REPRESENTATION IN SPACE AND TIME: CONTROL SCORE AND RESPONSIVE INTERFACE TO A VIRTUAL PERFORMANCE

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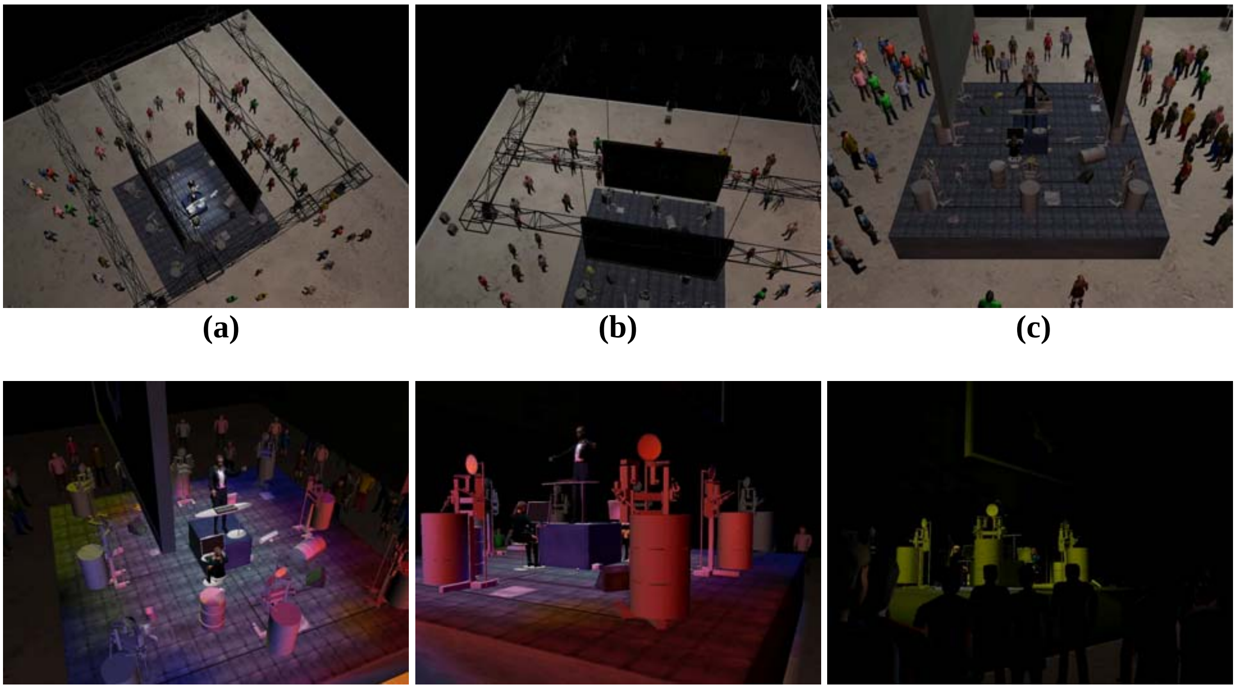
ABSTRACT

This lecture is about the application of the *simulative methodology* brought over by the digital culture to the design, portability and fruition of a performance. The simulative methodology is a computer-based approach that organizes and delivers the aural and visual elements of a performance according to the temporal sequence defined by a control score, to provide a realistic experience through a responsive interface to a virtual reality environment (Brooks 1999). The result is a *virtual performance*. The simulative methodology provides a novel approach to the representation and control of a performance, bringing together the descriptive power of storyboard drawings (that here become more or less realistic 3D objects and scenes), the algorithmic and interaction capabilities of the computing machine, and the attractive mediation of a virtual reality environment (though adequate interface design is necessary to realize a satisfactory simulation).
With more and more sophistication in computer graphics representations (with high mimetic quality) and the simulation power provided by the programming environments, the virtual performances become a powerful tool to design and pre-visualize a complex event. Both static (representation) and dynamic (algorithmic) aspects must obey the lexicon and the rules of a formal language that become the symbols manipulated by the control system. Contemporary shows are complex events with contributions from several sources (each requiring specific competencies) and the existence of a common paradigm for representation and control is a viable possibility for providing a connection over operational attitudes that hardly communicate (consider, e.g., video and programming practices) and that conversely require neat and unambiguous responses.
The virtual performance is useful to designers to provide a first idea of what the final performance will be to commissioners and collaborators (like storyboard and animatic for animated cartoons), to producers to understand the ideas conceived by an author and decide about the funding of a project (like pilot shows for TV series), to audience to experience the performance in a different modality (like TV representations of theatrical performances), to artists (different than the creator) to propose a new performance of the same show (like score in music). Each category of possible users requires an appropriate interface for the best experiencing results: we go from immersive stereoscopic view through helmets and binaural audio through headphones to standard computer monitors and stereophonic loudspeakers; also the interface control depends on the user, from position tracking to joysticks to mouse and keyboard. The acceptance of such simulative techniques will depend on several elements that include the expressivity/complexity of the descriptive language, the effectiveness of computer graphics and aural representational items, the viability of the user interface.

In this lecture we present the Enthusiasm software, an open-source project (on http://enthusiasm.sourceforge.net/) that incorporates such issues in a comprehensive environment. Enthusiasm has been used to design and visualize live performances, multimedia shows, game environments. For example, Figure 1 reports six screenshots from an under-development multimedia show, the concert-performance "Orchestra Meccanica Marinetti", by the artist Motor (see the website http://www.toshare.it/ACTION_SHARING/omm_eng.htm for more information). The performance features drummer robots playing steel bins on a stage guided by a conductor/performer (the inspiration source are the "Tambours du Bronx"), with videos played over two screens above the stage and sounds processed in real-time and delivered by loudspeakers all around the audience.



(a) (b) (c)

(d) (e) (f)

Figure 1. Screenshots from the pre-visualization of the concert-performance "Orchestra Meccanica Marinetti", (http://www.toshare.it/ACTION_SHARING/omm_eng.htm), with illustrations of the total space with the stage and the audience (a, b, c), and details of the stage (d) and views from the audience place (e, f).

The re-visualization provides a clear idea of the space occupancy in a theater, the effect that results from the sequence of organized events, visually and aurally perceived from multiple points of view. Also the software supports a TV direction of the video documentation of the show, by positioning cameras and creating an event-list for camera-switching during the shooting of the show. The whole show is represented by visual and aural elements organized in a temporal sequence, and objects can also be responsive to user input when the installation is of an interactive type. There are two representational aspects: the physical, both visual and aural, appearance of the virtual objects, that result from an enough accurate 3D modeling and rendering and that are positioned and oriented in the event space (so-called *nodes*), and the dynamic evolution of the event, including both scripted parts for objects, camera motion and positioning, and reaction to some user's input. Both aspects are encoded in formal languages that a motor engine executes to visualize the show. The following instructions represent the positioning of a robot in the scene:

```
<node name="robot1_node">
  <position x="3" y="1.2" z="-3"/>
  <rotation angleX="0" angleY="2.3544" angleZ="0" />
  <entity name="robot1" meshFile="robot.mesh" />
  <node name="robot1b_node" />
</node>
```

Each object is a node, with a position in the XYZ space (measured in meters), with an orientation, a name, and a 3D model that represents it (in this case, it is the same for all the robots – *robot.mesh*). Similarly, here is a light node of the scene. Notice that there could be no object corresponding to a light node; in such a case only the illumination result (and not the light source) would be seen in the visualization.

```
<node name="faro1_node">
```

```
  <position x="9" y="14" z="-16" />
  <light name="faro1" type="spot" castShadows="false">
    <colourDiffuse r="0.1" g="0.1" b="0.7"/>
    <colourSpecular r="0.7" g="0.7" b="0.7"/>
    <normal x="-0.6" y="-1" z="1.1" />
    <lightRange inner="0" outer="0.3" falloff="1"/>
  </light>
</node>
```

The is a light node with a name, a position, a type (one of point light, spot light, directional light), an attribute that states whether it cast shadows or not, what is the diffuse color (for all directions), what is the specular color (for one privileged reflection direction), the width of the beam (`lightRange`).

Once the possible actions for animated objects have been defined in terms of elementary patterns with a certain duration and rules of combination, it is composed in a score that defines the sequence of occurring events. In the following sequence, the robots 1, 7, and 8 are playing the same animation pattern (`PatternI_R1R7R8`) only once, starting at the eighth second; then, just after the fifteenth second they are playing another pattern; finally, at 27 seconds the robot 3 enters to play a new pattern.

```
8000 play_mesh_anim robot1 PatternI_R1R7R8 once
8000 play_mesh_anim robot7 PatternI_R1R7R8 once
8000 play_mesh_anim robot8 PatternI_R1R7R8 once

15380 play_mesh_anim robot1 PatternII_R1R7R8 once
15380 play_mesh_anim robot7 PatternII_R1R7R8 once
15380 play_mesh_anim robot8 PatternII_R1R7R8 once

27047 play_mesh_anim robot1 PatternIII_R1R7 once
27047 play_mesh_anim robot7 PatternIII_R1R7 once
27047 play_mesh_anim robot3 PatternIII_R3R5 once
```

Same idea for switching lights on and off.

```
26000 light_on faro3
26100 light_off faro3
27000 light_on faro7
27100 light_off faro7
28000 light_on faro5
28100 light_off faro5
29000 light_on faro1
29100 light_off faro1
```

All the documentation in terms of text files is read off by the rendering engine, that visualize (and auralize) the events occurring in the scene, and responds to user's input (the screenshots in Figure 1 are taken from such a simulation).

The focus of the lecture will be on the application of the simulative methodology and the Enthusiasm software to the recovery and re-proposal of a multimedia show, a paradigmatic example of a complex performance, occurred in 1958 at the Brussels World Fair and never repeated, Le Corbusier's *Poème électronique*. This project faces a current challenge of ephemeral art maintenance, as is the case with performances. A common approach of conservators is to pose emphasis on documentation, and some rely upon a questionnaire posed to the artist to identify the meaning, intent, or message, and forms to be filled in with technical data useful for artwork restoration (Laurenson 1999, Stringari 1999, Depocas et al. 2003, Lombardo&Valle 2007, http://variablemedia.net/e/welcome.html).

There are two issues to be considered here, namely the philological methodology induced by the

simulative approach in the recovery and the presentation of the reconstructed material through a virtual performance in the re-proposal. The two issues are strictly related, because the choice of what to recover and the format it assumes after recovery depends upon the presentation, here in terms of a virtual performance. We have called the whole process *archeology of multimedia* (Lombardo et al 2006). Similarly to traditional archeology, the archeology of multimedia retrieves the documents and objects that contribute to the description of the structure and functioning of the original installation; then, while traditional archeology pursues a descriptive methodology in which the media fragments contributes to enrich some narration in book or video formats, the archeology of multimedia pursues the simulative methodology in using the media fragments, possibly augmented with guessed parts, to recreate the original performance, a dynamic description of the installation that can deliver a strong impression of the original artwork on the novel user/visitor.
The *Poème électronique* has been a unique experience, originated from the request made by Philips to Le Corbusier for the design of the company's pavilion at the Brussels World Fair in 1958 (Petit 1958, Treib 1996). The whole project was initiated and directed by Le Corbusier, who also created and selected the images for the audiovisual show, with the organized sound composed by Edgar Varèse, and the stunning surfaces of the building designed by Iannis Xenakis (Figure 2). The result was the first multimedia project to involve a sense of total experience of vision and sound, an immersive environment, since the space of the Pavilion hosted the audio and the visual materials as integral parts of the architectural design. Unluckily, such a visionary synthesis of innovative ideas remained a unique episode. The Pavilion, notwithstanding the incredible number of spectators (2 millions), for reasons connected with the maintenance costs (the thin walls could not bear the load of snow in the Brussels winter) and the vanguard character of the artwork with respect to Philips concerns, was turned down at the end of the Exposition. The disappearance of the Pavilion makes the *Poème électronique* a destroyed masterpiece with a few fragments of the various components that witness the absolute value of the work.

Figure 2. The pavilion, exterior from the entrance side and interior (notice the loudspeakers over the walls) and two archival images of the *Poème électronique* (the two screens displaying the same video material and one of the tritous near one of the screens).

The Virtual Electronic Poem (VEP) project, funded by European Community, has recovered the original media material and assembled in a VR installation for a regained attendance of the artwork (Figure 3). The regain of the *Poème électronique* through the simulative methodology has taken into account four issues.
The first is a definition of the logical/perceptual requirements for re-experiencing the installation in the virtual performance. This issue individuates what aspects are relevant for the virtual reality encoding: two major categories are the *perceptual aspects* (what are the aural and visual elements that have to be necessarily rendered to re-experience the artwork?) and the *logical aspects* (what kind of controls are required to test the function of the virtual installation with respect to the original controls?). The Poème électronique (intended as a whole) consists of three perceptual components: (1) the continuous, mathematically generated, surface of the Pavilion internal walls,

which, like stretched “pellicles”, cover the internal stomach-shaped space, and such surfaces are relevant for the virtual performance because of the deformation of the projected images (Figure 3); (2) the visual elements, consisting of global light settings (called *ambiances*) upon which other luminous elements are superposed (“sun”, “moon”, “stars”, “lightning”, “clouds”), two video projections (called *écrans* - screens) on the surfaces surrounded by other smaller projections (called *tritrous* – three holes), and all these elements must be represented in virtual terms and accommodated inside the virtual pavilion (Figure 4); (3) the spatialization of sound, that still remains the most complex ever realized, as it involves three tracks of audio materials to be distributed over 350 loudspeakers. organized in clusters (acting as a whole) and “sound routes” (along which the sound can move), and the virtual reconstruction must be able to deliver sound from virtual sources distributed all around the audience/spectator in spherical space. The logic of control, that describes what content is conveyed to the audiovisual equipment, determines the sequence and timing of events that occur in the installation. In the simulative perspective each perceptual element is assigned a node in the representation with a number of possible behaviors; the sequence and timing of behaviors is written on a score similar to the one above.

Figure 3. The reconstructed pavilion. The two images display the same viewpoints of the “real” images in Figure 2.

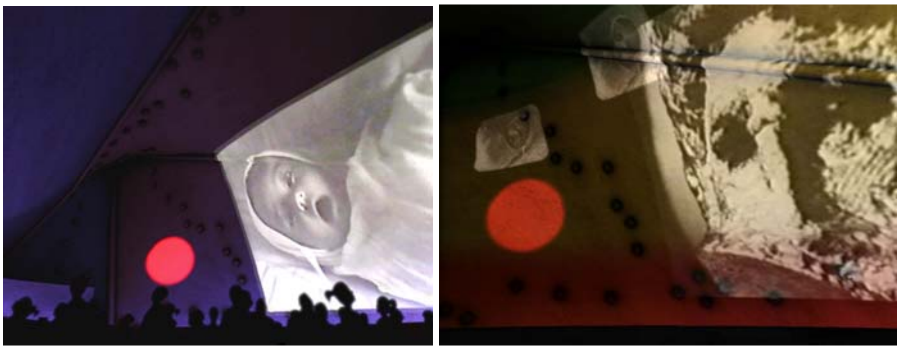


Figure 4. Two screenshots from the regained Poème électronique. On the left a purple ambiance with an infant image in the video plus the “sun” effect, on the right a three-stripe (red-yellow-green) ambiance with the image of Michelangelo’s day head, the sun effect and tritrous containing the infant on the left.

The second issue has been the retrieval of the media materials from archives and the insertion into the virtual environment. In some cases, when documentation is missing, we needed to guess plausible fillers for the gaps. The strength of the simulative perspective is the satisfaction of multiple constraints at the same time, thus providing a coherent figure of the whole installation. In the VEP project it happened that: the computer graphics model of the pavilion was constructed following the mathematical approach used by Xenakis (Xenakis et al. 1958); the écran in video format was provided by Philips archives; the content of tritrous were retrieved from the indications of the control score retrieved at the Getty Center of Los Angeles and Le Corbusier Foundation in

Paris, where we also found the colors of the ambiances; projectors were placed in the virtual structure to calculate the exact position of images on the walls; loudspeakers had to be placed on the internal surfaces for an accurate delivery of sound spatialization. Original photos, which could provide clues to the correct positions, were few, and with photo-matching we were able to locate 243 loudspeakers. Then, empirically, with a long hypothesize-and-test method that took into account the association amplifiers-loudspeakers (20 amplifiers that could bear at most 12 loudspeakers each), the telephone selectors that controlled the sound routes (which featured 52 positions), the distribution density over the surfaces (guessed from the existing pictures), a piece of the music control score available (around 30 seconds from 2:05 to 2:35), we were able to place 350 loudspeakers. After the access to the individual sounds of the Poème through Varèse's original production tapes (stored in the archives of the Institute of Sonology in The Hague) we have been able to rebuild the three audio-content tracks. The problem of spatializing the Poème has been a guessing approach that has taken into account some aspects of the Varèsian poetics on space (Dobson et al. 2005), as stated in some lectures (Bernard 1987).

The third issue was to express the events of the installation in the Enthusiasm representation language. The language describes the succession of events in terms of *scenes*, segments of the show when specific objects were lit and specific sounds were emitted by some specific source. In (Lombardo et al. 2006) we describe a number of primitive commands that we included to represent all the significant events. With this encoding we could explore different settings in the virtual performance until we found an acceptable one, given a few subjective tests.

The fourth issue concerns the hardware/software architecture design of the engine that automatize the virtual performance. The architecture includes output tools for the spatial audio and the stereoscopic video and a routine that reads the control score and delivers such perceptual components. Such delivery depend on the position of the visitor with respect to the installation and his/her possible interactions with the installation (so, we need an input detector and parser). In the case of the virtual electronic poem, the architecture simulates the Poème by using stereoscopic video (through helmet or wall projection – Figure 5, left) and spatial audio (through binaural headphones or multiple-channel speakers – Figure 5, right). Each spectator can interactively explore the pavilion's space during the show: positional data relative to the observer are tracked and used to process in real time audio and video elements (the images the spectator sees and the sounds he/she hears). The high computational demand does not allow a completely free exploration of the Pavilion during the show, but a fixed position. Also we can simulate additional audience with a crowd of animated characters inside the virtual environment, thus giving the spectator some relevant metric/proportional indices in order to correctly recognize the Pavilion's internal space.

Figure 5. Single user setup with stereoscopic helmet and binaural audio (left); multiple user setup, with monoscopic screen and multichannel audio (right)

After tuning a prototypical installation, we have validated the final result with a committee of experts drawn from various areas. The experts were both technicians of the single components (lighting experts, audio technicians, architects) and contemporary art experts, scholars, conservators, curators, eye-witnesses of the original installation, the artist him/herself. We were also lucky to meet an eye-witness of the Brussels installation in one of our installations (Lombardo et al. 2005) and the response was enthusiastic (documented with video).

The applications of the simulative approach to a number of projects, from linear artworks to interactive installations support the usefulness of the Enthusiasm software for the visualization, reconstruction and maintenance of complex projects. The simulative approach includes a formal encoding of the spatial and temporal cues of the project and a virtual reality environment for the aural and visual perceptual result. The variety of applications also leads to a possible convergence of production methods. However, the success of the simulative approach is probably dependent on the design of effective interfaces to the various components of the representation language.

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