THE IMMERSIVE TIME-MACHINE:
A VIRTUAL EXPLORATION OF THE HISTORY OF LIVORNO

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ABSTRACT:

In this paper we present the results of a multimedia project dealing with the virtual reconstruction and the immersive visualization of the urban development of the town of Livorno, in the Italian region of Tuscany, on the 400th anniversary of its promotion to the rank of City. The project involved the realization of a 3D model of the town in ages, aiming to show its evolution and development in time. The results have been demonstrated in the context of a dedicated exhibition, making use of an immersive stereoscopic installation conceived for large audiences, hosted in the premises of Museo Fattori in Livorno.

1. INTRODUCTION

The use of 3D graphics and Virtual Reality for the visualization of urban data-sets is becoming increasingly common for a wide range of possible uses: urban planning, communication, emergency management, architecture, documentation, social networking, education etc. This variety of uses corresponds, as it is reasonable to expect, to different requirements and needs and, consequently, to different solutions. Urban planning, for instance, requires high precision geo-referenced datasets coherent with the corresponding real counterparts. Architectural applications usually need for a high visual realism, not only from a spatial-volumetric perspective but also, and overall, in terms of lighting. Cultural heritage applications commonly stress the historical accuracy and the fidelity to the existing and validated documentary sources. Social networking systems stress the need for a strong visual appeal in order to attract users and enlarge the communities. All of these application sectors, moreover, may or not require the digital model to be interactive. This requirement can make a big difference in terms of implementable features. Indeed when dealing with real-time rendering, despite of the repeated breakthroughs in graphics hardware performances, it is often necessary to find the right balance between quality and resources. This requirement usually implies that either the geometrical complexity of the 3D model, or the texture images quality, or both, have to be kept in reasonable limits in order not to affect real-time performances. As a consequence, this may lead to a certain visual "roughness" which, depending on cases, may be unnoticeable, tolerated, unwelcome or even unacceptable.

In this paper we present the results of a multimedia project based on the virtual reconstruction and visualization of the urban development of the town of Livorno, in the Italian region of Tuscany, on the 400th anniversary of its promotion to the rank of City. The project involved the realization of a 3D model of the town in ages, aiming to show its evolution and development in time. The virtual model has been realized on the basis of several documentary sources, like maps, paintings, texts and, whenever possible, geo-referenced data. The aim of the project was mainly to setup a divulgation tool for dwellers and students. Hence, the stress was mainly set on the visual appeal (exploiting high-quality rendering and immersive stereoscopy), on the same time putting a particular care in the provided historical and art history information. Although the first step of this project produced a non-interactive VR system, the 3D model has been realized keeping in mind the eventual transmigration to an interactive system. A considerable effort was therefore devoted to finding a good compromise between visual pleasantness and geometrical complexity, so as to allow a painless shift to real-time. The results have been demonstrated in the context of a dedicated exhibition, making use of a stereoscopic installation conceived for large audiences, hosted in the premises of Museo Fattori in Livorno.

2. RELATED WORK

An important distinction in the case of virtual cities can be made based on the technical solutions adopted both for modeling and rendering. When the best accuracy is needed, models are usually produced by means of 3D scanning techniques (when dealing with urban elements usually time-of-flight devices are used). The most flexible solution is that of 3D modelers: general purpose programs like 3dsMax, Maya, or Blender, or specifically devoted CAD applications, allow generating 3D urban models with the wanted level of precision and accuracy. However, this solution commonly implies, as a non negligible trade-off, a huge modelling effort in terms of time (which can result particularly burdensome) and the need of non-common modelling skills. A very interesting opportunity is provided by procedural engines which, with a minimal parameters setup and sufficient input data, can produce incredibly vast and detailed models of very large areas.

As far as real-time rendering is concerned, two main options are commonly possible: using off-the-shelf technologies (for instance game engines, like Torque (Andreoli et al., 2005), Unreal or Quake (Fritsch and Kada, 2004) or VR engines, either

commercial or academic, like Virtools (http://www.virtools.com) XVR (http://www.vrmedia.it) and similar), or purposely developing a rendering engine optimized for the specific needs of the application.

Furthermore, in the latest two years a great deal of interest has arisen in dedicated internet-based platforms. An example is Second Life which, despite of a quite original and somehow unpractical methodology of modeling, has allowed the creation of a wide user community and of an even wider virtual world created by users itself, with lots of realistic, unrealistic and hyper-realistic architectures.

Another increasingly popular platform for visualizing virtual cities is without doubt Google Earth (http://earth.google.com). Started mainly as a map viewer, with limited 3D functionalities for low-detail models, it has become a widespread platform for the deployment of geographic information content, aiming to become the "virtual globe" application par excellence.

A nice recent example of VR for urban planning is provided by the Peachtree Corridor Project which aims to setup a tool to assist the "transformation of one of the main street of Atlanta in a world-class boulevard" (http://www.peachtreecorridor.com). The tool is based on the real-time exploration, achieved by means of the Unreal 3 engine, of a 3D digital model obtained by a combination of laser scanned and manually modeled elements.

Another relevant example is the Virtual 3D City Model of Berlin (Dollner et al., 2006) a system for integrating, managing, presenting, and distributing complex urban geo-information. As authors claim, their virtual 3D city model can be considered to be "a 3D geo-virtual environment". This model makes use of CityGML (Kolbe et al. 2005), a first open data model and XML-based format for storing and exchanging 3D city models data.
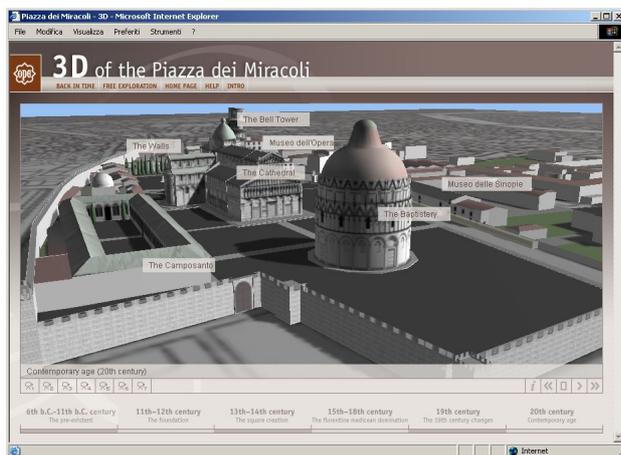
Figure 1. The web-based 3D interactive exploration of Piazza dei Miracoli in Pisa (http://piazza.opapisa.it/3D)

In the field of Cultural Heritage several examples exist spanning almost the whole range of available solutions, depending on the specific purpose and on the rendering terminal. One of the most recent and popular is Rome Reborn (Guidi et al., 2005) a project aimed to the reconstruction of the urban development of ancient Rome over a period of about 15 centuries. The model has been realized in several steps, the first one involving the digitization of a pre-existing large plastic model. The current version replaces almost all models derived from the physical model with procedural models created with the City Engine software (http://www.procedural.com). Currently the model is also available on Google Earth.

Other interesting examples dealing with the visual representation of the urban development of cities or cultural sites are Trento (De Amicis et al, 2008), making use of Google Earth, Piazza dei Miracoli in Pisa (Carrozzino et al., 2005), based on the XVR technology (Figure 1), and the Appia Antica project (Forte et al., 2005), realized with Virtools.

Many of these examples are web-oriented or web-enabled. However, several other projects exist which aim to achieve a great visual impact and to keep the reconstructions as faithful as possible. Indeed, in this case high-performance immersive hardware platforms are usually needed, so these projects are commonly demonstrated in dedicated exhibition spaces, like the Virtual Archaeological Museum of Ercolano (http://www.museomav.com), the Cineca Virtual Theatre (http://www.cineca.it), the Virtual Museum of Sculpture of Pietrasanta (Carrozzino, 2008 – Figure 2), and many others.

Figure 2. The immersive powerwall of the Virtual Museum of Sculpture

3. VIRTUAL LIVORNO

3.1 Historical Background

Livorno, born and built in the XVII century, is the expression of a culture combining themes developed in the previous century, based on treatises of military architecture, with the full maturity of an original specificity dealing with issues of baroque design. The economic and demographic growth of Livorno was unrestrainable (from 900 at the end of XVI century to 20000 residents at the end of XVII, which made the town the second one in Tuscany, after Florence): architects, officials, soldiers and technicians, both from Italy and from abroad, give to the new Lorena dynasty a town strongly different from the Renaissance regularity. Prosperity, ambition, and the new exigencies of a unique and peculiar situation, lead to the elaboration of novel schemes and to the confrontation with models still unfamiliar in Tuscany. This is quite a noteworthy period, being Livorno the only Italian city entirely designed in

the XVII century, which produced, as a consequence, a picture of Livorno as a "baroque city", which remained untouched up to the heavy devastations occurred in the course of World War II, when almost the whole centre of the town was completely destroyed by bombing.

In order to make more understandable modes and times of the urban development of Livorno, we identified in this age four main periods. This distinction, although with the simplifications related to this kind of schematization, should make easier the understanding of this quite original episode of urban history.

3.2 The project

The main aim of both the 3D architectural reconstruction and the narration, was to visually recover the consistency of Livorno, severely modified by the WWII destructions, so as to restore the memory of a remarkable urban and monument complex, important not only on a regional scale, but also at a national and international level

Figure 3. The plano-volumetric layers identifying the main periods of the urban development

The first step of the project, ended in 2007, produced as an initial result a non-interactive single-segment passive stereoscopic installation, which has been exposed in a dedicated museum exhibition, showing a high quality animated rendering of the urban evolution of Livorno starting from 1606 till 1732.
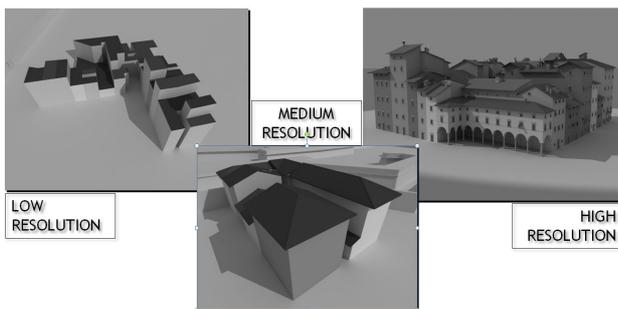

Figure 4. Different levels of detail

The resulting reconstruction is composed of four plano-volumetric layers (Figure 3) related to the selected different historical periods. The urban components have been modelled in three levels of detail (Figure 4), according to the relevance of the specific building, or block, and to the availability of reliable and detailed iconographic sources, giving back in any case a volumetrically correct representation of the involved element.

The application itself can be considered as a blend of digital storytelling and immersive virtual environments. Being narration a fundamental component of multimedia applications oriented to edutainment, it is important to structure the tale so as to provide the message without drowning users in too many information. Therefore, the evolution process of Livorno was described by using two modalities. The first one, the main tale, provides a complete overview of the city evolution (Figure 5), whilst the second one offers several in-depth micro-tales dealing with particular districts and infrastructures.
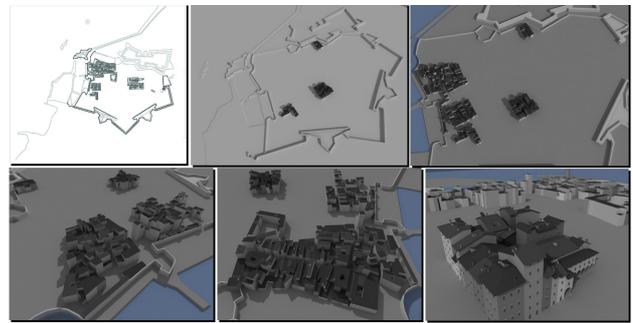

Figure 5. Steps of the virtual reconstruction

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Prior to the modelling of the city, a long stage of historical research has been carried out in order to retrieve the needed iconography (Figure 6) and to be able to structure the model on different levels of detail. Once the model has been realized, keeping into account the aforementioned issues related to the subsequent shift to real-time, like in the aforementioned case of (Carrozzino et al., 2005), it has been used as the base for a non-interactive stereoscopic movie (Figure 7) to be displayed in a VR immersive installation.
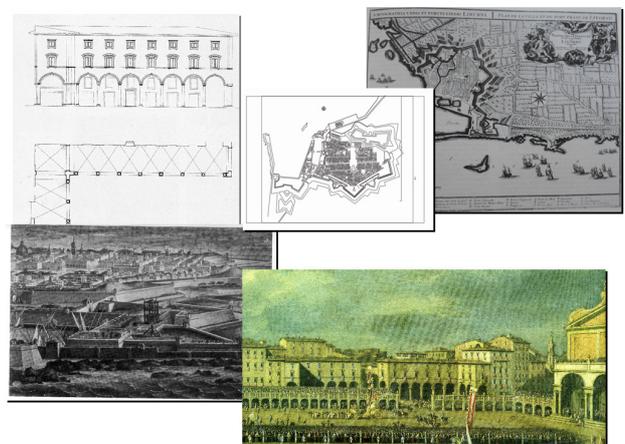

Figure 6. Examples of maps and iconographic sources used for the 3D reconstruction of Livorno

Figure 7. A stereo pair

VR is an appealing technology offering unique features in terms of immersion and interaction. In the VR context, Immersion can be defined as the physical feeling of being in a virtual space. Usually it is achieved by means of sensory interfaces which "surround" the user. Interaction is related to the user capability of modifying the environment and receiving a feedback to his/her actions. Oversimplifying, interaction and immersion can be considered as variables, placed on a two perpendicular axes, which concur to create the sense of user *presence* (Figure 8). This is commonly one of the main aims of a VR system, as it is proved that immersive presence may play a big role in enhancing learning. The narration paradigm adopted for this first step did not require interaction, with the partial exception of the choice of the "chapter" to visualize through a touch-screen interface; therefore we used stereoscopy to partially counterbalance, in a sense, the lack of interaction through the enhancement of immersion features.

As a matter of fact, a cultural experience is, per se, an immersive experience. Whenever we read a book, or we watch a movie, we usually tend, more or less markedly, to identify with the described characters and environments, until we form an inner mental image of that world. Each of the experiences related to a particular communication means (such as words, music, images, etc.) brings us to a different level of immersion in the world created by that means (Ryan, 2001).
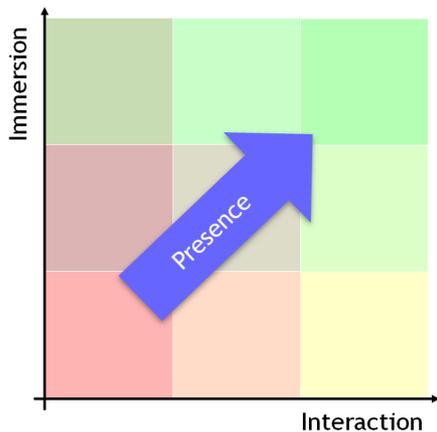

Figure 8. Interaction vs. Immersion diagram

Immersion in VR can be created not only by way of hardware devices such as Powerwalls, CAVEs or HMDs, but also through software features that enhance specific perceptual issues: photorealism (Figure 9) is one of the possible ways to achieve this goal. In this case, this was made possible due to the choice of non-interactive rendering, which made unessential all the time-related limitations which real-time requirements imply.
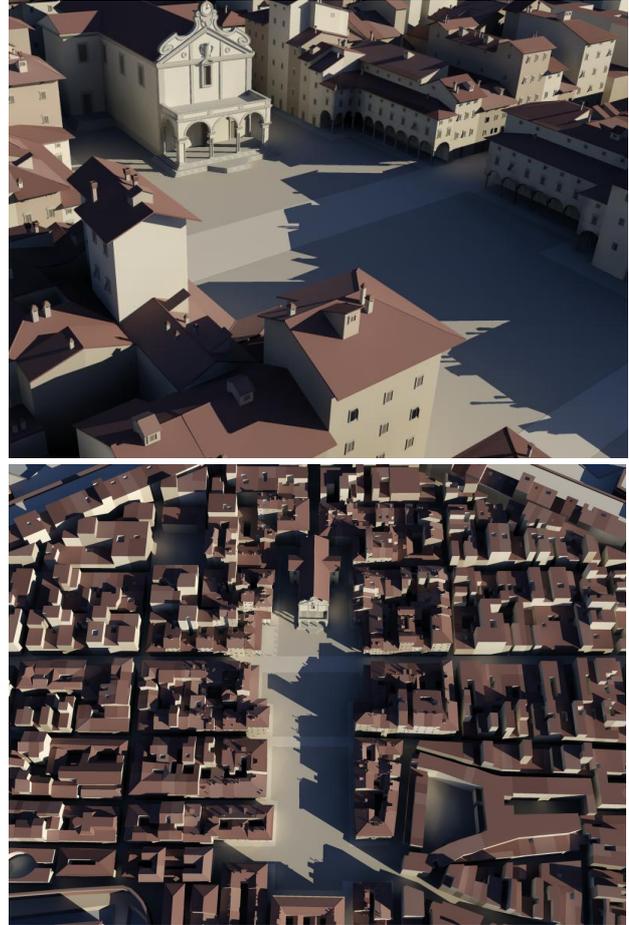
Figure 9. Screenshots of the final application

The project was presented in an exclusive exhibition, held at Museo Fattori, which was to last one month but, due to the good success in terms of audience and requests of cultural and educational institutions, was extended to last six months. The system has been meant for a large audience (as shown in Figure 10) with a slight cinematographic approach. Yet, despite of the lack of interaction, people felt enough immersed in the narration to enjoy a forty-minute experience, quite longer than usual.

Figure 10. A "sci-fi" audience wearing 3D glasses

4. FUTURE WORK AND CONCLUSIONS

The reconstruction of Livorno we have presented was meant to be the first of a long series of steps which, expectedly, should provide to the city an important instrument of education, divulgation and information. Despite the considerable interest of the involved institutions, so far the main activity in progress is fund raising; therefore the project is currently in stand-by.

The next steps of the project will involve the completion of the history of the urban development up to nowadays, the expansion to the installation to a three-segment panoramic Powerwall, and the implementation of interactive functionalities in order to allow a free navigation of the virtual model, in addition to the guided modality so far available. The interactive version of the product, already under development, will be also available on the web by means of the XVR technology [XVR] , jointly developed by PERCRO and VRMedia s.r.l., which allows the deployment of real-time virtual reality applications on HTML pages. The final rendering quality is ensured by the use of high-resolution light maps able to store information related to photo-realistic static lighting.

The final step will involve a faithful reconstruction of Livorno in the contemporary age, based on images and geo-referenced data made available by the local government, with the additional aim of integrating 3D data in the GIS system already in use. The 3D model will in fact constitute not only an additional information layer, which can serve for several purposes such as city planning, simulation, tourists information or cartography, but also as an advanced interface to access geographically referenced contents, like documents related to artworks or monuments.

5. ACKNOWLEDGEMENTS

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