# *Echi tra le Volte*, a sound design project for churches

Andrea Taroppi

Conservatorio di musica di Como, Italy,

tesi biennio specialistico in Musica Elettronica e Tecnologie del Suono

taroppi@infinito.it

*Abstract* — **This work is about the relation between music and architecture. In particular we are interested in the concept of space, as the way where music and architecture meet each other. The study of this topic offer the starting point to the development of *Echi tra le Volte*, a music installation for churches, where sounds are from the natural reverb of the place, excited by a sinusoidal impulses, which receive its pitches from a genetic algorithm**

## I. INTRODUCTION

The aim of the *Echi tra le Volte* project is to create a music which could be closely related to a specific building. Such a music would be the acoustic completion of the visual aspect when visiting valuable buildings.

When we think about music composed to be site specific, music with an intense link to a specific site, either a building or a natural place, we can observe that, taking due account of differences, generally speaking the used strategy is a descriptive or analogical one.

Such a methodology is based on the common use of numbers and proportion, for example the golden ratio, in music as well as in architecture.

Roots of this equivalence are in ancient Greek, when Pitagora found a relation between music perception and physical world, discovering the law that links string length with the pitch of the sound produced.

Consequently, it started and could develop an aesthetic of the number, well summarized in the words of the Italian architect Leon Battista Alberti (1404 – 1472), who wrote in his *De re aedificatoria*: "Those numbers that have the power to give smartness to sounds, that is so pleasant to our ear, are the same that could fill our eyes and our soul with admirable delight [1]."

Roughly in those same years, it is considered that Guillaume Dufay used elements related to measures and size of the Florence Cathedral "Santa Maria del Fiore", for the composition of his motet *Nuper rosarum flores*. According to some studies, e.g. in [2], the dimensional proportions of the church, to witch the music is intended are related to the music structure of the motet's tenor and contratenor.

Also, there are examples of inverse path: from music to architecture. One for all the Steven Holl's *Stretto house*, "designed as a parallel to Béla Bartok's *Music for Strings, Percussion and Celesta* [3]."

Finally, showing that the idea and desire to link eyesight and hearing could be found also outside the Western culture, should be mentioned the case of the Australian aboriginals and the songs they use to determine boundaries and particular areas. In those songs "The contour of the melody […] describes the contour of the land with which it is associated [4]."

In all cited cases, the link between sound and visual is in the geometric features, or more generally in quantifiable ones, as elements by which to make the translation from architecture to music.

However, it is not said that what is clear in terms of interpretation, it is so in terms of perception as well.

Also, it should be noted, that we are in front of a one way path: from architecture to music *or* from music to architecture. But It could be better: from architecture to music *and* from music to architecture; as a sort of dialogue between the two areas, so that not only the building influences the perception of music, but also the music influences the perception of the building.

So I think it is not in numbers, measures or proportions we can find the better channel of communication between sound and site, or focusing on architecture, between a music and a building. Furthermore, a numbers based relationship could not be considered peculiar of these two disciplines. Indeed, also in other areas, such as painting or even in literature, we can find measures and proportions.

Rather, it is in space that happens the meeting between music and architecture, because space is the common place of existence of music and architecture, and the object of design not only for architecture but for music too.

## II. MUSIC AS SPACE DESIGNER

Ambient perception is modified by sounds, in at least two ways. One relates to where sounds are perceived, that does not necessarily coincide with the position of sound sources. Think about the "in the middle" position of the singer, i.e. as if the voice come from a point on the wall, exactly halfway between the loudspeakers; a feeling we all can test, listening to almost all the popular music by a stereo equipment.

In addition, sounds can affect on the perception of a particular place, acting on aesthetical or emotional level.

This happens, when sounds contributes even heavily to make more or less pleasant a place. Think to the background music, or muzak, in supermarkets, waiting-rooms and so on.

We can read the most famous silent piece by John Cage *4'33"*, as a case in which space gives birth to a relation between music and the place it is played in, without use of any analogue similarity or quantifiable element.

In 4'33" playing instrument is not a traditional one, but the concert room itself. And all the sounds in it are no longer noises, but *the* composition. Soundscape becomes at the same time material for and result of composition, in a no end feedback.

In *Modes of Interference* by the Italian Agostino di Scipio, the composer explores the Larsen effect by the feedback from a microphone – loudspeaker system, so that "the room acoustics does not simply *host* the performance, but shapes it and contributes actively to it, while also setting precise material conditions and boundaries for it to happen [5]."

Something similar happened in the XVI century Venice, where composers like Andrea Gabrieli were able to make a composition purpose use of the San Marco Cathedral reverb.

In another Di Scipio's work: *Interactive Island (Sea Lights and Colors)*, we can find this kind of dialectical exchange between sounds and ambience. In *Interactive Island,* all sounds in the performance place are "captured by a number of microphones and sent back to the computer. The computer analyzes the numerical difference between the waveform of the feedback signal and that of the synthesis signal. The difference tracks the timbre modifications resulting from amplification and room acoustics [6]." And gives to the computer, values to be used as control signals for the automated composition process.

So, "both the "dead," abstract data structure captured in the computer and the live room acoustics of the material ambience become responsible for the development of the musical flow (*ibidem*)."

In conclusion we can observe that, differently from a numerical kind approach, in a space oriented relation between music and architecture, it seems pre-eminent the will to achieve an exchange of information, resulting in a more site specific music.

## III. ECHI TRA LE VOLTE

From this point of view, starts the *Echi tra le Volte* (Italian for: echoes among vaults) project.

The here presented version was commissioned to be realized for churches and was performed from 5 to 25 in November 2007, at the "Santa Maria del Popolo" church in Vigevano (Italy)

The work is in two phases: the pitches generation, and the execution. In the first one, a genetic algorithm generates sequences of numbers, representative intervals from a base pitch. In the second phase, after defined the base pitch from the dimension of the church, a patch of the software "pure data" ([PD] http://www-crca.ucsd.edu/~msp/index.htm) uses the values from the first phase to set the pitches of a sinusoidal grain generator. The output from the generator sent to a four channels loudspeakers system, works as an exciter of the natural reverb of the church.

## IV. GENERATION PROCESS

A library named GA for the genetic algorithm use in musical composition, created before [7] for Open Music (http://recherche.ircam.fr/equipes/repmus/OpenMusic), was useful for getting the values of the generation process.

I obtained 8 evolution steps, using fitness functions derived by the analysis of interval classes in Gregorian chant [8].

The evolution process goes from randomness to order, generating sequences developed around a *corda di recita* (reciting tone) avoiding tritons and others prohibited intervals, or too wide ones. A specific kind of mutation operator was created for the generation of neuma like groups of values.

After reaching the maximal complexity, slowly the process comes back again to a chaotic situation, allowing a new generation to start again.

## V. SYNTHESIS AND REALIZATION

The getting values are loaded on PD and after being converted in hertz, sent to a sinusoidal oscillator.

A train of sinusoidal impulses is created multiplying the output of the oscillator by the output of a continuous table reader (as in fig 1).

There are 6 table to choose from, everyone with a different curve stored: gaussian, hanning, percussion envelope etc. Every impulse have a stochastically variable duration between 40 and 60 millisecond, while the inter-offset time is between 20 and 30 millisecond. After a time between 1 and 3 seconds the table reader stops and the train impulse (one note effect) comes to its end.

Those values are derived by the reverb time and the dimension measures of the church.

For example, it was measured the reverb time in 4 different point of the church, and the average value was 3 seconds. This value was used as the maximum duration time of the train impulses.

At the end, a specific algorithm gives every train impulse its amplitude and an increasing type envelope. So every value from the generation process results in a note of a virtual Gregorian chant. The time sequence of the notes follows the different evolutionary steps described before: from a medium of one note per 30 seconds, at the beginning in the random phase of the generation process, to a progressive approaching of little groups of note as the stochastical appearance of neumas, until a more fluent output, in imitation of long melismas.
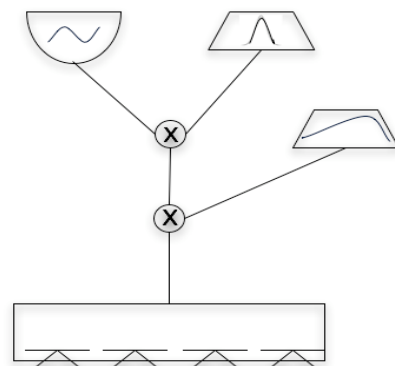


Fig. 1. PD patch scheme.
**Impulses are created multiplying the output of the oscillator (top left) by the output of the continuous table reader (top right), another table gives the envelope (centre ). Then, the four speakers spatialization system.**

Then, again, notes leave each others progressively, and the system comes back to the rarefied starting point situation.

A computer with the PD patch was installed in the church and connected to a four loudspeakers system.

This spatialization system is organized so that every grain or impulse is sent to an always different couple of loudspeakers. The two loudspeakers are in phase opposition, simply multiplying by –1 one of the two outputs.

This version of *Echi tra le Volte* completes all the 8 steps in about 7 hours.

For technical reason it was no possible to change the values from the Open Music generation process, loaded in PD; so after that time the process start again with the same values.

However, this is not a big trouble because others parameters are always different, so it is like to read a score every time altering everything but the note pitches. Indeed, it was possible to let *Echi tra le Volte* goes on for about 32 hours (from Friday morning to Saturday evening) without interruption, also in the night (during closing time!), and according to the visitors opinions the result was good.

## VI. CONCLUSIONS

*Echi tra le Volte* makes possible the direct participation of the building *on* the sound and musical structure, extending the sound synthesis chain outside the computer into the performance space.

This is the main difference from works like Di Scipio's *Interactive Island,* where computer elaboration is an answer *to* and *after* the action (proposal) of the performance place.

Besides, the *Echi tra le Volte* use of elements derived from Gregorian chant, it seems to add one more dimension in the achievement of a full relationship between music and architecture.

The result is a composition strongly linked with the building, so that it will play completely different in others places. In this sense, It could be say that *Echi tra le Volte* is the sound of the specific hosting architecture.

The project gives the occasion to think over the relation between music and architecture as a synergical connection, a way of linking sound and vision where the two (music and architecture as well as sound and visual) affect each others.

## AKNOWLEDGMENT

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