Designing a virtual theatrical listening space

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Abstract

The research at CRM has been oriented in the last years, at the study of “space” as new parameter for music composition and hearing processes. This allows to conceive concerts, and multimedia events in which the “acoustic space” is being designed coherently to the artistic criteria of the pieces presented. The paper will illustrate some artistic projects realized in the last two years. In particular, production of multimedia and technological events for which “acoustic space” has been designed coherently to the artistic criteria proposed.

Introduction

For the last two years research at CRM has centered on the study of space both as a compositional element and as an element in performance. Our concerts have often taken place in halls whose architectural limitations have necessitated the use of complex sound installations without which the works could not be properly presented. These experiences have led us to study the aural and visual elements necessary to achieve satisfactory presentation of musical works. We have experimented with multiple independent loudspeakers in the creation of "virtual listening spaces" and explored new visual techniques in the creation of "installations". We have found that used correctly, these elements create a sort of metalanguage that helps listeners achieve a more complete understanding of the works presented.

1. The technological concerts

The members of our work group come to us from many different professional backgrounds and this facilitates the exchange of ideas and suggestions. It also has made possible immediate artistic and scientific feedback. This has made it possible for CRM to be involved in many different aspects of music including compositional techniques, music production and education. These in turn have led us to scientific study. These musical and scientific studies have helped us, above all, in the creation of "technological concerts" concerts that take advantage of different multimedia and scientific elements. To create adequate acoustical spaces it is necessary to work on two fronts:

a) The creative use of the acoustical properties of the space at hand;

b) the creation of virtual-acoustical environments.

To these ends we have been active in the creation of powerful computer systems and programs for physical modeling simulation. We have also designed cutting-edge diffusion systems which include:
- loudspeakers for the accurate reproduction of acoustic and electronic music for use in installations requiring large numbers of localized sound sources;
- planephones, or vibrating systems for sound diffusion.

Here below we’ll illustrate some of the artistic events produced by CRM that use different acoustical spaces including:

1. radio productions
2. sound installations
3. multimedia events
4. musical theatre

These events make use of the most recent scientific and technological advances. In addition they all make use of different architectural environments and their acoustic characteristics.

2. The radiophonic listening space

The research work on the radio as a privileged medium for musical listening begins with the Radiofilms, or musical radioscenes. The initiative, promoted by RAI Radiotre in 1994, involved composers and writers who worked together in a project on musical theatre for the radio. For the authors, one of the more interesting features of the whole project, mostly as far as perceptive aspects are concerned, was the design of a “virtual scenic space”.

The idea was that of suggesting, through the stereophonic listening only, an image of the story and dialogues
setting, making all the sounds move inside this context. Each setting would change accordingly to the transformation and evolution of the sound materials. This particular research field was developed through several productions, the last of which were two compositions commissioned to some composers by the Radio Vaticana, based on the figure of the Virgin Mary.

The compositional techniques are different: in the first example (L. Bianchini) spoken and sung words are processed in order to become pure sound elements going beyond or integrating their meanings; the use of band-pass filters with dynamic variation of frequency and bandwidth have deformed, transformed and musically combined words whose meaning and sound are deeply different. In the second example (M. Lupone), the expression of sounds and words studied with the singer were recorded and, starting from this material, the composer realized an abstract model, a mathematical one, that returns the natural voice, but with a high degree of transformation and integration with other sound materials, not natural but synthetical. The composer has tried to develop the different levels of transformation of the sound, that starting from a virtual XXXX, lead to a virtual voice, and from this to the singing and uttering of the word “madre” by a natural voice.

The two compositions have utilized elaborations that could transform the signal spectrum, in order to strengthen the perception of the position and movement of sound. In particular, two systems based on digital filters have been used. The first is based on 11 Comb filters, simulating the behaviour of early reflections on a wall against which the sounds are projected; the changing of the filter parameters stresses the shiftings of the sound source along the wall. The second is processed through the Pipe Simulator program (CRM), for the study of the cylinder physical model. Through this program, based on a combination of Allpass and FIR filters, the sound input is deeply transformed in timbre, mostly when the cylinder dimensions and the reflection of the walls reach the highest degrees.

3. Sound Installations

The research done at CRM on concert hall and art installation acoustics is based on perception, noise (psychoacustical), the simulation of virtual spaces, sound diffusion and other elements. These are critical when designing multiphonic systems for sound diffusion such as Planephones.

The sound project by Michelangelo Lupone uses the Planephone in various forms. Constructed from vibrating panels made of various materials (wood, metal, plastic or leather) and designed for use in artistic venues, they allow a uniform propagation of sound along the surface and allow the sound to be shaped to fit different architectural spaces.

3.1 Sound design

First introduced in 1998, at the occasion of Musica Scientia ’98 held in Rome at the museum Acquario Romano, Planephones have found wide use in the design of concert halls, museums and, above all, as instruments in electroacoustic and computer music compositions. The term Planephone means 'a plane that transmits sound' and was born to achieve two goals:

a) the uniform and controllable diffusion of sound in space;

b) the creation of perceptible differences in sound propagation based on the material used in their construction.

Sound travels through the air but its propagation is also effected by the volume and shape of the room in which it travels. These properties give listeners clues as to the geometric space of the area, direction of sound, movement in the acoustic field and the speed of sound propagation. The position of the sound source and the location of the listener can alter sound perception considerably. The first result in this research has been achieved by controlling sound propagation in space, through obtaining a uniform vibration of the vibrating panels.

Limits imposed by the source and listener location can be overcome if the acoustic energy is radiated uniformly and the radiating source is subtracted to the typical effects that identify localization: frequency and transmitter’s behaviour. Planephones homogeneously diffuse sound in an environment, and the radiating surface, which is functional to the wavelengths reproduced thus to the frequencies, can assume any shape and can be placed anywhere in a listening space. This allows to design acoustic space in accordance to the specific characteristics of each place, of the type of music being performed and the listening one wants to achieve. Planephones are conceived to meet the need of the spatial modelling of contemporary music and they represent a flexible tool for controlling sound spatialization parameters. They can be used in conjunction with normal loudspeaker systems. By designing them in different shapes, different frequency bands and acoustic power can be obtained.

The most significant result of this research is the artistic use of Planephones: they can be considered as a new instrument, capable of investigating and bringing out sound properties of many different materials. The ceramic technology on which they are based allows electric excitation and dynamic control of the vibrational state of matter, and to build instruments that simultaneously generate, elaborate and diffuse sound.
Planephones have been made from paper, plastic, iron, steel, copper, brass and wood in a variety of sizes to meet the need of the composer. We believe they are a breakthrough in they way music is thought of and perceived.

### 3.2 Design

Work with Planeophones, and other CRM functional installations (Sonic Pipes, waveguides, etc) differ from other work in the field of sound installations in the unique combination of design, craftsmanship and staging. As with other musical events, the goal is to create a system that allows the best listening environment possible while eliminating unwanted distractions to the audience. The visual aspect is important. These new technologies afford the artistic director another element when staging his work. In many ways they are musical instruments constructed for specific uses. Master artisans have worked on their construction. Unlike the Planeophones used at the Rome Aquarium (whose main function was to fuse with the particular architecture of the surroundings), each Planeophone installation can be considered unique depending on the sound requirements. The latest presentation named “Infinite”, attempted to create two small rooms, one made of metal, the other made of resonating wood. The two rooms are connected creating a unique tension and a feeling of infinite space.

#### 3.3 Constructing the harmonic boards

The wood used was chosen for its resonance and structural properties. Cedar wood with a compact even grain met our requirements nicely. The raw boards, which measured 2000 mm x 50 mm x 4 mm, were glued together with a common adhesive used in the construction of musical instruments. A thickness of 2.8 mm was considered optimal. This allows the separate pieces to vibrate as one. A system of ‘anchoring’ was used to create uniform vibration while adding stiffness to the resonators. Cross anchoring was used to eliminate nodal vibrations which colour the sound. Before final finishing the surface was treated to eliminate porosity and improve the consistency of the grain.

### 4. Multimedia events

One of the most complex experiences regarding the design of an acoustic space is the reconstruction of Poème Electronique, by Varese-Le Corbusier (Rome, 1999). An exhaustive paper on this project can be found in another session. Another work, preceding this one, but always inspired by Varese, is Varesiana. The performance took place in the Air Terminal Ostiense in Rome, a building that features many acoustic problems: high reverberation time, resonance effects due to the height and shape of the ceiling, and to the form of the hall and quality of the walls, almost completely in glass. In the designing of the listening space all these obstacles have been used in a creative way. The acoustic space has been designed in order to obtain a diversified sound diffusion, accordingly to the several music interventions: the loudspeakers position, their number (12 independent channels), the power, height, trajectory and dynamics of sound movements have been carefully studied. The performance wanted to show Varese’s influence on other artists, and suggesting a revisitation of his work through a visual and sound point of view.

Bill Viola’s movie on Déserts and the collaboration between two composers, inspired by rhythmic themes of Varese have supported this project, that involved six percussionists on stage, three live electronics operators, one sound engineer, one light and video operator. The performance was processed in real time, using different algorithms on two Fly30 systems . The control has been done with both analog and digital systems.

### 5. Musical theatre

“...il resto è quiete”, is a cycle of four compositions by the author, based on texts of William Shakespeare: Hamlet, Macbeth, King Lear, The Tempest. It shows the influence of works conceived for the radio on the idea of a “listening dramaturgy” in a live opera. In fact, the research on the voice and on the relationship text/music which the composer has been carrying out over several years, above all for radio broadcasts, has motivated an investigation on the expressive potentialities of the voice, on the use of speech sounds in a musical sense, on the modalities of perception.

The studies of “virtual acoustics” and of Psychoacoustics conducted at CRM have proved an important incentive and assistance both in the choice of sound processing techniques and in the definition of an acoustic ambience coherent with the dramaturgic contents of the work. A great deal of the work of analysis and translation of the texts was carried out in collaboration with Silvia Schiavoni (singer, specialising in Shakespeare’s works) with whom, following a lengthy period of experimentation on the voice, the “acoustic-musical” characteristics of the personages were also defined. Each character is distinguished by different vocal timbres by which they can be recognized. The choice of these four texts originated in the

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1 Fly30 (CRM ‘90) is a floating point system based on TM5320C30 DSP, for sound synthesis and processing in real time.
consideration that through these works we have an evolution of the principal motifs of the Shakespearian theatre, in particular the use of the spoken word which in the last work, The Tempest, undergoes a profound metamorphosis and rises to a motive of reconciliation with the world, in particular with the theatre.

Nearly all the sound material is obtained by processing the voice of the actress/vocalist; the processing algorithms concern both the use of extended techniques of voice emission and the use of digital filtering, granular synthesis and synthesis for physical models.

One of the most interesting compositional aspects for the composer was the project of the "acoustic space". This developed on two differentiated but interacting levels emphasized by the presence of a mixed chorus, placed around the public and contrasted with a virtual chorus realized with diverse algorithms for voice processing.

The live chorus represents a very strong scenic-acoustic element, localized in space, while the virtual chorus represents a changeable and dynamic acoustic presence whose movements in space are controlled during the performance.

In addition to output power control, which permits the organization of displacement of the sound signal, the work has also utilized processes that transform the spectrum of the signal in such a way as to render the differentiation of sound levels more sensitive on a perceptive level.

Two compositions of the cycle, Hamlet and The Tempest, were performed for the first time on the occasion of the MUSICA SCIENZA '99 Festival in the gardens of the Accademia Filarmonica in Rome with Silvia Schiavoni, actress and vocalist; Macbeth and King Lear are in the final phase of completion.

6. Conclusions

All the works mentioned above consider sound as a central element of perceptive and expressive attention. The study and experimentation on space is the sole aspect still unknown for the musical culture. For this reason it is a crucial point for the construction of a scenery in which “the sound plays the main role and the music is its plot”. We are now at the beginning of a research that leads composers towards the design of a “virtual theatrical listening space”.

7. References


