/~johgibso/software.htm

msd (Nicolas Montgermont)
http://nim.on.free.fr/msd

multiconvolve~ (Alex Harker and Pierre Alexandre Tremblay)
http://www.thehiss.org/

OSC-route (Matt Wright)
o.route (Adrian Freed)
http://www.cnmat.berkeley.edu/MAX

pipo (IRCAM IMTR)
http://forumnet.ircam.fr/shop/en/forumnet/59-mu.html

quat2car (freeware)
http://www.mat.ucsb.edu/~wakefield/soft/quat_release.zip

sigmund~ (Millar Puckette et al.)
http://vud.org/max/

SpT.ranspose (abstraction)
Spectral Toolbox (William A. Sethares et.al)
http://www.dynamictonality.com/spectools.htm

CELLO_2.ARTIFICIAL
MAX/Msp 6.1 or *CELLO_2* standalone application

LIST OF EXTERNALS AND ABSTRACTIONS

analyzer~ (Tristan Jehan)
http://web.media.mit.edu/~tristan/maxmsp.html

dag.statistic (Pierre Guillot)
http://www-irma.u-strasbg.fr/~guillot/

dot.smooth, dot.std (Joseph Malloch et al.)
http://idmil.org/software/digital_orchestra_toolbox

ej.line (Emmanuel Jourdan)
http://www.e--j.com

f0.distance, f0.round (Fredrik Olofsson)
http://www.fredrikolofsson.com/pages/code-max.html

ftm, ftm.list, ftm.mess, ftm.object, ftm.reschedule,
gbr.slice~, gbr.yin,
mnm.alphafilter, mnm.delta, mnm.list2col, mnm.list2row, mnm.list2vec, mnm.onepole, mnm.win-filter
FTM-Gabor library (Norbert Schnell et al.)
http://ftm.ircam.fr/index.php/Download

jgn.mesh~ (John Gibson)
http://pages.iu.edu/~johgibso/software.htm

modalys~, mlys.force, mlys.mono-string, mlys.point-output, mlys.script
(IRCAM Instrumental Acoustic Team)
http://forumnet.ircam.fr/product/modalys-en/

msd (Nicolas Montgermont)
http://nim.on.free.fr/msd

multiconvolve~ (Alex Harker and Pierre Alexandre Tremblay)
http://www.thehiss.org/

OSC-route (Matt Wright)
o.route (Adrian Freed)
resonators~ (Adrian Freed et al.)

http://www.cnmat.berkeley.edu/MAX

pipo (IRCAM IMTR)
http://forumnet.ircam.fr/shop/en/forumnet/59-mu.html

quat2car (freeware)
http://www.mat.ucsb.edu/~wakefield/soft/quat_release.zip

sigmund~ (Millar Puckette et al.)
http://vud.org/max/

CELLO_3.SAMPLER
MAX/Msp 6.1 or *CELLO_3* standalone application

LIST OF EXTERNALS AND ABSTRACTIONS

ambiencode~, ambidecode~, ambimonitor (Jan Schacher)
http://trondlossius.no/articles/743-ambisonics-externals-for-maxmsp-and-pd

analyzer~ (Tristan Jehan)
http://web.media.mit.edu/~tristan/maxmsp.html

bonk~ (Millar Puckette et al.)
http://vud.org/max/

centroid~ (Ted Apel et al.)
http://vud.org/max/

dag.statistic (Pierre Guillot)
http://www-irma.u-strasbg.fr/~guillot/

dot.smooth, dot.std, dot.timedsmooth (Joseph Malloch et al.)
http://idmil.org/software/digital_orchestra_toolbox

ej.line (Emmanuel Jourdan)
http://www.e--j.com

f0.distance, f0.round (Fredrik Olofsson)
http://www.fredrikolofsson.com/pages/code-max.html

ftm, ftm.list, ftm.object, ftm.reschedule,
mnm.alphafilter, mnm.delta, mnm.list2col, mnm.list2row, mnm.list2vec, mnm.onepole, mnm.win-filter

FTM (Frederic Bevilacqua et al.)
http://ftm.ircam.fr/index.php/Download

imubu, mubu, mubu.granular~, mubu.knn, mubu.process, mubu.record~, mubu.track, pipo, pipo~ (IRCAM IMTR)
http://forumnet.ircam.fr/shop/en/forumnet/59-mu.html

msd (Nicolas Montgermont)
http://nim.on.free.fr/msd

multiconvolve~ (Alex Harker and Pierre Alexandre Tremblay)
http://www.thehiss.org/

OSC-route (Matt Wright)
o.route (Adrian Freed)
http://www.cnmat.berkeley.edu/MAX

quat2car (freeware)
http://www.mat.ucsb.edu/~wakefield/soft/quat_release.zip

CELLO_4.HARMONISER
MAX/Msp 6.1 or *CELLO_4* standalone application

LIST OF EXTERNALS AND ABSTRACTIONS

analyzer~ (Tristan Jehan)
http://web.media.mit.edu/~tristan/maxmsp.html

bach.roll, bach.score, bach.transcribe (Andrea Agostini, Daniele Ghisi)
http://www.bachproject.net

dot.smooth, dot.std, dot.timedsmooth (Joseph Malloch et al.)
http://idmil.org/software/digital_orchestra_toolbox

ej.line (Emmanuel Jourdan)
http://www.e--j.com

f0.round (Fredrik Olofsson)
http://www.fredrikolofsson.com/pages/code-max.html

ftm, ftm.copy, ftm.list, ftm.mess, ftm.object,
gbr:fft, gbr.slice~, gbr.wind=, gbr.yin,
mnm.list2row, mnm.moments, mnm.winfilter
FTM-Gabor library (Norbert Schnell et al.)

http://ftm.ircam.fr/index.php/Download

lhigh (Peter Elsea)
http://peterelsea.com/lobjects.html

M4L.gain1~, M4L.delay~ (abstractions)
https://cycling74.com

multiconvolve~ (Alex Harker and Pierre Alexandre Tremblay)
http://www.thehiss.org/

o.route (Adrian Freed)
http://www.cnmat.berkeley.edu/MAX

sadam.stat (Ádám Siska)
http://www.sadam.hu/en/software

supervp.trans~ (IRCAM Analysis/Synthesis Team)
readaptation of SuperVP.HarmTransVoice
http://forumnet.ircam.fr/product/supervp-max-en/

LAPTOP_5.VIDEO
MAX/Msp 6.1, Jitter or *LAPTOP_5* standalone application

LIST OF EXTERNALS AND ABSTRACTIONS

o.route (Adrian Freed)
http://www.cnmat.berkeley.edu/MAX

sadam.stat
http://www.sadam.hu/en/software

INDEX

LIST OF FIGURES

Wires's

PRESENTATION

Studio recordings at: https://soundcloud.com/nicola-baroni/wires
https://soundcloud.com/nicola-baroni/shamans-wires
Live video at: http://www.youtube.com/watch?v=-E1B0DQmNFA
Performance instructions at: https://www.dropbox.com/s/evxyhf1obs487qx/Shaman-instructions.mp4?dl=0

SHAMAN'S WIRE

Shaman's Wires is a collaborative project involving the composer-vocalist Angelina Yershova and the cellist-composer Nicola Baroni.
The project, in its concert based facet, develops a 50' lasting macro-form, whose narrative unfolds through improvisation.
The stage setup is arranged as 2 parallel extended instrument assemblages:
-female voice and ethnic percussions *(Bodran)* embedded in a live electronic environment
-prepared cello, augmented through interactive live electronics equipment.
The 2 personal stage equipments are independent augmented instruments partially interfacing through technology.

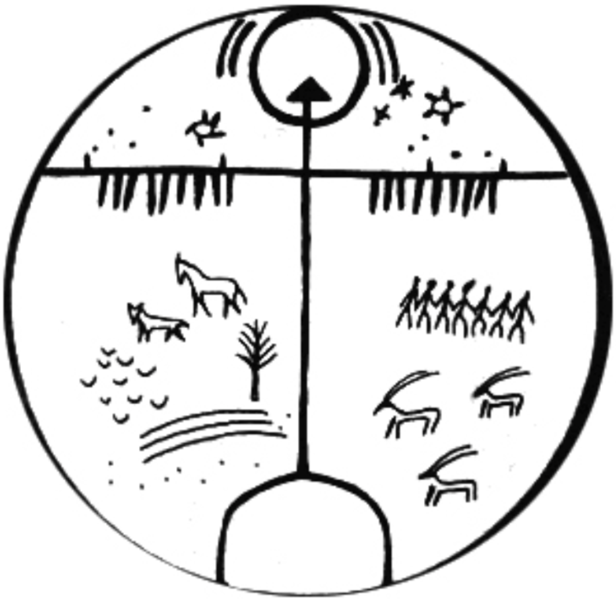


Fig.W_1 Shaman's wire

Fig. W_2 Angelina and Nicola

Yershova's background as a native Kazakh contemporary composer, and Baroni's position as a cellist involved in computer interactive composition, fashion a cross-cultural project based on ethnic composition, cello extended techniques and Live Electronics.

The performative role of the cello is centred upon new sound vocabularies absorbing Kazakh sounds and techniques. The actions of the electronics disembody, helping to reformulate the sounds of the cello with respect to its native Western practices, and the same happens on the other side for the Asian ethnic instruments.
Live Electronics, being unconventional in terms of practice and music "grammars", act as a mediating open space between Western and Central Asian approaches to contemporary music.

SHAMAN'S SOUNDS

Syncretism, the state of "being both", is treated as an action of preserving traditions (Eastern and Western as well), putting into question, whilst developing, their native motivations to make music.

On the other hand the electronics allow the mutation of the acoustic sounds onto imaginary soundscapes, moving towards the shared compositional contexts animating the concert.

"Being both" is an actual shamanic state, and in fact the animistic Kazakh conception of music maps sounds onto a transcendent and therapeutic space by which physical energy is charged: in a word, music is more a spiritual practice than a form of "Art".

Inside our project the Western concert-based rite meets the Central Asian dimension of sound as meditation, soundscape and self-emergence, through the mediation of the electronics.

The storytelling macro-form of the whole concert is traced upon the metaphor of the shamanic harmony with the energies of the upper world, giving power to transform lower energies.

Originally the word *Shaman* (from the sanskrit S*aman*) means chant, which is a primary healing practice; and our music is in fact a broad exploration of the harmonic chant techniques, through acoustic and electroacoustic instruments.

SOUNDS

The sweeping overtones emanating from extremely low pitches which distinguish the Kazakh-Mongolian singing practice, are boundaries of a corporeal resonance where sound meets mantra.

The tension between these simultaneous vibrations, obtained through special body techniques (the shaman voice, or its corresponding instrumental sounds) reveal different corporeal energy states, tuned to existential dimensions intertwined with health, balance, ethics, esoteric knowledge, relationships with nature and ancestors.

Raucous vocalisations, besides any music representations, are symptoms and means to dissolve energy blockages and trauma, breaking up dense energies through sound rattles.

On the other hand the music interrelation with tunes, melodies and note-scale systems are not primarily viewed as means for composition nor perfect imitation, but as sound links with universals resonating within our energy-body. In this context rhythmic patterns show the emergence of interior motions (leading to focussed textural densities), rather than being a form of metered time division.

CELLO AND *KYL KOBIZ*

Kyl Kobiz is the principal bowed string instrument of Kazakhstan: generally it is not bought from a luthier, but it is assigned to the musician by a shaman, as a sounding entity tuned to the inner personal qualities and relationships with the environment and the ancestors. Being more than a tradition, these cultural aspects persist inside the Kazakh classical and contemporary music community.

http://www.bukhara-carpets.com/kazakh-musical-instruments.html

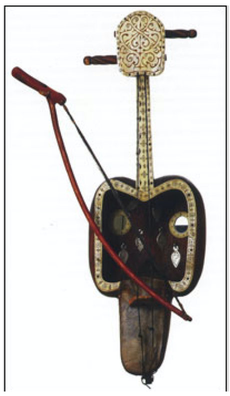


Fig.3 *Kyl Kobiz*

The role of the *Kyl Kobiz* is represented inside this project by the cello through a specialised research involving extended techniques and interactive live electronics.

WIRE'S

The interactive system here proposed has been natively built as the central part of the whole duo *Shaman's Wires*. The composed interactions called *Wire's* behave musically in a hyper-cello fashion, and can be considered both as an autonomous solo, as well as a prominent cello section maybe accompanied or dialoguing in duo.

Any further performance of *Wire's* could be independent of this original program, developing totally free and autonomous choices by the cellist.

The interactive system *Wire's* "listens to" and interprets the cello timbre as it is played inside the performance, and sensitively responds with electronic sounds shaping different levels of attunement, abstraction and energetic intensity with respect to the cello sound. **The cellist structurally and interactively organises and influences the electronic evolutions of the solo through music segmentations and timbre** (whose features feed the composition algorithms, operatively following the intentions of the cellist).

The electronic sounds have a perceptual (as well imaginary) connection with the Kazakh music styles, and their characters are musical resonances responding with their own qualities and autonomy to the cello input. The electronic system is organised as a subliminal self-organising sound entity. Its junctions cross-resonate with the energetic and reflexive music intentions of the cellist, as if they were arousing *chakra* vortexes.

The performance develops as a **free improvisation**.
No playing instructions are given, the laptop screen application is displayed for settings, the electronic interaction will be conducted by listening.

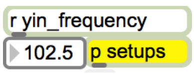
The following performance explanations are structured as:
-Ethnic sounds and cello extended techniques
-Software composed interactions
-Augmented cello improvisation and performance

ETHNIC SOUNDS

Even if each performance of *Wire's* could be independent of this program, the following notes offer guidelines for a faithful performance with respect to the native Western-Kazakh electroacoustic interaction. The notes regard styles and cello extended techniques, in accordance with the performative analysis here documenting possible symmetries between cello and K*yl Kobiz*, as they were found through music rehearsals.

1) The cello will be tuned:

A flat	- slightly lowered	= frequency	206
A flat	- slightly lowered (1 octave below)	= frequency	103
G	- 1/6 of tone higher	= frequency	100
C sharp	- slightly lowered	= frequency	69



Tuning can be afforded through the fundamental frequency monitor located inside the the bottom left section of the laptop screen (turning on the DSP).

Fig.W_4 Tuning monitor

This tuning permits:
- A more relaxed and edgeless timbre throughout the high ranges (the upper strings are lowered).
- A more pushing sound in the low ranges (the lowest string is higher).
- A middle range mainly producing faint resonances, giving rise to microtonal beats.

The division of the open cello strings in these 3 pitch regions engages with:
-strong sustained low drone tones expanding to a preferential detuned 5th double-stop
-higher melody ranges springing from the low *bordone*, but passing through the deconstructing resonance of the middle strings
-higher tones show a heterophonic attitude because of the role of the middle strings
-middle strings in addition help to create a secondary higher drone, or a secondary inner voice (more or less centred one octave below)

2) Low sustained tones are central to the performance and they can be:
- modulated in timbre (full tones, sweeping-sibling bowing conductions, harsh vs. slow-increasing modes of attack, gradations of grattato styles, sul-tasto -> ponticello zooms)
- enhanced through low double-steps
- the 3rd string allows for natural harmonic sweepings recalling the Asian harmonic chant
- the ordinary open-string style can occasionally be alternated with different sustained pitches (by left hand fingering)
- implicit rhythmic patterns vs. drones are means to structure the improvisation

3) Higher melodic sketches can be designed through short intervallic fragments and ornamentations around few selected pitches
-melody should be highly fragmented, and interleaving with low and middle open string resonances
-melodic fragments are often performed through left finger half-pressure, quick glides, nail lateral contact with the high string
-ornamentation is microtonal, gliding with the same finger, occasionally extending to larger pitch-tremolos up to a minor third
-the middle strings offer the opportunity for secondary voices, intermediate drones, scraping accompaniments, differentiated *bariolages*

4) Bow-string noises are more important than melodic fragments:
-extreme bow pressure, pitch-timbre clusters, fast-extended left hand glides and sweeping harmonics through different bow pressures
-timbre shaped through a rich vocabulary of bow roughness (half-pitches, fast tense tremolos, small pressure distortions, unstable bow-bridge distance)
-the rotational bow activity through the strings increases beats, rough note attacks, collateral bow-noises, re-bouncing resonances

5) The irregular melodic trend does not preclude occasionally developing a tune-like melody, or shaping implicit rhythmic divisions
-a free unmetered performance can alternate with background rhythms conceived in an additive fashion (similarly to the Indian *Tala*)
-rhythms can be freely chosen within slow or faster motion, strictly mingling binary and ternary impulses in cyclic patterns (i.e. 4-4-2-3-2, 3-2-3-4, etc.)
-the additive rhythmic conduction frees the performer from the need to follow a fixed meter, the rhythmic patterns can be dynamically changed during the performance

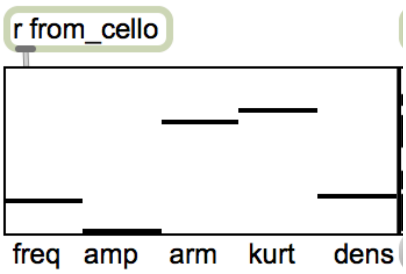
6) A small set of external objects preparing the cello is recommended
-copper thin wires (wearing low or/and high strings) for rumbling effects (raising intermodulations and detuning the cello spectrum)
-small metal rings (such as key rings) fixed around the low string, rhythmically rattling against the cello bridge
-small clips attached to mid portions of the strings in order to block the string vibration at special nodes: the clip positions can be modified during the performance
These objects need to be easily fixed/removed during the performance

A sequence of predefined time segments needs to be planned in advance, at least for the initial 2'-3' in order to shape an organised sound interaction with the electronics.

SOFTWARE INTERACTIONS

The electronic system develops music by means of a Self Organising Map. SOM is an unsupervised Machine Learning technique based on the Adaptive Resonance Theory (ART)[12].
The software program reads the continuous stream of **5 cello timbre descriptors,** and consequently behaves in response of how and when the music created by the cellist is performed.
At the beginning the SOM progressively expands its mapping space from an initial point zero.
Subsequently the SOM automatically fixes some nodes (relative to the cello input articulations and time evolutions), until it fills its mapping space.
The self organised mapping, even if apparently abstract, hence depends on the cello timbre and the music segmentations as they are performed during the initial phrases of the solo.

CELLO TIMBRE
The system extracts the real-time analysis of the following cello features:
frequency, amplitude, periodicity, spectral kurtosis, timbre density.
-frequency individuates the pitch registers
-amplitude tracks the sound global volume intensity
-periodicity regards pure vs. noisy sounds
-kurtosis reveals if the timbre is resonant vs. *ordinario* vs. compressed
-density tracks timbre intensity (full tone) vs. airy timbre (i.e. sul tasto, light bowing, pizzicato)



The fluctuations of these 5 sound qualities are tracked in order to detect their evolutions along a time span of 2.5 seconds.
They are computed as continuous values between 0. and 1.
Their streaming values are sent to the SOM.

Fig.W_5 Timbre cello descriptors

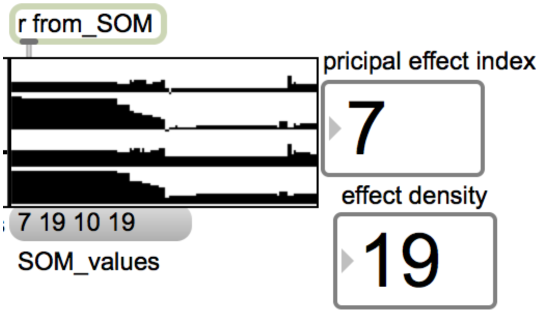
If the cellist plays contrasting episodes at the beginning of the solo, the SOM will be faster to organise its mapping space. On the contrary, slow initial cello transitions showing longer music segmentations of similar timbre contents will slow down the Machine Learning phase.
Slower initial transitions will be beneficial to the consistency of the automatic mapping process.
The cellist cannot control the detail and the timings of the SOM, as the system is self-regulating.
The cello improvisation therefore creates an indirect remote dialogue with the system. Rather than a strict instrumental loop of control-reaction upon each effect, the cellist will be focussing on high-level decisions involving the global music behaviour of the interaction.
In a sense the electronics behave more as an "alter-ego" than an objective instrument.

---

[12] B.D.Smith, G.E.Garrett, 2012
http://www.nime.org/proceedings/2012/nime2012_68.pdf

SELF ORGANISING MAP

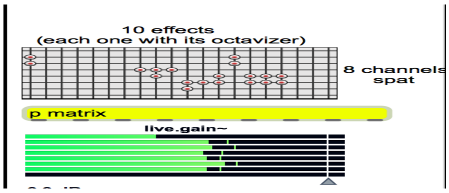
The SOM, taking as input the stream of the 5 cello timbre descriptors, creates **nodes of cello-timbre similarity**. The system organises its mapping space by identifying cello timbre characters (as inputs), and creating (as output) a code related to the **sequence of occurrence of these timbres,** as they were performed by the cellist during the initial part of the solo.



Wire's is structured in order to make the SOM progressively generate output numbers from 0 to 19 in 2 x/y dimensions during the initial part of the solo performance (the Machine Learning phase). **The output numbers X are mapped to the electronic effects, the output numbers Y are mapped to the density of the electronics** (how many effects are running in parallel).

Fig.W_6. Self organised mapping outputs

The figure above shows, as an example, a situation in which the mapping space Y (density of effects) was filled quite briefly, reaching its maximum of density in a short time.
A smoother process would be preferable.



Two further SOM output dimensions are mapped to the spatialisation.

Fig. W_7 Output display monitor

ELECTRONIC RESPONSE

As listed below, there are 20 electronic effects in all, **the electronic sounds with a low index number are lighter in character**. The more the index number rises, the more the referenced effect will be intense and abstract.

Your laptop screen (as in Fig.5) shows the currently active **"principal effect index" and the "effect density"** (when more effects are active in parallel they are neighbours of the principal effect). When the cellist performs timbres very similar to those played at the beginning, the machine should output very low output numbers: the output numbers increase when the cellist performs timbres previously played, but during subsequent music segmentations. In this way the machine shifts from light, middle and stronger effects, and with a narrow or larger band of effects density.

The cellist can monitor the mapping numbers as output by the SOM, as shown in figure 5. But the true effective monitor (consistent with the audible response) is afforded through the colour changes of the sound modules appearing on the laptop screen. But it is not necessary to exploit the laptop as if it were a graphic score (looking at it exaggeratedly), since *Wire's* is an improvised interaction.

After the start the laptop screen can be considered nothing more than a global monitor of the electronic densities and directions, and it should not disturb the listening priority of the interaction (previous setup and calibration maybe requiring the help of an assistant).

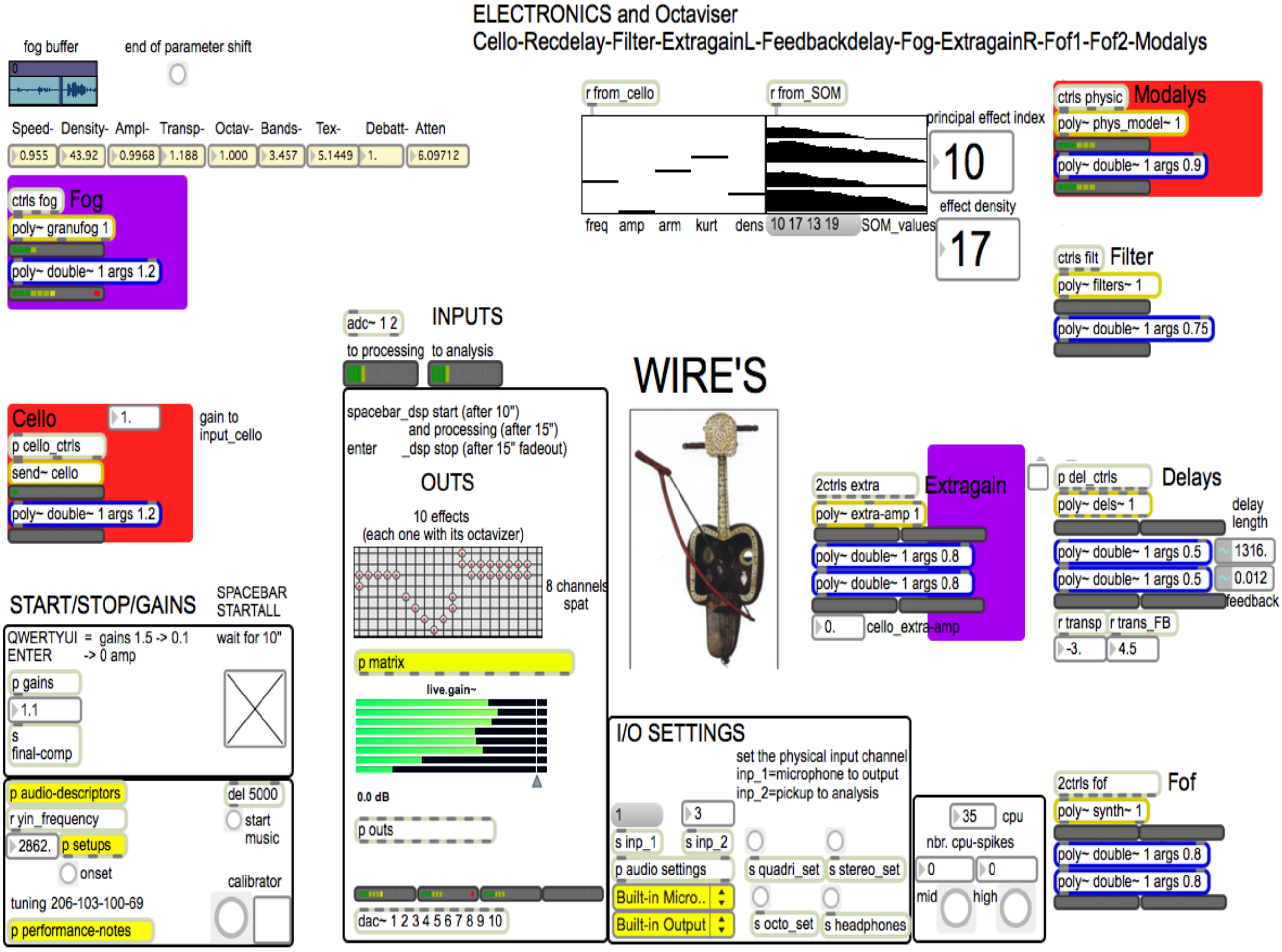


Fig.W_8 Main "Wire's" MAX patch

The previous image shows an example of your laptop screen in action. The SOM monitors are in the upper portion. The lower left part contains the start/stop/gain settings.

Seven modules arranged on the screen contain the electronic effects: the coloured interfaces show you dynamically which sound effects are currently active.
Three of the modules are actually double-modules, and each module can play one octave lower.

Red squared module means "the effect is active and playing"
Blue means "the effect is performing one octave lower"
Violet means "the effect is performing at normal pitch plus its low-octave"

ELECTRONIC SOUNDS

Taking into account all the internal variants, **the system provides 20 sound effects. Each effect is tagged as an index to the SOM output maps.** Starting from a "point zero" mapping, represented by the amplified cello alone, **the most artificial effects are located as the most distant points from the origin of the self-growing mapping space.**

The effects are ordered by surrogacy, that is timbral abstractedness and distance from the cello

1 amplified cello	**2 amplified cello low octave**
3 live recorded cello	**4 live recorded cello low octave**
5 filtered cello	**6 filtered cello low octave**
7 very amplified cello (ch1)	**8 very amplified cello (ch1) low octave**
9 cello with delay-feedback	**10 cello with delay-feedback low octave**
11 FOG cello granulator	**12 FOG cello granulator low octave**
13 very amplified cello (ch2)	**14 very amplified cello (ch2) low octave**
15 FOF synthesis 1 - artificial voice	**16 FOFsynthesis 1 - artificial voice low octave**
17 FOF synthesis 2 - artificial voice	**18 FOF synthesis 2 - artificial voice low octave**
19 Modalys physical model	**20 Modalys physical model low octave**

INTERACTION

The more the cello performance is varied and contrasting, the richer the electronic performance will be. The more the cello performance is slow pacing and reflexive, the lighter, more controlled and slowly evolving will be the electronic result. Maybe it is not necessary to exploit the full range of the electronics, and a climax could be an isolated event.

The internal response of each effect is quite complex and should be performed intuitively, but **the internal local mappings are detailed inside each module (by double-clicking the labels** inside the main app you access mappings and explanations).

Each electronic response, even the most subtle, depends on the cello timbre as you are performing it. In other words you sonify the timbre analysis of yourself. The most important thing is to keep a clear connection with the conceptual aspects of the mappings:

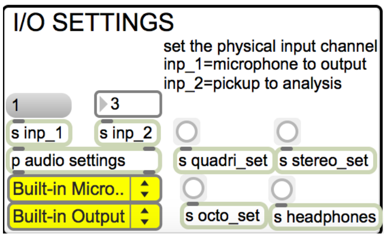
-the initial sound characters building the overall system response,
-the kind and density of the effects during the middle part of the performance,
-how and when to create points of climax.

You can also individuate at your choice a few elements out of the complex detail of all the mapping parameters, upon which to interplay giving nuance to the improvisation. Since timbre is complex and multidimensional it will be impossible to force the machine into deterministic responses in terms of a precise chain of cause and effect: the electronics will be a further sound dimension coupled with the music and the intentions coming out of the cello performance.

More details are contained inside the module “performance-notes” inside the main app.
-the module “setups” contains the messages for calibration,
-“audio-descriptors” shows the sound analysis functions,
-inside the module “matrix” all the internals of the system are running.

PERFORMANCE

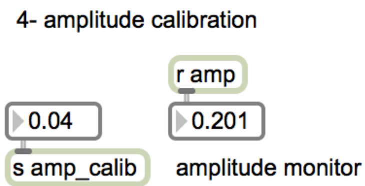
SETUP



"I/O settings" section allows to **set:**
-the sound card and the logical input channels,
-the outputs (**by default the system is quadraphonic,** press the relative button for a different option).

Fig. W_9 I/O section

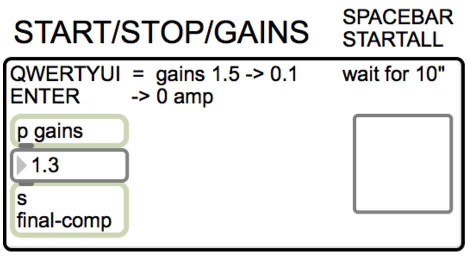
At the bottom left of the screen, the module "Setups" contains the calibration system:
-the inside section 5 involves the optional advanced option (requiring direct experimentation) of setting the parameters of the SOM (plasticity, learning rate, neighbourhood).



-the amplitude calibration of section 4 is necessary: by pressing "Tab" (with DSP on, and before starting the piece) you have 10" time to play the loudest cello sound as possible (2 flashes signal the beginning and the end of the calibration time window)[13].

Fig.W_10 Amplitude calibration

START



Optionally you can set the final gain (0.9 by default) by pressing one of the laptop keys QWERTYUI.
By pressing the Spacebar you start the music: after 10" the sounds will be coming out, after 15" the full interaction will be running. At the end, by pressing Enter, a long fadeout steers the music to its conclusion.

Fig.W_11 Start-stop interface

More details can be found inside the module "laptop-controls" (double-click " performance-notes") inside the main app. The start and stop functions are the only physical interaction that the cellist has to perform with respect to the computer. **All the interactive music information is sent to the system exclusively by means of the cello sound.**

[13] The system automatically sets the number box "amp_calib" to the value as returning inside its neighbour number box "amplitude monitor". After that press the message "write", the application should remember your levels at the next use, until a new calibration is stored again.

FORM BUILDING

The music interaction develops as a consequence of the sound choices of the cellist.
From the beginning the SOM observes the cello sound as it develops during the performance and automatically builds its self-growing and abstract mapping space.
The cellist has to improvise a music characterised by different time regions (formal segments, music phrases, contrasting timbral zones) possessing specific pitch-ranges (static or evolving), mean volumes (i.e. piano, mezzo-forte, fortissimo), and timbres (pure vs. noisy, light vs dense, resonant vs. intense).

Similar timbre cello inputs will move the system towards similar electronic outputs. The consistency between cello timbres and electronic outputs is a result of the initial part of the solo: the time development of the initial timbre characters (from the point of view of the cellist), Machine Learning from the point of view of the computer.
Depending on the cello improvisation, *Wire's* grows differently in terms of sound abstractness (orders of sound surrogacy), density and spatialisation.
If the cellist during the initial 2'-3' of performance creates well shaped differentiated sound regions (i.e. very low pitches / pianissimo / sul-tasto, after ca. 10” to 20” medium-low pitches / mezzo forte / dense bowing, after ca. 10” to 20” high pitches / forte /noise-distorted etc.) the system should couple the initial region with low-surrogacy effects, few effects active, and involving speaker 1.
As the system detects new sound characters it will start to progressively activate higher surrogacy effects, a higher number of effects working in parallel and more dynamic spatial movements.
Similar cello sounds will always recall similar electronic situations.

If the cello improvisation develops through stable and slowly evolving music sounds the system response will be smoother, more cello contrast will recall degrees of electroacoustic entropy.

ARTIFICIAL SOUNDS

Inside each of the effect modules you can find the description of the internal mappings.
The electronic effects are built in order to recreate concrete or imaginary features recalling Kazakh sounds and techniques: enhancing, mimicking or estranging timbre qualities.
Starting from the simpler effects, towards the last more abstract ones it can be noticed that:

A) <u>Cello treatments</u>

-all the effects are provided with a low octave doubler, mimicking the deep throat voiced Central Asian style.
-filtering allows for a pseudo harmonic chant result
Quick and nervous loudness variations by the cello increase the filter sweeps into different harmonic frequencies; a bright timbre (i.e. sul ponticello) increasing the effect.
-the intricate delay system suggests multiple heterophonic textures
You amplify this effect by decreasing your cello volume
-the extra-gain effect fits for grungy subtle noises
It is very sensitive to soft and very noisy sounds

B) **<u>Synthetic sounds</u>**

-FOG enacts overtones/irregular-granulations/sound-distortions
-FOF modulates voiced/guttural/rumbling sounds
-physical models (*Modalys*) produce rumbles/percussions/abstract-bow-scrapings

Augmented interaction
Each internal modulation of these artificial effects responds to the cello timbre in a consistent way, but the more abstract the effects are, the less predictable will be their response.
The cello improvisation, through its non obvious association with the electronics, acts as a timbre based corporeal meta-language accessing different levels of remoteness and energy response.

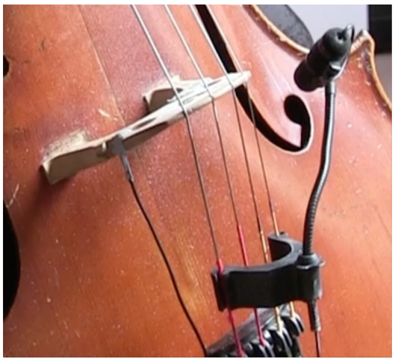
The cellist has an indirect access to the means of electronic control, which are not in fact controls at the low level of analytic instrument parameters. Especially at the level of macro-form, the cellist, preserving his/her traditional instrument holistic approach to performance gains the power to influence the compositional behaviours. But these compositional behaviours are the result of a mediation between the musician's choice and the mirroring autonomous behaviour of the self-organising abstract machine. Both the cellist and the system have a strict relation with their past choices which influence the present music events. The continuous negotiations between the cellist, his/her mirroring self-organising alter-ego and the past of both, suggested the creation of such a system as a means to convey the idea of energy exchanges through different spiritual dimensions.
In this sense the electronic sounds can be viewed as extra corporeal extensions, localised and accessed through a "shamanic" body-based, but multi-dominant and interdependent balance.

PREPARED CELLO

-Copper wires and small mutes
-Rattling metal rings
-Clips

Fig.W_12 Modulating objects

HARDWARE EQUIPMENT



-1 Microphone (phantom powered) for the audio, possibly DPA (adc~1)
-1 Bridge-contact pickup for the sound analysis, possibly Fishmann (adc~2)
-1 Audio card (minimum 4 outputs)
-1 Mac laptop (minimum dual core, 2.4 GHz),
running MAX/Msp (some externals requiring IRCAM authorisation) or otherwise the *Wire's* standalone
-PA quadraphonic at least

Fig.W_13 Cello microphones

SOFTWARE

MAX/Msp 6.1, or *Wire's* standalone application

LIST OF EXTERNALS AND ABSTRACTIONS
banger (Peter Elsea)
http://peterelsea.com/lobjects.html

contrast-enhancement (Michael Edwards)

dot.smooth, dot.std (Joseph Malloch et al.)
http://idmil.org/software/digital_orchestra_toolbox

f0.fold, f0.line_log, f0.round (Fredrik Olofsson)
http://www.fredrikolofsson.com/pages/code-max.html

fiddle~ (Millar Puckette et al.)
http://vud.org/max/

fof~ (Michael Clarke and Xavier Rodet)
http://eprints.hud.ac.uk/2331/

fog~ (Michael Clarke and Xavier Rodet)
http://eprints.hud.ac.uk/2331/

ftm, ftm.copy, ftm.mess, ftm.object,
gbr:fft, gbr.resample, gbr.slice~, gbr.wind=, gbr.yin
FTM gabor library (Norbert Schnell et al.)
http://ftm.ircam.fr/index.php/Download

ml.som (Benjamin Smith, Guy Garnett)
http:/nime.org/proceedings/2012/2012_68.pdf

modalys~, mlys.bi-string, mlys.bi-two-mass, mlys.bow, mlys.point-input, mlys.point-output, mlys.position, mlys.signal, mlys.speed (IRCAM Instrumental Acoustic Team)
http://forumnet.ircam.fr/product/modalys-en/

multiconvolve~ (Alex Harker and Pierre Alexandre Tremblay)
http://www.thehiss.org/

roughness (John MacCallum)
http://cnmat.berkeley.edu/downloads

sadam.stat (Ádám Siska)
http://www.sadam.hu/en/software

zsa.flux~ (zsa.easy_flux) (Mikhail Malt, Emmanuel Jourdan)
readaptation of the abstraction zsa.consonant tracking
http://www.e--j.com/index.php/download-zsa/

INDEX

LIST OF FIGURES

Suite

audio-video interaction for 8 self-observing audio files

Stereo rendering at: https://youtu.be/BNzoDeourno

Suite is a formal self-regulating method of composition.
Eight stereo files are processed, mixed and spatialised in real-time.
The resulting audio output feeds a sound analysis module upon which, in a ring fashion, the algorithmic processor creating the sound-video composition is based.
The internal analysis-synthesis loop is deterministic but the video-sonic result is never the same, although showing asymmetric recursions.
The module continuously analysing the overall sound output is called **"Observer"**.

The Observer interprets and slices the sound signal regressed as a stream of features representing:
1) the overall amplitude, fundamental frequency, brightness, roughness, noisiness, onset time-point,
2) the local amplitudes of the 8 lowest Bark bands (the energy content detected inside the range 20-920 Hz, segmented as 8 perceptually relevant frequency bands).
-The overall sound qualities (1) are tracked in real-time;
-The Bark amplitudes (2) are instead analysed in their behavioural flow, taking in account their individual stability, prominence and gait with respect to their own short-time "history".

This streaming and complex analysis vector is assigned to a dense net of algorithmic decisions and nuances operating upon the 8 stereo files, forming in this way the final audio.
A similar net processes 8 fix images producing the parallel video rendering.
The audio output thus obtained is in turn sent to the analyser (the Observer), circularly feeding the algorithmic "decision-making" process.
In this way this structurally closed system is based on the absolute coincidence of input and output.

Even if the compositional internals are strictly shaped, the result shows an organisationally open behaviour, enhanced in addition by the fact that even the most detailed analysis cannot apparently avoid reductions and distortions, being a conceptual representation. Besides the metaphor of a virtual embodied knowledge of the sound upon itself, this dynamic system shows different levels of resistance between its input sound matter and its human-organised reading, computationally re-assembled inside the compositional machine. More than exploring the new-cybernetic idea of a self-aware system able to grow and behave, this work is intended as **a study upon the concept of instrument,** at the edges of its interesting boundary state of a complete input-output conjunction.

The crucial composition algorithms of *Suite* mostly rely on the Bark-bands energy behaviours (agencies) with respect to their recent time evolution (spanning up to 2 seconds).
Obviously the length of 2 seconds is not enough to speak of "history", but it is a sufficient feedback time for disengaging the mechanism from a straight real-time dimension. In this way the compositional decision-tree acts as the consequence of a virtual short-term action-reaction domain, in this way taking into account the mediating dimension of temporal expressivity, which could be defined as "the time of the performance".

Since these 8 audio files globally self-process themselves through audio analysis and automations, we could say that the musical result is a sound output and an instrument at the same time. A similar loop grounds the concept of the hyper-instruments, inside which the performative actions (of the living instrumentalist) feed the output sound and the methods of machine processing in one take. In this sense the compositional *Suite* ecology could be viewed as a virtual hyper-performer.

The affordance of this interactive feedback loop in the context of a hyper-instrument can be often motivated by the aim to extend the compositional tasks of the performer, or to dynamically ground complex self-emergent structures to perceptible human performative gestures.
This kind of interaction puts the performative gestural dimension of a living sound at a same level of information trade as the compositional dimension of abstract structural choices.
In other words it allows direct synergies between the low levels of signal analysis and control (i.e. sonic parameters, raw energies, physical interactions and modulations) with the mid levels of structural decisions (i.e. musical patterns, regularities, directions, densities, repetitions, formal interactions) which are considered as linguistic-compositional tasks.

The choice of exploring the interactive potentials of fixed sound files inside an automatic and autonomous performative time domain, is linked to the operational necessity to aesthetically test the consistency of infrastructures which elicit non obvious paradigms of composing by listening, and symbolisms emerging from energetic perception/action gaps.

HISTORY OF THE COMPOSITION
The 8 sound files were originally composed as short electroacoustic commentaries for the play “Il Padre de li Santi”[14] (The Father of the Saints).
The concrete, satiric and psychoanalytic contents of the show, and in addition the theatrical requirement of short occasional sound commentaries, suggested me the idea of brief time-expiring automatic systems: “found” sound files sampling and processing themselves through the data obtained by chains of self-automatic sound analysis. The resulting audio files were devised in order to comment precise contents happening during the course of the show: my choice was to exploit anecdotic music quotations, whose recognisable content and deconstruction was intended to convey the required satire, thus each quotation was self transforming, self processing and self expiring through a built-in strategy of automatic audio analysis.

After the play I decided to collect the separated short excerpts as an autonomous work.
How could I make these satiric, quotational and self-reflexive short sound entities dance and unify? My decision was to extend their means of composition (automatic self-analysis) as a further global meta-level: a process of automatic decision-making about the occurrence, fragmentation, mixing and spatial movement of the thus obtained assemblage. At every new occurrence, each file is exposed to a different pitch transposition, speed of reproduction, point of departure and “life duration”; in addition each triggered file follows a trajectory of internal shifts between the states of normal, slightly granulated, and dynamically equalised reproduction.

---

[14] by Luigi Lunari, performed at the *Teatro dell’Orologio* in Rome from the 29 October until the 3rd of November 2013

The individual files are called:

1-Ingresso (entrance/ouverture)

2-Campane (bells)

3-Folla (crowd)

4-Wanda (recalling Wanda Osiris)

5-Esorcista (exorcist)

6-Tamburi (drums)

7-Maggiordomo (butler)

8-Uccello di Fuoco (Firebird)

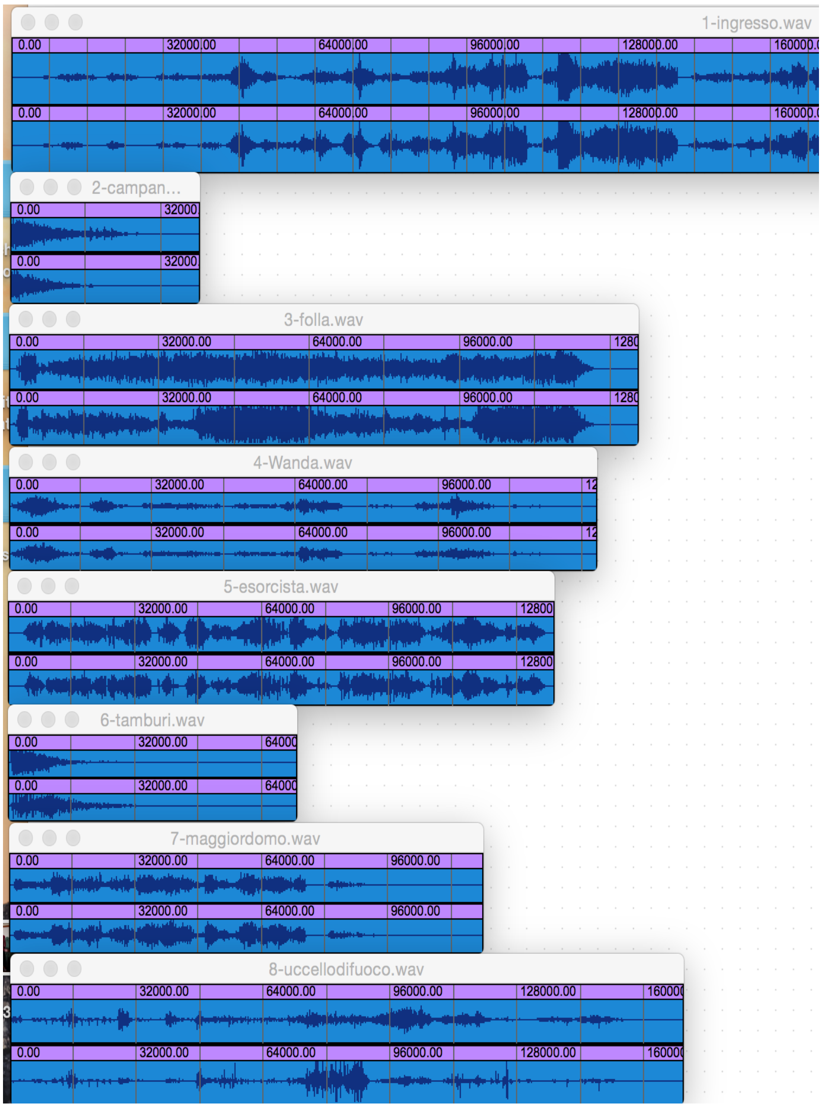


Fig.S_1 The pre-sampled sound materials

The only explicit historic quotation originally requested by the actors team was Strawinsky's *Firebird.* The consequent idea of structuring a formal system based on quotations and stolen sounds, taking Strawinsky's music as a structural model appeared to be a quite rational solution. Just as the music is a formal reshuffling of "stolen musics", the video in parallel works on "stolen scores" intensively remixed by exactly the same sound analysis methods manipulating the audio.

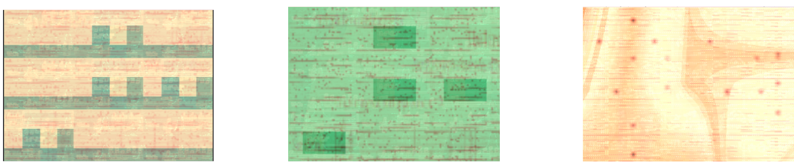


Fig.S_2 Screenshots from the video

ANALYSIS
The total output sound is sent to the analyser (*analyzer~*, and *roughness~* MAX objects)
The following features of the 8 lowest Bark bands are tracked in real-time:
-their amplitudes in dB
-their amplitude difference (positive or negative) inside a time window of 2"
-their standard deviation inside a time window of 500 ms.
-their amplitude derivatives with respect to the previous sample (delta distance)
-selection of the currently most increasing and decreasing bark bands (inside their last 2" window)
-the sorted index (and current delta value) of the 8 bands with respect to their energy of change

METHODS
<u>Layer A</u>
Each of these 8 bands references a different output audio file (all the files are in loop mode):
-the positive and negative amplitude maxima determine the file occurrence (start/stop)
-the standard deviation influences the output amplitudes (volumes)
-the delta distances influence the spatial movements (speaker assignment)
-the absolute individual amplitudes determine the starting point of the files ("seek" function)

Further mappings connect the bark amplitudes to the parameters of granulation, equalisation and delay, and determine the final video rendering. The onset attacks influence some step-by-step processing modules (in opposition to further continuous effects).

Amplitude, frequency, noisiness, roughness and brightness vectors distribute their effecting details and internal shapes inside the audio-video processing machine.

<u>Layer B</u>
A second collateral process is active: the quasi-random probabilistic selection of very short excerpts taken from the original Strawinski's Firebird, extremely fragmented and strongly filtered. It acts as a nested sound skeleton of the overall music, able to offer a point of departure for the analysis-composition loop, and an opportune background region filling the unavoidable intervals of stillness occurring inside the "layer A" procedure.
Part of this fragment selection, and also the whole filtering, are also determined through mappings by the global sound analysis engine (the Observer).

MOTIVATION
The automatic system was built with the aim of conveying formal abstract associations through its internal parts, as a study on the form-bearing potentials of sound gesturally conceived and segmented. The audio analysis treatments collect the energy behaviours of perceptually relevant frequency bands (Barks), formally framed by long term segmentation through onset detection.
By associating the selection of each sound file to recurrent global timbre qualities the result is to drive musical form through functional extensions of timbre.
The internal tensions and natural energy articulations of the analysed (output) sound add, through global mappings, a further layer of pulses, selections, dynamic movements, cyclic ornaments and contours to the principal semantic layout of the 8 original stereo files.

PERFORMANCE

The performance coincides with the real-time automatic audio-video rendering.
Every new performance will be different, since the system is a meta-composition. Potentially the system could maintain its behaviour of output -> self-analysis -> self-structuring, as an eternal circular loop; that's why the final performance is conceived in the style of a sound-installation, and does not require the audience to be positioned in a concert-like fashion. The audience could be moving and walking around the central video projection and inside the space of the 8 speakers ideally arranged as an external circle.

Every speaker is intended as a singular instrumental-like sound source, therefore site-specific unconventional different speaker deployments are advocated.

The demo version lasts 10', and it should be be differently or indefinitely extended in case of a gallery-style performance. The overall duration (in minutes, i.e. 3 hours = 180 minutes) has to be manually set in advance inside the application.

The rendering is completely automatic, after having set the analogue system and a few software parameters, as it is described inside the main checking-list of the application.

The performance interaction accounts for the minimal gesture of just pressing the start button.
As shown inside the main MAX application:
1) Check the sound card (audio settings at the bottom)
2) Select a different diffusion option if 8 speakers are not available
3) Press start (yellow button on the left)
Optionally:
- enable/disable the video rendering (by default performed by a second laptop).
-select different means of sound analysis (the self-observing state sets the "no-file" message)
otherwise you will define 1 vs. multiple different internal sound analysis sources.
-set the duration time

Default: self-observing, 8-speakers, video-off, 10' demo-length.
It is not recommended to perform audio and video on a same laptop.

Laptop_1 loads the application *Suite* for the audio rendering.
Laptop_2 loads the application *Image* for the video rendering.

HARDWARE EQUIPMENT

2 laptops in network (minimum OS X 10.8, 2 Ghz)
1 Ethernet cable (1000Mbit/s)
1 projector
1 sound interface (possibly RME or MOTU), minimum 8 outputs
8 speakers

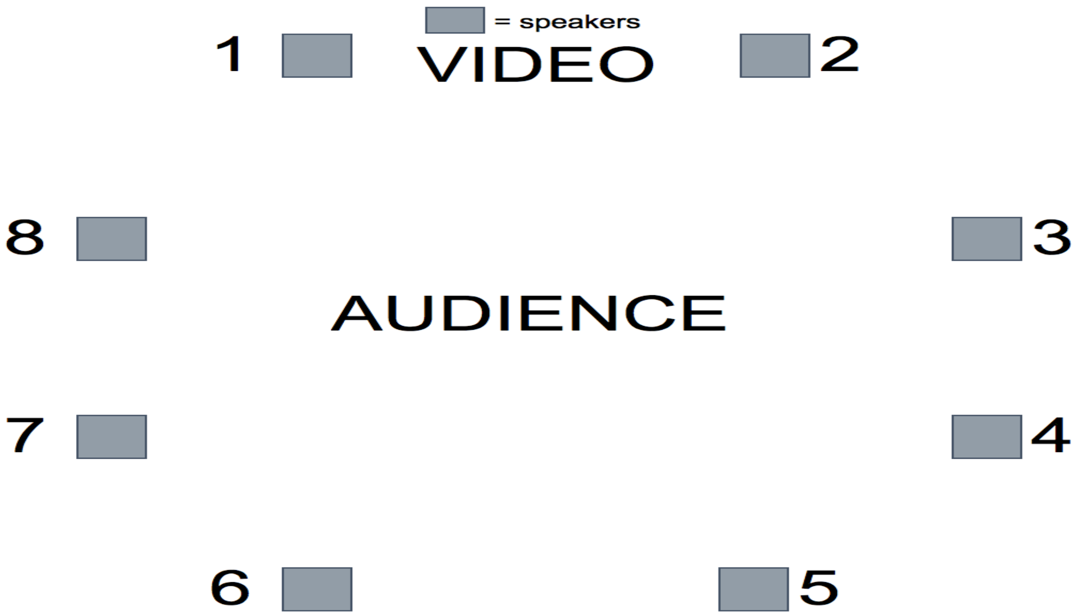


Fig.S_3 Speaker arrangement

SOFTWARE

LAPTOP_1 LIST OF EXTERNALS AND ABSTRACTIONS
ambiencode~, ambidecode~, ambimonitor (Jan Schacher)
http://trondlossius.no/articles/743-ambisonics-externals-for-maxmsp-and-pd

analyzer~ (Tristan Jehan)
http://web.media.mit.edu/~tristan/maxmsp.html

dot.smooth, dot.std (Joseph Malloch et al.)
http://idmil.org/software/digital_orchestra_toolbox

ej.line (Emmanuel Jourdan)
http://www.e--j.com

f0 distance, f0.fold, f0.round, (Fredrik Olofsson)
http://www.fredrikolofsson.com/pages/code-max.html

fiddle~ (Millar Puckette et al.)
http://vud.org/max/

ftm, ftm.list, ftm.mess, ftm.object,
mnm.list2row, mnm.minmax, mnm.onepole, mnm.sum, mnm.winfilter
FTM library (Frederic Bevilacqua et al.)
http://ftm.ircam.fr/index.php/Download

jg.granulate~, jg.spectdelay~ (John Gibson)
http://pages.iu.edu/~johgibso/software.htm

multiconvolve~ (Alex Harker and Pierre Alexandre Tremblay)
http://www.thehiss.org/

roughness (John MacCallum), o.route (Adrian Freed)
http://cnmat.berkeley.edu/downloads

LAPTOP_2 LIST OF EXTERNALS AND ABSTRACTIONS
dot.smooth, dot.std (Joseph Malloch et al.)
http://idmil.org/software/digital_orchestra_toolbox

f0 distance, f0.fold (Fredrik Olofsson)
http://www.fredrikolofsson.com/pages/code-max.html

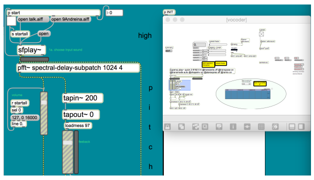
ftm, ftm.list, ftm.mess, ftm.object,
mnm.list2row, mnm.minmax, mnm.onepole, mnm.sum, mnm.winfilter
FTM library (Frederic Bevilacqua et al.)
http://ftm.ircam.fr/index.php/Download

Jitter
https://cycling74.com/

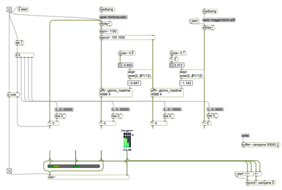
o.route (Adrian Freed)
http://www.cnmat.berkeley.edu/MAX

Table 1. The 8 original external self-observing systems, from which the stereo files were created.

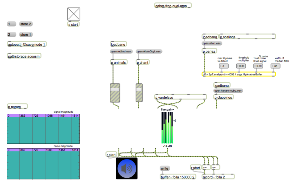
1-Ingresso (entrance/ouverture)



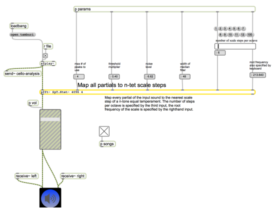
2-Campane (bells)



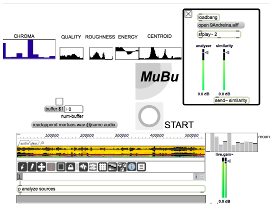
3-Folla (crowd)



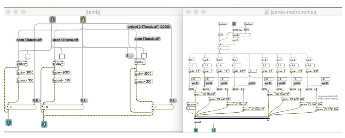
4-Wanda (recalling Wanda Osiris)



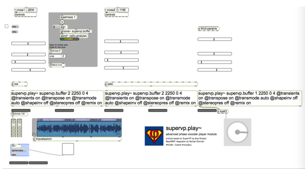
5-Esorcista (exorcist)



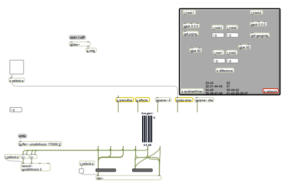
6-Tamburi (drums)



7-Maggiordomo (butler)



8-Uccello di Fuoco (Firebird)



INDEX

LIST OF FIGURES