

Lost Cities as a Virtual Experience: The Example of Pre-Earthquake Lisbon

The study of a lost city is always a great challenge. The city of Lisbon that was destroyed by the 1755 earthquake is more than a distant memory. In fact, we are mainly in the presence of an absent memory, because it disappeared abruptly, leaving few records of its former existence. Evidently, it is vaguely present in the districts around the castle, which were rebuilt outside of the adopted reconstruction plan. It is also perceptible through the existing fragmented and dispersed documents that survived the earthquake and Lisbon's subsequent history. However, the city centre that disappeared on 1 November 1755 was more than a vague collection of buildings, streets and alleys reminiscent of an extended past. It was a long-standing memory, consubstantiated in a lived urban and architectural setting that connected past and present. As such, it was able to generate, as all living cities are, a dialectic relationship between its material and social dimensions. The long and significant historiography of pre-earthquake Lisbon has been shedding some light on this lost urban reality. However, it fails to clearly reveal its all-encompassing character and to enable a visual outlook of the city as a whole. The project *City and Spectacle: A Vision of Pre-Earthquake Lisbon* was thus devised as a virtual, interactive and immersive laboratory of research on the lost city of early eighteenth-century Lisbon. It aims to recreate not only the city destroyed by the earthquake, on which the reconstruction plan was carried out, but also some aspects of its daily life, through the recreation of some events such as processions, bullfights, opera performances and the infamous inquisition exe-

Helena Murteira
Alexandra Gago da Câmara
Paulo Simões Rodrigues
Luís Sequeira

University of Évora –
Centre for Art History and
Artistic Research (CHAIA),
Lisbon Open University, and
University of Trás-os-Montes
and Alto Douro, Portugal



1. Georgius Braunius and Frans Hogenberg, Civitates Orbis Terrarum (Cologne, 1598). Lisbon in the mid-sixteenth century. Engraving. Lisbon City Museum.

cutions known as *autos de fé*. Its goals are the furthering of knowledge and debate on pre-earthquake Lisbon, but also the sharing of this experience with a wide audience in a context of social interaction.

This chapter will address the place of this project in relation both to Lisbon's historiography and to the study of lost cities in general in the realm of virtual archaeology and cyber-archaeology. As such, it will analyse its scientific, pedagogical and leisure potential and its new ontological value both as a scientific venture and a sensory experience.

The 1755 Earthquake in Lisbon as Both a Disaster and a Catalyst for Change

On the eve of the 1755 earthquake, Lisbon had long since lost its early-sixteenth-century status as the capital of the most prominent European colonial empire. However, it still held a significant place in the maritime trade network of the time. Its strategic location, facing the Atlantic at the western end of Europe, and its active role in the European colonial trade were responsible for its cosmopolitan character and large population (fig. 1).

2. Dirk Stoop. The Palace Courtyard in the seventeenth century (1662). Oil on canvas. Lisbon City Museum.



Lisbon was from the early seventeenth century one of the most populous cities in Europe (Vries 1981), having reached a population of 191,000 inhabitants in 1755 (Rodrigues 2008). Lisbon also harboured a large number of foreign citizens, particularly merchants and sailors. African slaves were used as domestic servants, giving a distinctive imprint to daily life in Lisbon.

Lisbon was also known for its many convents and churches, the winding and narrow character of its urban layout and its dirtiness, ‘the stinking Lisbon’ as the Scottish architect Robert Adam emphatically labelled it (Fleming 1962).¹ In fact, Lisbon was not dissimilar to other European cities in the way it addressed urban challenges such as building regulations, sanitation, policing and lighting. However, the sharp contrast between the wealth generated by the Brazilian trade, manifest in the Baroque surge of early-eighteenth-century Lisbon, and the city’s deficient response to those challenges was frequently noted by foreigners – particularly the British, who compared it to the steady progress of their own capital towards modernity (Macauley 1946, 1990) (fig. 2).

1. Robert Adam knew about the 1755 earthquake in Lisbon while touring in Italy and aspired to be appointed by the Portuguese king to rebuild the city. In his letters to his family, he compares Lisbon to Edinburgh, his hometown, which was as well known for its lack of regular street cleaning (Fleming 1962).



3. Francisco Zuzarte (attribution). The Palace Courtyard on the eve of the 1755 earthquake (n. d.). China-ink drawing. Lisbon City Museum.

But Lisbon was also a city in transition. Notwithstanding the fact that the city remained in its core a medieval urban structure, a significant effort towards modernization is traceable mainly from the second half of the seventeenth century (Murteira 1999). The city council discourse reveals the development of a concept of the city as a coherent entity in need of all-inclusive management, which we can date back to the sixteenth century (Carita 1999; Murteira 1999; Caetano 2005).

The serpentine maze of the city centre was in some areas torn apart by the widening of some of its main streets, following regular patterns; new quays and public buildings were built; a 58-kilometre aqueduct was constructed, testing the engineering skills of Portuguese military engineering; old quays and roads were repaired and legislation was issued regarding the construction of new buildings or extensions of old ones (Pinto 1989; Rossa 1998; Murteira 1999). The Portuguese crown matched these endeavours by planning architectural ensembles that enriched the city centre and some adjacent areas (fig. 3).

This latter program of works largely benefitted from the Brazilian trade in gold and diamonds that had turned Portugal's King D. João V (1689–1750) and his son King D. José I (1714–77) into two of the wealthiest kings in Europe (Ayres de Carvalho

1962, Bottineau 1973, Mandroux-França 1989, Ferrão 1994, Calado, 1995, Rossa 1998, Delaforce 2001, Pimentel 1991, 2002, 2012, 2013, Câmara 2006, 2007, 2013, 2015, Januário 2008, Gallasch-Hall 2012). The aristocracy followed the crown's example and built several new palaces in the city.

Lisbon was slowly but relentlessly trying to modernize its image and seeking to adapt to the demands posed by its role in the commercial network of eighteenth-century Europe (Murteira 1999; Rossa 2002). On the eve of the earthquake, the Lisbon City Council was informing King D. José I that the public works of the previous decades had exhausted its financial resources (Murteira 1999).

At 9.30 AM on 1 November 1755 a violent earthquake shook Lisbon. Three shocks separated by only a minute were felt, with a total duration of nine or ten minutes, a rare and highly destructive occurrence. Estimated today as 8.7/ 9.0 on the Richter scale, the earthquake ruined Lisbon's city centre and caused severe damage in its adjacent areas. A powerful tsunami and a fire that lasted for five or six days completed the destruction. Several aftershocks followed, the first at noon, with almost the same intensity as the original quake (Paice 2008). In the first week twenty-eight aftershocks were felt in Lisbon, and some five hundred earthquakes shook the city before the end of 1756.

The 1755 Lisbon earthquake is considered the most powerful earthquake to have ever taken place in Europe. It was felt in a wide area extending from Portugal to Spain and North Africa. It occurred along the Azores-Gibraltar fracture zone (AGFZ), just off the S. Vincent Cape on the southwest coast of Portugal, and also badly damaged the cities of Seville, Cordoba, Granada, Cadiz, Algiers and Mequinez (Davison 1936; Baptista *et al.* 1998, 2003). Algarve fishing villages and other towns along the Alentejo Coast were inundated by the tsunami that followed the earthquake and reached as far as the coast of Brittany, southern Ireland and southwest Britain (Chester 2008).

For its role in the European trade, Lisbon held a significant colony of foreign merchants, of which the British were the most numerous. The letters written by some of these British merchants to their families at home are to this day the most vivid accounts of the terror and suffering undergone by those caught in the 1755 Lisbon earthquake (the British Historical Society of Portugal 1985, 1987). The trauma was extensive and severe. King D. José I refused to live again in a stone building and ordered the construction of a wooden palace. The court followed suit.

It is difficult to ascertain today the loss of human life with much accuracy. The lack of reliable census data from this period and the destruction of a significant number of the city's parish records do not help in this task. Estimates of the death toll at the time vary from 10,000 to 100,000 people in Lisbon alone. Recent studies suggest 30,000

to 40,000 deaths in Lisbon, including children, visitors and the injured that perished in the subsequent months (Pereira 2009; Paice 2009).

The material damage is even more difficult to establish. The Ribeira Royal Palace, with more than 250 years of history, the new Opera House, the new Patriarchal Church, the Custom House and several other public buildings, all the city hospitals, thirty-two palaces, and approximately sixty of the city's seventy-two convents vanished, and two-thirds of the city's building stock became unsafe for habitation (Moreira 1758; Sousa 1909, 1919; Boxer 1956; Estorninho 1956; Kendrick 1956; França 1983; Murteira 2004; Pereira 2009; Paice 2008). An innumerable number of records, books, works of art, money and goods disappeared in a few hours. Foreign losses may have reached twelve million pounds sterling, of which more than half were British losses (Kendrick 1956). Studies of the Portuguese losses propose very different estimates that range from 43% to 57% (Estorninho 1956), 32%–48% (Pereira 2006), 75% (Cardoso 2007) and 115–153% (França 1983) to 133–178% (Sousa 1928) of the nation's GDP. However, as Edward Paice claims, it is not possible to ascertain with any precision the value of the extensive loss of built heritage and its contents (Paice 2008) (fig. 4).

The 1755 earthquake in Lisbon shocked Europe to the core. The catastrophe was close to home whilst having a significant impact on the European maritime trade of the time. It quickly became the topic of the day, benefiting from the emerging media network brought about by newspapers. It occupied news headlines for more than six months, and as such it was probably the first event to deserve this media attention (Dynes 2003; Murteira 2004; Pantti *et al.* 2012). An impressive international aid campaign was put in place. From Britain, Spain, France, the Netherlands and the German States came money, goods, workers and technical expertise (Murteira 2004; Paice 2008).

More than a thousand texts were written on Lisbon as a result of the 1755 earthquake. The fast-growing production of copper engravings and etchings at the time also played a role in the widespread European interest in this city. In fact, several pictures were published portraying Lisbon before and during the earthquake (Moreira *et al.* 1998).

The discussion this literature generated encompassed many lines of thought (Araújo *et al.* 2007; Buescu and Cordeiro 2005; Murteira 2004; Almeida 2009). Religion and superstition were undoubtedly the main topics addressed. However, the discussion extended to the philosophical debate and furthered the search for a scientific explanation of natural catastrophes, particularly seismic occurrences. Optimism, as formulated by Gottfried Leibniz and Alexander Pope, deserved a strong criticism from Voltaire. In his works *Le désastre de Lisbonne* (1756) and *Candide ou l'Optimisme* (1759), Voltaire refuses to accept that ours is 'the best of all possible worlds' and argues that evil is a significant part of nature. However, it is Rousseau who points out

4. Bernardo de Caula.
View of Lisbon ruined by the 1755
earthquake. The Palace Courtyard (detail).
Quill pen drawing with sepia and grey ink.
National Library of Portugal.



the real difference in thinking, claiming to Voltaire that the scope of the catastrophe was in a great part a result of man's actions:

“Moreover ... the majority of our physical misfortunes are also our work. Without leaving your Lisbon subject, concede, for example, that it was hardly nature that there brought together twenty-thousand houses of six or seven stories. If the residents of this large city had been more evenly dispersed and less densely housed, the losses would have been fewer or perhaps none at all” (Rousseau 1756).

In this, as we shall see, he is in tune with the Secretary of State to King D. José I, Sebastião José de Carvalho e Melo (1699–1782), known in Portugal as the Marquis of Pombal, a title he would receive in 1770. His innovative approach to the catastrophe is considered today to be the first modern response to a natural disaster.

Pombal had already envisioned plans for Lisbon, which were supported by the experience and expertise of the Portuguese military engineering. The 1755 earthquake gave him the opportunity to develop an extensive program of works that would equip Lisbon to serve as the heart of a vast plan of reforms for Portugal. His aim was to reform and modernize the country within the political and social confines of ancient regime society (França 1983; Cardoso 2007). After the earthquake, his priority was to restore some sort of normality amidst the chaos. Most of the population had fled the city and refugee camps were settled on the outskirts of Lisbon. They lacked the most

basic needs, including water and food. Meanwhile, hordes of outlaws looted the ruined city, killing everyone in their path. Defying the odds, Pombal issued legislation regarding the punishment of the rioters, fixing the prices of basic foods, forbidding the uncontrolled reconstruction of any buildings in the city centre, setting up a team of medical experts to evaluate the risks of a plague and commissioning the old military engineer Manuel da Maia (chief engineer of the kingdom) to prepare a plan for the reconstruction of Lisbon (Freire 1758; Conceição 1818; França 1983; Almeida 2009). He also ordered a survey of all the destroyed properties, which included their location and dimensions, the identity of the proprietors, and a questionnaire to all the parishes about the effects of the earthquake (Freire 1758; Conceição 1818; França 1983; Almeida 2009). This last survey also included questions about any unusual phenomena witnessed that day that could provide vital information for the study of similar occurrences. As such, it represented the first politically centralized attempt to look at seismic phenomena from a scientific perspective. The reconstruction of Lisbon was a major enterprise that combined both political and legal expertise with a state-of-the-art approach to architecture and city planning. It was one of the first and most revealing examples of the ability of Enlightenment Europe to respond to natural catastrophes of this magnitude. A regular and standardized architectural and urban unit was constructed that took into account not only the economic and social challenges facing eighteenth-century European cities, but also their risk management response in the face of this type of adversity (fig. 5). However, the reconstruction plan also buried the old city and with it a significant part of its memory.

The Lost City as a Multisensory Virtual Reality: *City and Spectacle: A Vision of Pre-Earthquake Lisbon*

The Historiography of Pre-Earthquake Lisbon: Attainments and Constraints

In Portugal, the study of the physical dimension of the city as a civilizational object, and of its built urban structure as a manifestation of certain historical circumstances, dates back to the last quarter of the nineteenth century, with Lisbon being the first focus of interest. For instance, the neighbourhoods in which the material memory of Lisbon's pre-earthquake period better resisted the passage of time provide a good perspective on that era. Examples can be found in the configuration of certain streets, buildings and architectural elements, such as a window, an arch or a section of the castle walls.

This new approach to the city's past was owed to a group of scholars who, passionately curious about the past of the Portuguese capital, began investigating the history behind its most ancient neighbourhoods and disclosing this new information in the-

5. João Pedro Ribeiro. Copy of the adopted plan for Lisbon by Eugénio dos Santos and Carlos Mardel. Lithography (1947). Lisbon City Museum.



matic publications (Castilho 1879, 1902, 1884; Oliveira 1882–1911; Carvalho 1898; Sequeira 1906–09; Silva 1900; Brito 1911). The first of these scholars was Júlio de Castilho (1849–1919), and the first of such publications was his own *Lisboa Antiga: o Bairro Alto*, published in 1879 (with revised and improved editions in 1902 and 1904). Eight more volumes followed, dedicated to the *Bairros Orientais* and published from 1884 onwards.

Julio de Castilho's *Lisboa Antiga* was innovative due to its approach to the neighbourhood as a unit that conferred an urban and historical dimension to the sub-units, namely its buildings. The perception of the historical value of the buildings was the result of their architectural and material characteristics as well as their topographical implementation and the way in which they articulated themselves within the built urban environment (Rodrigues 2005). In the buildings constructed before the 1755 earthquake, these aspects were clear due to the formal and urban contrast established with the modern city. They were valued as a result of the knowledge they transmitted of the oldest ways of urban life, which were otherwise only accessible through iconography or through documentary and literary descriptions.

In *Lisboa Antiga*, Júlio de Castilho began a literary tradition with immediate followers and which eventually constituted itself as an autonomous thematic area – the Olisipography, a field exclusively dedicated to the study of the city of Lisbon (Branco 1994). This field is largely represented by works of monographic character or documentary surveys with the objective of raising awareness of the personalities, figures, habits, ways of life and social and urban practices of the past. The exception

goes to the studies of the engineer Augusto Vieira da Silva (1869–1954), which were dedicated to the reconstitution of the medieval walls of Lisbon, and which include the study of the layout of the buildings and adjacent streets. To achieve this, Augusto Vieira da Silva used a plan of the city destroyed by the 1755 earthquake, drawn up by the architects responsible for the reconstruction of Lisbon, namely Eugénio dos Santos and Carlos Mardel, whilst in preparation for the new city plans (Silva 1900). This plan allowed Augusto Vieira da Silva to compare the destroyed urban maze with the new layout, the first attempt at reconstituting the pre-earthquake urban configuration of Lisbon.

In essence, Olisipography, or the history of the city of Lisbon, did not exit these theoretical parameters until 1966, when the art historian José-Augusto França published in Portugal a doctoral thesis entitled *Lisboa Pombalina e o Iluminismo*. The book draws on the study of Lisbon rebuilt under the orders of the Marquis of Pombal after the catastrophe. The focus is on the reconstruction process and how it was determined by the aesthetic and ideological principles of the Enlightenment. In his study, for the first time in Portugal, José-Augusto França placed the urban form as an object of study in art history. He viewed it as an artistic fact determined by concrete historical circumstances, manifest in a conjunction of political, social and economic factors, such as political absolutism or the economic reforms introduced by Pombal, and its effects on the social organization of the country. Architecture and the remaining arts are also understood according to the urban form, thus arising as an integrative and regulatory framework of the parties through the aesthetic values of the Enlightenment (França 1987). With the establishment of this inter-dynamic relationship between space, architecture and art, the urban form is no longer the only issue at stake, but the city itself as an historical aggregation of society becomes the primary focus of art history. The concept of art history as the history of a city also began to be explored by Giulio Carlo Argan in the late 1960s, but in the context of the Italian cities of the Renaissance and Mannerism (Argan 1998) – a concept which José-Augusto França would reaffirm about forty-two years later in one of his last works dedicated to the history of the city of Lisbon, *Lisboa: História Física e Moral* (França 2008).

The publishing of the book *Lisboa Pombalina e o Iluminismo* was pivotal in the context of the historiography of art, of cities, and of Lisbon in particular. From it derived a set of studies that deepened the methodology and applied it to other periods of the history of Lisbon, namely the most ancient periods that preceded the earthquake (Araújo 1990; Rossa 1998; Murteira 1999; Carita 1999; Senos 2002; Caetano 2004).

In regards to eighteenth-century Lisbon, the works of Helena Murteira and Walter Rossa stand out (Murteira 1999; Rossa 1998). Whilst the work of Helena Murteira comprises an integrated analysis (both urban design and architecture) of the devel-

opment of the city between the late seventeenth century and the early eighteenth, Walter Rossa focuses essentially on the configuration of urban space, understood as the autonomous and individual study of urban form, which becomes one of the main topics of the history of Lisbon of the first half of the eighteenth century. This theme of the history of Lisbon's urban form emphasizes the viewpoint of planning and regularity as structuring values of a distinctively Portuguese urbanism, and even of an eighteenth-century Portuguese school of urbanism, which is thought to combine the geometric spirit of the Italian Renaissance treatises and the study of mathematics with the pragmatism of the military architectural experience in the Portuguese empire. This was the result of a political power needing efficiency and swiftness in the occupation and organization of its overseas territories (Correia 1995; Rossa 2002).

The other main topic in the history of eighteenth-century Lisbon is restricted to the available knowledge of the architecture and the interior of its main buildings, namely those that were part of the palace complex by the river Tagus and which disappeared with the earthquake: the Ribeira Royal Palace, the Patriarchal Church and the Tagus Royal Opera House (Carvalho 1962; Bottineau 1973; Mandroux-França 1989; Calado 1995; Delaforce 2001; Januário 2008; Pimentel 2012, 2013; Gallasch-Hall 2012). By studying the available documentary sources – such as iconographical sources (paintings, drawings and engravings), cartographical sources, city plans, administrative documents, letters and travel literature – authors attempted to establish what those buildings were like inside and out, how they were furnished and decorated, and how they were integrated into the artistic culture dominant in Portugal and Europe.

From the twenty-first century onwards, the application of digital technology to history and to the archaeology of a city through digital recreations or reconstitutions has made the amalgamation of urban and architectural structures possible. The present project is structured in this context, but it seeks to go even farther in that it aims to integrate in the same model the interior of the buildings, the sounds of the surrounding urban environment, and the representation of social events. Digital technology has made it possible to virtually synthesize the body of accumulated information and the current state of knowledge which has turned the city into a civilizational object of study in perhaps the most complete and complex manner.

The City and Spectacle Project: Origins, Aims and Scope

The interaction and bridging between cultural heritage and digital technologies has been promoting in the last few decades a consistent and widening debate about the way in which we understand the past, specifically in the context of art history and urban history, by imposing new challenges and different epistemological contours.

6. The Navy's Arsenal in Lisbon.

7. Ruins of the Royal Opera House. MM. Paris, Pedegache and Jacques Ph. Le Bas [n.d.]. Engraving. National Library of Portugal.

8. Tagus Royal Opera. Second Life recreation, 2005.

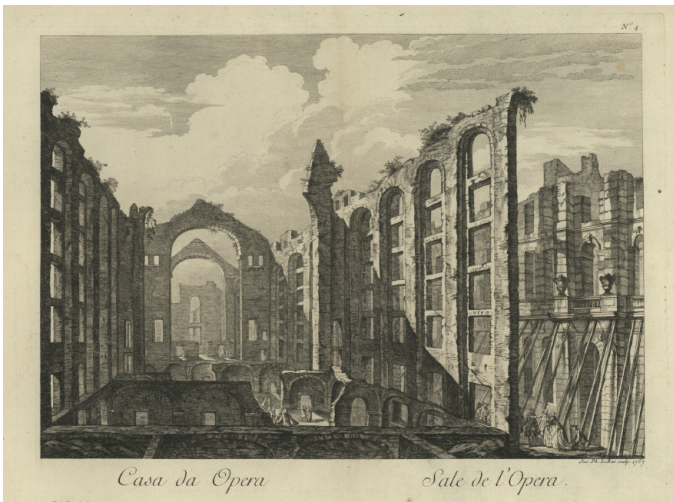


6.

By using Second Life technology in the OpenSimulator (OpenSim) version, the project *City and Spectacle: A Vision of a Pre-Earthquake Lisbon* was born with the purpose of virtually recreating the destroyed Tagus Royal Opera House, which had been inaugurated on 31 March 1755 with a production of *Alessandro nell'Indie*. The Opera was one of the most emblematic spaces of eighteenth-century Lisbon, conceived by the architect and set designer Giovanni Carlo Bibiena (1717–60). As a result, a first digital model of the theatre at a spatial, volumetric and scenographic level was presented in 2005 in commemoration of the 250th anniversary of the 1755 earthquake (Câmara 2006).

As a result of the 1 November 1755 earthquake, the Opera disappeared from the urban fabric. Although it stood no more than six months, it has remained in the collective memory and the imagination of Lisbon's citizens to the present day. The memory of its unexpected disappearance, the witnesses' accounts, the few iconographic elements that have survived, in addition to a certain degree of controversy regarding its urban implementation, all led to an initiative to recreate this exemplar of artistic excellence, which in recent years has been the object of a pertinent, exhaustive and rigorous investigation.

The massing of this building would have clearly made an impression on Lisbon's waterfront. From the documentation to the analysis and comparisons of Lisbon's city plans prior to the 1755 earthquake, one realises that the location of the Opera House near the waterfront was intended to maintain a civic presence in the area. It would have occupied the vast space to the west of the Royal Palace and the India House, an area where today we can find the Navy's Arsenal (fig. 6).



7.



8.

Recent studies based on analyses of the documentary and iconographic data point to a correlation between the old urban fabric and the post-earthquake layout, indicating coincidences between the deployment and location of the Opera House and the current building of the Navy's Arsenal (Januário 2008; Gallash-Hall 2012; Câmara 2015).

We believe that one of the most effective ways of evoking this forgotten heritage is to recreate the splendour and magnificence of the building, with the support of computer graphics technology, from the documentary and iconographic elements available to us. These include the well-known record of the ruins of the Opera House in an open engraving by Le Bas (fig. 7), a plan and longitudinal section, and engravings of the scenarios executed on the basis of the drawings of Giovanni Carlo Bibiena for the two main productions shown there, *Alessandro nell'Indie* and *La Clemenza di Tito* (Câmara 2013). We thus proceeded towards a conjectural recreation of an interpretative and representative model of what might have been the interior of the Opera House.

The proposal for the 2005 modelling effort intermediated between the constructed theatre and the imagined theatre, and it aimed to understand the spirit of the epoch in which it was originally designed. The usage of an interactive platform like *Second Life* allowed not only for the reconstruction of the building's structure and appearance, but also its animation through the production of a *machinima* (low cost 3D animation) and the inclusion of an excerpt of the opera *Alessandro nell'Indie* presented at the inauguration of the building (fig. 8).

Taking into consideration the fact that a historical virtual reconstruction is always a conceptual task, we found it interesting at a later stage to deploy the Opera House into the urban fabric. We reconstituted its facade and extended the building into its urban context, the designated palace complex, and then proceeded to recreate the entire area destroyed by the 1755 earthquake. This provided the context in which to implement the reconstruction plan.

Choosing the Digital Tool: Second Life/OpenSimulator Technology in the Context of Historical Research and Visualization

In past projects, exhibits of heritage sites – whether on location, in a museum, or recreated digitally (either for specific haptic devices or for common technologies, such as a web browser) – have tended to show architecture and artefacts only, with limited interaction. They replace, in a sense, the traditional paper catalogue or brochure that is presented to visitors in a static form. Here we shall explore how to go beyond those limitations.

When using computer-generated models as part of a historical/heritage project, a few questions need to be raised beforehand. How do historians and archaeologists communicate their knowledge to the technical teams that develop the models? How is the researched documentation (architectural drawings, engravings, paintings, textual descriptions) incorporated into the model? How are decisions made when certain information is contradictory and/or incomplete, and how are those decisions recorded so that the whole process can be analysed and criticized at a later stage? How can a hypothesis be formulated and experimentally verified on a model? How easily can that model be changed if new documentation discredits some part of the hypothesis, or a different decision regarding the model is made? And finally, how can crowds be simulated inside the model, to test certain hypotheses, or to recreate historical events, as opposed to just presenting the architecture?

Early models of historical architecture that had been lost or changed were mostly considered experiments for testing technological advancements in graphics (Frischer *et al.* 2002). Historians and archaeologists only participated during the initial phases and were sometimes hired as consultants to validate the finished model. As a result, the historical accuracy and the validity of the models were often questioned, or at least criticized for the lack of transparency in the kind of decisions made over the documentation employed to create the model.

In the past decade, however, the research community in virtual archaeology has moved to adopt more systematic methodologies, such as the London Charter (Beacham, Denard and Niccolucci 2006) and the Principles of Seville (Lopez-Menchero and Grande 2009, 2012), where historians and archaeologists became the team

leaders of a multidisciplinary group involving the technical developers. The projects adopted an iterative approach in which at each stage the researched documentation would be stored in a database with appropriate metadata, and decisions to incorporate the documentation into the model would be properly recorded (Ryan 2001).

At the end of one iteration, the model would be critically analysed — a process that could also include external consultants — and the team leaders would propose further changes, adding more documentation, reviewing the acquired knowledge during the implementation of the model, and go to the next iteration, until the team leaders deemed that the formulated hypothesis was adequately tested and answered.

In fact, Forte (2014) suggests that the whole process of extracting information in digital form from a model that is being developed might constitute knowledge acquisition by itself, and is an important research result in itself, regardless of the original hypothesis. Developing the model, according to these methodologies, becomes a research field in its own right. Forte calls it *cyberarchaeology* (Forte 2008).

Still, traditional methods for developing 3D models of historical architecture follow a classical graphics development pipeline that is common to other industries, like computer-generated imagery (CGI) in movies or 3D models for architecture and computer games. The team proposing a model meets with the technical developers, who will then painstakingly create the models over a period of several months, until the finished models are finally rendered and can be presented to the research team for validation. Using modern graphics tools, the final model might be visualized from several angles, or walked through to check every element. Any change in the model, however small, requires a new start — waiting for days, weeks, or even months until the researchers are able to check the model again.

An alternative approach is to use virtual world technologies. Virtual worlds are persistent computer-generated environments where participants experience others as being there with them (Schroeder 2008); this definition focuses more on the sensory experience and the immersive quality of the participation in the environment. Beyond presenting 3D models, where users are ‘detached’ from the imaging (even if the model allows some degree of interaction), virtual worlds bring the participants ‘inside’ the simulated environment.

Among the several kinds of technologies enabling virtual world environments, there is a subset that allows users to create their own content and interactively display and even create content within a collaborative framework, often in real time. With these technologies, participants effectively design and create their own environment working ‘inside’ the platform. In such environments, created content is displayed in real time during the development cycle – there is no separate ‘rendering’ phase (a process

that can take several hours or even days) as each model is developed. Instead, developers ‘inside’ virtual worlds create models that are instantly visible for all participants.

This allows a different approach to developing heritage projects with 3D models. The team leaders – historians and archaeologists – no longer gather information that will be used to create the model, then hand the researched documentation to the developers and patiently wait until the model is done. Working ‘inside’ a virtual world is completely different: both historians and developers are logged in to the same environment in real time, discuss relevant details, and can manipulate the environment to explain to the developers what needs to be done. Similarly, developers can show the team leaders how the project is progressing, even in the middle of an interaction cycle, and ask historians for feedback or even to move some buildings around for fine-tuning. Historians, for example, can immediately move the camera’s viewpoint (usually attached to the virtual representation of the user in the virtual world, commonly known as virtual persona or avatar) in order to compare the models with existing pictures, paintings, or engravings, and point out to developers where some changes have to be made (Forte 2009).

Such interactive, collaborative participation among all team members happens in a digital environment, where communication is either text-based (via chat and private messages, in real time or stored on ‘notecards’) or by voice-over-IP communications. In both cases it is easy to keep records and transcripts of the discussions, storing them in the project’s database and later consulting them to validate the accuracy of the models. This is effectively an immersive virtual laboratory of archaeology (Câmara *et al.* 2009; Câmara and Murteira, 2010; Sequeira and Morgado 2013), in which historians and archaeologists are not merely passive observers of the 3D models developed by the technical team, but rather participate in the project during the development stage. At the end, once the models are validated, virtual worlds easily allow visitors to experience the 3D models, therefore simplifying the distribution of the content and raising awareness of the overall project.

Virtual worlds also allow more than mere ‘virtual tours’ of the environment. Because the environment can be programmed and populated with autonomous agents – ‘bots’ or ‘non-playing characters’ – crowds can be simulated using artificial intelligence, thus allowing researchers to explore how heritage sites had been effectively used (Maïm *et al.* 2007). In addition, visitors may be able to understand the context of the heritage site better by watching how bots populate the space and interact with the environment (Getchell *et al.* 2010). Virtual worlds also allow the staging of certain events, using actors or singers with their own avatars, to recreate a specific historical scene such as a public performance, which can even be attended by visitors (Bogdanovych *et al.* 2010). Such performances can also be recorded and distributed through other media.

In most virtual-world platforms, content can also be exported relatively easily in industry-standard formats, so that the same content can be used for developing mobile applications, interactive games (Anderson *et al.* 2010), or even used in documentaries and movies. An extensive description of all virtual-world platforms is beyond the scope of this chapter. For the project *City and Spectacle: A Vision of Pre-Earthquake Lisbon*, the choice was to use a relatively popular environment with a long track record, a considerable user base, technological maturity, and a promise of longevity in the future: Second Life® (Au 2008), a commercial product launched in late 2003 by Linden Lab. It implements a visually contiguous, persistent virtual world with user-generated content. It has attracted dozens of millions of users over the years, with a current active user base of about a million, and is available for all desktop but not mobile platforms. It supports haptic devices such as the Oculus Rift as well as 3D navigation devices, although it is perfectly accessible merely with a keyboard and a mouse. Content can be either built using the existing tools in the viewer interface – an open-source application developed originally by Linden Lab – or uploaded using industry-standard COLLADA files. It has stood the test of time as one of the longest-lived social virtual worlds and has been extensively used by many kinds of educational and academic projects (Allison *et al.* 2012; Duncan, Miller and Jiang 2012).

OpenSimulator (OpenSim) is an independently developed open source server platform launched in 2007 that allows precisely the same viewer application as Second Life to visualize content. Therefore content developed for Second Life will be viewed precisely in the same way under OpenSim. While some minor functionality is absent, and performance will vary according to the hardware used to run the server software, OpenSim shares almost all characteristics with Second Life, and research in one platform applies to the other, since content and programming can usually be exchanged in both directions. The main advantage of OpenSim over Second Life is its cost: it can be run on any available desktop computer without a licensing fee. The main disadvantage, however, is that Second Life has a much larger audience, and Second Life users wishing to connect to a virtual environment developed in OpenSim are required to register with a new avatar, even though they can use the same application to connect to both virtual world platforms.

In our case, the project was moved from a preliminary prototype done in Second Life to our own environment under OpenSim due to cost considerations. However, an effort has been made to keep the content fully compatible with both environments. Since content can be easily exported via COLLADA files, the whole project can easily be imported into future virtual world environments as they become available.

9. Aerial view of the Royal Palace complex. *City and Spectacle: A Vision of Pre-Earthquake Lisbon*, OpenSim version 0.7.5 Dev, November 2012.

10. The Terreiro do Paço (Palace Courtyard). *City and Spectacle: A Vision of Pre-Earthquake Lisbon*, OpenSim version 0.7.5 Dev, November 2012.

11. The Patriarchal Square and Church. *City and Spectacle: A Vision of Pre-Earthquake Lisbon*, 0.7.5 Dev, September 2013.



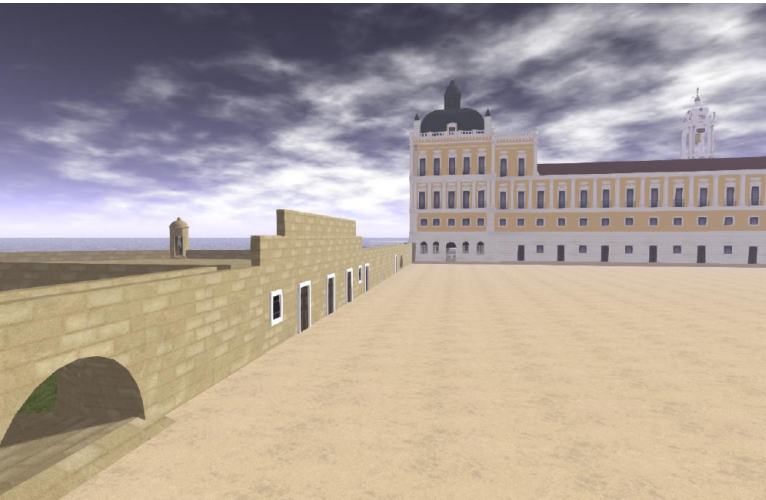
9.

The Outcome: A Novel Methodological and Epistemological Paradigm for Urban and Architectural History

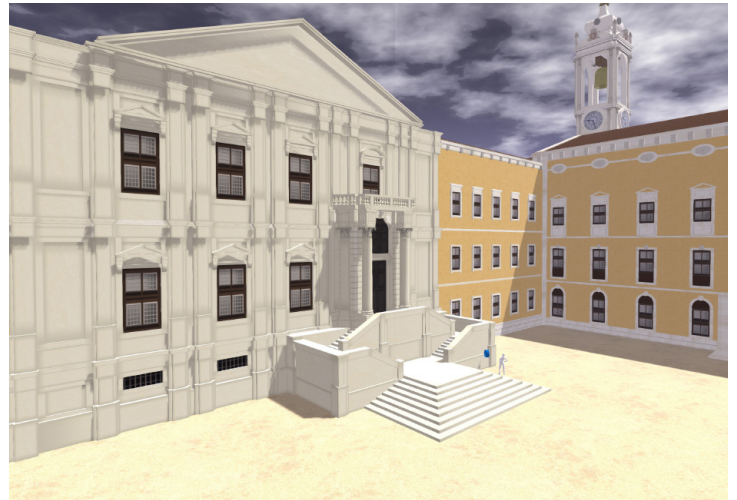
“A city cannot be comprehended merely by a regular route within a particular district, the orderly distribution of public and private functions, or a set of representative and utilitarian buildings. Much like architectural spaces, with which the rest identifies, a city’s urban spaces include interiors. A basilica’s porches, the patios and galleries of public palaces, and the interior of churches are considered public spaces. In addition, the environment of private homes, the altarpiece of a church, and the decor of a bedroom or dining room can also be considered public spaces. Even the clothes and adornments worn by people in the street play a role in the scenic layout of a city” (Argan 1998).²

In this statement, Giulio Carlo Argan defines a city as a complex system of a variety of intertwined sets of human and biophysical factors, from topography to the social activities of its inhabitants. The *City and Spectacle* project draws on this premise with the intent of digitally recreating something beyond the mere virtual illustration of the Lisbon that disappeared as a result of the 1755 earthquake. The project chiefly aims to create a simulacrum capable of emphasizing the qualities and historical circumstances of that complex structure. To achieve this, the buildings are recreated not only

2. Authors’ translation from the Portuguese edition of Giulio Carlo Argan, 1983, *Storia dell’arte come storia della città*.



10.



11.

according to their individual value as architectural objects, but mainly in accordance with their urban value as a result of their contribution to the shape of the city. Hence the option of having decided to initiate the project by recreating the palace complex, perhaps the area of eighteenth-century Lisbon where the urban dimension of architecture is most evident. However, the ultimate objective of the project lies in the recreation of the entire area of the city altered by the post-earthquake reconstruction plan (fig. 9).

The technology of virtual worlds is used as a symbiotic system of accumulated information, of diverse types and origins, gathered by investigators from the written and iconographic documentation found in archives and national museums (fig. 10). The information is then converged into a three-dimensional, interactive and immersive simulacrum of Baroque Lisbon (fig. 11).

The technology used makes it possible to recreate not only the urban configuration of the city, but also the buildings and interiors of some of the most prominent city buildings (such as the Ribeira Royal Palace in the Palace Courtyard, the Patriarchal Church and Square, the Opera House, the Convent of Corpus Christi, and the All-Saints Hospital). In addition, an animated audio component will also be available, allowing users/visitors to experience the city's soundscape, such as the ambience of a market, a procession, a bullfight, or even an opera performance.

- 12. Virtual Museum.
August 2013.
- 13. The Royal Opera House (interiors).
November 2014.
- 14. The Royal Opera House, the Royal
Palace and the Shipyard.
November 2012.



12.

The recreation of the interiors of some of the buildings and events associated with them enhances the perception of their urban value with the perception of the role they played in the complexity of the urban structure, since they manage to depict how the various architectural approaches responded to the public aspirations and needs. As a result, the project will be able to recreate Lisbon on the eve of the 1755 earthquake in its spatial, architectural, social and cultural dimensions.

In addition to the physical and ‘moral’ dimensions of the city, the model also includes a virtual museum with search tools and text boxes that enable users to understand the historical context of the recreated urban structure. Through these search tools and text boxes, users are able to identify the conceptual and theoretical assumptions of the project, and the primary sources which most contributed to the aforementioned recreation of Lisbon (fig. 12). The project is still in its initial stage, since only the Royal Palace complex has been recreated so far, and that mainly in its outward physical appearance. The model also includes the first attempt at recreating the interiors of the Royal Opera House, of which there is scarce documentary evidence (fig. 13).

The text boxes and the virtual museum also require further development and updating. A meticulous study of the animation to be implemented in the whole model is being carried out by one of the authors of this chapter, Luís Sequeira, as part of a doctoral thesis.

One of the main challenges that the research team is facing is the lack of documentary sources of Lisbon prior to the earthquake, as well as the fragmented character of



13.



14.

the existent ones. Also, while the historiography of Lisbon is extensive and significant, it is unable to offer an all-inclusive view of the lost city.

Digital technology, namely virtual worlds technology, not only provides the tools to test and assemble evidence in a single model, but is also able to challenge the evidence and knowledge and demand their constant updating. By simultaneously allowing the creation and regulation of a model of a city, this twin component of virtual world technology is a fundamental part of a process through which one's imagination becomes one of the resources used by authors and users alike to represent, capture and comprehend the possibility of a past proposed by the recreation of a city (Morton 2013). It avoids the so-called *Disneyfication* of the model of a city and delimits the mediation of one's sensory perception of historical knowledge, which is potentially more exposed to the subjective projection of the views of the past, and of the individual memories of each user. The working hypothesis put forward is presented as an interactive and animated model that cannot include gaps in the information it provides. Therefore the different levels of accuracy in the documentary sources, or the lack of sources, as well as the diverse stages of research, need to be presented as such. The virtual museum and the text boxes guide users through the conceptual and methodological framework of the project, and prevent the visual simulacrum of a lost reality from being taken as an exact reconstruction of the past (fig. 14).

One can thus state that the perception of the complexity of the system that characterizes a city is coalesced in the socio-cultural and emotional dimensions of the project, which are enabled through its interactive, immersive, and multi-sensory compo-

nents. These components enable the user to interact with the recreated urban reality or with other users for scientific, pedagogical or merely recreational purposes. Such interactions are not subject to pre-determined routes. The users are free to choose their paths and are able to do so either randomly or informatively, as a result of the supporting text boxes that give historical context to the recreation of the city. This possibility allows for a performative digital model. In other words, it gives the model a mediating function in the development of one's consciousness of the complexity of the historical knowledge of the city, with direct consequences for its study and comprehension (Niedderer 2007).

The ability of users to immerse themselves in the model and interact with it and its creators concerns us for two reasons. First, the application of digital technology to historical recreation borrows from the role our emotions play in the cognitive understanding of the model of a city. Second, it is interesting for the process by which knowledge is transferred, particularly in regards to our understanding of a city's heritage and history. Knowledge is transferred either, as we previously verified, through our faculty of imagination, such as the historical understanding of a city's possible past, or through one's empathy with the city's model, namely in respect to the numerous route options one can take in the model, which can broaden the user's understanding of the history of the city resulting from its virtual recreation and its present significance (Smith and Campbell 2015). This also raises the idea of the experiential history so dear to Romanticism, which saw in the experience of the past conveyed by the ruins of cities like Pompeii, monuments like the pyramids in Egypt, and museums like the National Museum of Antiquities and French Monuments the most pedagogic and efficient way of transmitting historical knowledge (Blix 2009). However, the latter approach does not come without risks, namely that of falling into an overly populist, puerile, playful, superficial and even embellished view of the past – one closer to speculative illustration, a technologically sophisticated spectacle, or even a nostalgic narrative of the past than historical understanding (Lowenthal 2009). To this end, this project makes available the historical sources and critical biography it uses, along with the publications resulting from it. It provides text boxes with factual information, and gives users access to the scientific criteria used in the recreation of the city and its theoretical and conceptual basis. And it reveals the various stages of the technological process of recreating the city. This transparency and rigor conform to what is postulated in the London and Seville charters – that we should aim to restrict the model of the city to what is scientifically sustainable and verifiable, thus preventing its uncritical use and display (Witcomb 2013).

As a result of the interactive, immersive and multi-sensory components, the digital model goes beyond the 'rhetoric conventions of perception and the solidity of such

conventions as epistemological models' (Nechvatal 2001) as a means of acquiring the aforementioned laboratorial dimension. In fact, it acts as an experimental support for the collection and comparative analysis of the diversity of the historical sources in use, since it allows for the combination of literary descriptions with the iconological, panoramic or planimetric representations of the city. The project also allows the result of these procedures to be debated among researchers, IT experts and visitors in the context of the model itself, and allows it to be amended if necessary and updated in a timely and cost-effective manner.

The objective thus becomes to provide the user with a critical and integrated historical understanding. The laboratorial character of the project is therefore apparent in the continuous testing and collection of the available primary and secondary documentary sources, and in their translation into a visual working hypothesis that is in turn open to interaction. Contemporaneity is present not only through the historical research process but also by means of the interchange that the model provides with a wide audience of users. This fact obviously poses questions as to the epistemological and ontological character of this type of project in the context of historical research.

Conclusion

Since they allow one to understand the city from a critical and integrated perspective, digital models are converted into landscapes or, better still, into *memoryscapes* (Nuttall 1991). In fact, strictly speaking, it is not the disappeared cities which are recreated, but the memories retained from them through the available documentation and their present interpretations. As memoryscapes, digital models are able to ontologically innovate, thus creating a new form of knowledge – digital knowledge. Such knowledge can translate itself through the convergence of factors constituting an urban reality, as a result of the memory of its inter-relations within a specific timeframe, and within a historic perception of the city. In the case of Lisbon during the first half of the eighteenth century, digital knowledge is manifested by its perception as a physical and material representation of a political and economic order, and of its social and cultural expressions as a spectacle.

We are thus confronted with a new and innovative research methodology, in that the recreation of a city does not constitute the final step through a mere illustrative synthesis of acquired results by means of traditional processes based on descriptive documentation, iconographic representation and archaeological interpretation. Instead, the recreation of the city embodies the main instrument of analysis of our object of study: the Lisbon that perished in the 1 November 1755 earthquake. It also tests the information obtained from the documentary, iconographic and archae-

ological sources within a virtual dimension that recreates the urban location, scale, disposition, and interior and exterior layouts of the lost buildings, in addition to their environment, spatial and landscape reality. The methodology used also verifies, in an urban space context, the articulation of the buildings in accordance with what is described or depicted in the documentation, or the architectural feasibility of their internal structures, as well as the contextual surroundings of their facades. Through Second Life technology it is possible to propose a recreation, debate it, and update it in a timely and cost-effective manner, whilst directly and simultaneously promoting the scientific, didactic and reconstructive dimensions and thus sharing the project with a wider audience.

The recreation in *City and Spectacle: A Vision of Pre-Earthquake Lisbon* is accomplished through a research methodology in which the virtual language is applied to historical research as a means of overcoming its heuristic and epistemological limitations. Concretely speaking, it allows for the long and complex process of researching the history of the city to be tested through its three-dimensional, immersive and interactive representation.

References

- Allison, C., Campbell, A., Davies, C.J., Dow, L., Kennedy, S., McCaffery, J., Miller, A., Oliver, I., Perera, I. (2012). Growing the use of Virtual Worlds in education: an OpenSim perspective. In *Proceedings of the 2nd European Immersive Education Summit: EiED 2012*, eds. M. Garner, F. Garnier, C.D. Kloos, 1-13. Universidad Carlos III de Madrid, Departamento de Ingeniería Telemática.
- Almeida, B. (2009). The 1755 Lisbon Earthquake and the Genesis of the Risk Management Concept. In *The 1755 Lisbon Earthquake: Revisited, Geotechnical, Geological and Earthquake Engineering*, vol. 7, ed. L.A. Mendes-Victor *et al.*, 147-165. Springer.
- Anderson, E. F., McLoughlin, L., Liarokapis, F., Peters, C., Petridis, P. and Freitas, S. (2010). Developing serious games for cultural heritage: a state-of-the-art review. *Virtual Reality* 14:255-275.
- Araújo, A.C. *et al* (eds). (2007). *O Terramoto de 1755: Impactos Históricos*. Lisboa: Livros Horizonte.
- Araújo, R. (1990). *Lisboa: a cidade e o espectáculo na época dos Descobrimentos*. Livros Horizonte.
- Argan, G.C. (1998). *História da Arte como História da Cidade*. Martins Fontes.
- Au, W.J. (2008). *The Making of Second Life*. Harper Business.
- Baptista, M. A., Heitor, S., Miranda, J. M., Miranda, P. and Victor, L.M. (1998). The 1755 Lisbon tsunami: Evaluation of the tsunami parameters, *Journal of Geodynamics* 25 (2): 143-157.
- Baptista, M. A., Miranda, J. M., Chierici, F. and Zittellini, N. (2003). New study of the 1755 earthquake source based on multi-channel seismic survey data and tsunami modeling, *Natural Hazards and Earth System Sciences* 3: 333-340 at <http://www.nat-hazards-earth-syst-sci.net/3/333/2003/nhess-3-333-2003.pdf>. Accessed 15 Mars 2017.
- Beacham, R., Denard, H. and Niccolucci, F. (2006). An Introduction to the London Charter. In *The E-volution of IC Technology in Cultural Heritage, Papers from the Joint Event CIPA/VAST/EG/EuroMed Event 2006*, eds. D. Arnold, M. Joannides, F. Niccolucci and K. Mania, 263-269.
- Blix, G. (2009). *From Paris to Pompeii. French Romanticism and the Cultural Politics of Archaeology*. PENN University of Pennsylvania Press.

- Bogdanovych, A., Rodriguez-Aguilar, J.A., Simoff, S. and Cohen, A. (2010). Authentic interactive reenactment of cultural heritage with 3D virtual worlds and artificial intelligence. In *Proc 9th Int Conf Intell Virtual Agents* (IVA '09) 24:617–647.
- Bottineau, Y. (1973). Le Goût de Jean V: Art et Gouvernement. *Bracara Augusta* 27 (64): 341-353.
- Boxer, R.C. (1956). Some contemporary reactions to the Lisbon earthquake of 1755. *Revista da Faculdade de Letras XXII* (1):113-129.
- Branco, Fernando Castelo. 1994. Olisipografia. In *Dicionário da História de Lisboa*, eds. Francisco Santana and Eduardo Sucena, 662-665. Lisboa [s.c.].
- British Historical Society of Portugal (The) (1985). An account by an eye-witness of the Lisbon earthquake of November 1, 1755. Lisbon.
- British Historical Society of Portugal (The) (1987). The Lisbon earthquake of 1755. Lisbon.
- Brito, J.J. G. (1911). *Lisboa do Passado, Lisboa dos Nossos Dias*. Livraria Férrin.
- Helena C, and Gonçalo (eds) (2005). *O grande terramoto de Lisboa: ficar diferente*. Gradiva.
- Caetano, C. (2004). *A Ribeira de Lisboa na época da expansão portuguesa (séculos XV a XVIII)*. Pandora.
- Calado, M. (1995). *Arte e Sociedade na Época de D. João V*. Doctoral thesis, Faculdade de Ciências Sociais e Humanas, Universidade Nova de Lisboa.
- Câmara, M.A. (2006). A Nostalgia de um Património Desaparecido: uma obra emblemática de encomenda régia na Lisboa do século XVIII – A Real Ópera do Tejo. In *O Grande Terramoto de Lisboa: Ficar Diferente*, eds. Helena Carvalhão Buescu and Gonçalo Cordeiro, 202-211. Edições Colibri.
- Câmara, M.A. (2007). Reconstruir a Ópera do Tejo. *Pedra & Cal* 33: 15-18.
- Câmara, M.A. (2013). Desenhar para os teatros em meados do século XVIII: os trabalhos de Giovanni Carlo Sicinio Bibiena em Lisboa (1752-1760). In *Le nove son tante buone, che dir non se pó. Lisboa dos Italianos: História e Arte (séculos XIV-XVIII)*, eds. Nunziatella Alessandrini, Pedro Flor, Mariagrazia Russo and Gaetano Sabatini, 239-251. Cátedra de Estudos Sefardistas Alberto Benveniste.

Câmara, M.A. and Trindade G. (2015). Controvérsias a propósito de um teatro efémero. A real Ópera do Tejo e a Lisboa nas vésperas do Terramoto. In *Colóquio Um Acervo para a História II*, 247-257. Arquivo Histórico Municipal de Lisboa.

Câmara, A., Murteira, H. and Rodrigues, P. (2009). City and Spectacle: A Vision of Pre-earthquake Lisbon. In *15th International Conference on Virtual Systems and Multimedia (VSMM '09)*, 239-243. IEEE.

Câmara, A.G. da and Murteira, H. (2010). Presentation of the collaborative project City and Spectacle: a vision of pre-earthquake Lisbon. In *Recreating Renaissance and Baroque Spectacle: the Hispanic Habsburg Dynasty in Context*, eds. L. Fernandez-Gonzalez et al., 30-31. Edinburgh: The University of Edinburgh at <http://www.recreatingearlymodernfestivals.co.uk/conference.htm>. Accessed 15 Mars 2017.

Cardoso, A.P. (2005). *O Terrível Terramoto da Cidade que foi Lisboa: Correspondência do Núncio Filippo Acciaiuoli (Arquivos Secretos do Vaticano)*. Alethéia.

Cardoso, J.L. (2007). Pombal, o terramoto e a política de regulação económica. In *O Terramoto de 1755: Impactos Históricos*, eds. A. C. Araújo, J. L. Cardoso, N. G. Monteiro, W. Rossa and J. V. Serrão, 165-181. Livros Horizonte.

Carita, H. (1999). *Lisboa Manuelina e a Formação de Modelos Urbanísticos da Época Moderna (1495-1521)*. Livros Horizonte.

Carvalho, A. (1962). *D. João V e a Arte do seu Tempo*. Lisboa: Author's edition.

Carvalho, J.P.C. (1898). *Lisboa de Outros Tempos*. Lisboa: Livraria de António Maria Pereira.

Castilho, J. (1902). *Lisboa Antiga: o Bairro Alto*. Antiga Casa Bertrand.

Castilho, J. (1884). *Lisboa Antiga : Bairros Orientais*, 18 vols. Imprensa da Universidade.

Chester, D.K. (2008). The effects of the 1755 Lisbon earthquake and tsunami on the Algarve region, southern Portugal. *Geography*, 93 (2): 78-90 at <http://repository.liv.ac.uk/742/5/742.pdf>. Accessed 21 May 2015.

Conceição, C. (1818). *Gabinete Histórico que a Sua magestade Fidelíssima o Senhor Rei D. João VI em o dia de seus felicíssimos annos 13 de maio de 1818*. Imprensa Régia.

- Correia, J.E.H. (1995). Pragmatismo e utopismo na criação urbanística de raiz portuguesa no século XVIII. *Revista da Faculdade de Ciências Sociais e Humanas* 2 (8): 103-112.
- Davison, C. (1936). *Great Earthquakes*. Thomas Murby & Co.
- Delaforce, A. (2001). *Art and Patronage in Eighteenth-Century Portugal*. Cambridge University Press.
- Duncan, I., Miller, A. and Jiang S. (2012). A taxonomy of virtual worlds usage in education. *Br J Educ Technol* 43:949-964.
- Dynes, R.E. (2005). The Lisbon Earthquake in 1755: the first modern disaster. In *The Lisbon Earthquake of 1755. Representations and reactions*, eds. Theodore E. D. Braun and John B. Radner, 34-49. Oxford: SVEC at <http://dspace.udel.edu/bitstream/handle/19716/294/PP%20333.pdf?sequence=1>. Accessed 23 May 20015.
- Estorninho, C. (1956). O terramoto de 1755 e a sua repercussão nas relações luso-britânicas. *Revista da Faculdade de Letras*, XXII (1): 198-233.
- Ferrão, L. (1994). *A Real Obra de Nossa Senhora das Necessidades*. Quetzal.
- Fleming, R. (1962). *Robert Adam and his Circle, in Edinburgh & Rome*. John Murray.
- Forte, M. (2008). Cyber-archaeology: an eco-approach to the virtual reconstruction of the past. In *Proceedings International Symposium on Information and Communication Technologies in Cultural Heritage*, eds. T. A., Mikropoulos, N. M. Papachristos, N. M. and G. Zacharias, 91-106. Ioannina: University of Ioannina.
- Forte, M. (2009). Participatory Research in Cyber Archaeology. In *Proceedings of the International Conference: Making History Interactive. Computer Applications and Quantitative Methods in Archaeology*, eds. B. Frischer, J. W. Crawford and D. Koller, 22-26. Archaeopress.
- Forte, M. (2014). Virtual Reality, Cyberarchaeology, Teleimmersive Archaeology. In *3D Recording and Modelling in Archaeology and Cultural Heritage: Theory and best practices*, eds. F. Remondino and S. Campana, 113-127. Archaeopress.
- França, J-A. (1983). *Lisboa Pombalina e o Iluminismo*. Bertrand Editora.
- França, J-A. (2008). *Lisboa: História Física e Moral*. Livros Horizonte.
- Freire, F.J. (1758). *Memorias das principaes providencias, que se deraõ no terremoto, que padeceo a Corte de Lisboa no anno de 1755, ordenadas, e*

- offerecidas à Majestade Fidelissima de Elrey D. Joseph I. Nosso Senhor por Amador Patricio de Lisboa.* Lisboa.
- Frischer, B., Niccolucci, F., Ryan, N.S. and Barceló, J.A. (2002). From CVR to CVRO: the Past, Present and Future of Cultural Virtual Reality. In *VAST 2000*, ed. F. Niccolucci, 7-18. Archaeopress.
- Gallasch-Hall, A. (2012). *A Cenografia e a Ópera em Portugal no século XVIII: os Teatros Régios*. Doctoral thesis, Universidade de Évora.
- Gallasch-Hall, A. (2012). A Ópera do Tejo e a sua ligação ao Paço Real: possíveis vestígios arquitectónicos. In *Do Terreiro do Paço à Praça do Comércio. História de um espaço urbano*, ed. Miguel Faria, 93-109. Lisboa: Imprensa Nacional Casa da Moeda, Universidade Autónoma de Lisboa.
- Getchell, K. Miller, A., Nicoll, J.R., Sweetman, R.J. and Allison, C. (2010). Games Methodologies and Immersive Environments for Virtual Fieldwork. *IEEE Trans Learn Technol* 3:281-293.
- Januário, P. (2008). *Teatro Real de la Opera del Tajo (1752-1755), Investigación sobre un teatro de opera a la italiana para una posible reconstituicion conjetural, basada en elementos iconográficos y fuentes documentales*. Doctoral thesis, Universidad Politécnica de Madrid.
- Kendrick, T.D. (1956). *The Lisbon Earthquake*. London, Methuen and Co., Ltd.
- Leigh, J.A. (ed.). (1967). Letter to Voltaire, 18 August 1756. In *Correspondence complète de Jean Jacques Rousseau*, vol. 4, 37-50. Geneva at <http://www.indiana.edu/~enltnmt/texts/JJR%20letter.html>. Accessed 13 June 2015.
- Lopez-Mencheró, V. and Grande, A. (2009-2012). The Principles of the Seville Charter at <http://cipa.icomos.org/fileadmin/template/doc/PRAGUE/096.pdf>. Accessed 6 June 2015.
- Lowenthal, D. (2009). Patrons, populists, apologists: crises in museum stewardship. In L. Gibson, and J. Pendlebury (eds.), *Valuing Historic Environments*. Ashgate, 19-31.
- Macauley, R. (1946). *They went to Portugal*. Jonathan Cape.
- Macauley, R. (1990). *They went to Portugal too*. Carcanet Press.
- Maïm, J., Haegler, S., Yersin, B. et al. (2007). Populating Ancient Pompeii with Crowds of Virtual Romans. *Eurographics* 0:109-116.
- Mandroux-França, M.T. (1989). La Patriarcal du Roi Jean V de Portugal. *Colóquio-Artes*, 83: 34-43.

- Mendonça, J.M. (1758). *História Universal dos Terramotos*. Lisboa.
- Moreira, V. S., Nunes, C. and Kozak, J. (1998). *Historical depictions of the 1755 Lisbon earthquake* at <http://nisee.berkeley.edu/lisbon/>. Accessed 7 June 2015.
- Morton, A. (2013). *Emotion and Imagination*. Polity.
- Murteira, H. (1999). *Lisboa da Restauração às Luzes*. Livros Horizonte.
- Murteira, H. (2004). The Lisbon earthquake of 1755: the catastrophe and its European repercussions. *Economia Global e Gestão (Global Economics and Management Review)* 10: 79-99.
- Nechvatal, J. (2001). Towards an immersive intelligence: Nervous Views from Within. *Leonardo: international journal of the contemporary artist* 34 (5): 417-422.
- Niedderer, K. (2003). The Performative Object: Enacting the Human Dimension within Design. In *Electronic Proceedings of the 5th International Conference of the European Academy of Design*. European Academy of Design.
- Nuttall, M. (1991). Memoryscape: a sense of locality in Northwest Greenland. *North Atlantic Studies* 1(2): 39-50.
- Oliveira, C.S. (2008). Review of the 1755 Lisbon Earthquake Based on Recent Analyses of Historical Observations. In *Historical Seismology*, eds. J. Fréchet, M. Meghraoui and M. Stucchi, 255-295. Springer.
- Oliveira, E.F.O. (1882-1911). *Elementos para a História do Município de Lisboa*, 17 vols. Lisboa: Typographia Universal.
- Paice, E. (2008). *Wrath of God: The Great Lisbon Earthquake of 1755*. London: Quercus.
- Pantti, M., Wahl-Jorgensen, K. and Cottle, S. (2012). *Disasters and the media*. Peter Lang.
- Pereira, A.S. (2009). The opportunity of a disaster: the economic impact of the 1755 Lisbon earthquake. *Journal of Economic History* 69(2):466 at <https://www.york.ac.uk/media/economics/documents/cherrydiscussionpapers/0603.pdf>. Accessed 5 June 2015.
- Pereira, Â. (1953). O Terramoto de 1755: Narrativa de uma Testemunha Ocular. *Terra Lusa* 3: 89-95.

- Pimentel, A.F. (1991). Les grandes entreprises du roi D. João V. In *Triomphe du Baroque*, ed. Frank Vanhaecke, 33-41. Fondation Europalia International.
- Pimentel, A.F. (2002). *Arquitectura e Poder. O Real Edifício de Mafra*. Instituto de História da Arte.
- Pimentel, A.F. (2012). D. João V e a imagem do poder: o Terreiro do Paço ao revés. In *Do Terreiro do Paço à Praça do Comércio - História de um Espaço Urbano*, ed. Miguel Faria, 73-91. Imprensa Nacional Casa da Moeda, Universidade Autónoma de Lisboa.
- Pimentel, A.F. and Henriques, A.C. (eds.) (2013). *A Encomenda Prodigiosa: da Patriarcal à Capela de S. João Baptista*, Museu Nacional de Arte Antiga.
- Pinto, L.L. (1989). *História do Abastecimento de Água à Região de Lisboa*. EPAL.
- Rodrigues, P.S. (2005). *Lisboa. A Construção da Memória da Cidade*. Casa do Sul, Centro de História da Arte da Universidade de Évora.
- Rodrigues, T. (2008). Lisboa. Das longas permanências demográficas à diversidade social. In *Jornadas Demografia Histórica de Lisboa*. Gabinete de Estudos Olisiponenses (GEO) at http://geo.cm-lisboa.pt/fileadmin/GEO/Imagens/GEO/Demografia_historica/Jornadas_demografia_2008/Demografia_doc1.pdf Accessed 30 June 2015
- Rossa, W. (1998). *Além da Baixa: Indícios de Planeamento Urbano na Lisboa Setecentista*. Lisboa: IPPAR.
- Rossa, W. (2002). *A Urbe e o Traço - Uma Década de Estudos sobre o Urbanismo Português*. Almedina.
- Ryan, N.S. (2001). Documenting and Validating Virtual Archaeology. *Archeologia e Calcolatori* 12:245-273.
- Schroeder, R. (2008). Defining Virtual Worlds and Virtual Environments. *Journal of Virtual Worlds Research* 1:1-3.
- Senos, N. (2002). *O Paço da Ribeira: 1501-1581*. Editorial Notícias.
- Sequeira, G.M. (1906-1909). A Velha Lisboa: Memórias de um bairro. *O Ocidente* 29-32.
- Sequeira, L.M. and Morgado, L. (2013). Virtual Archaeology in Second Life and OpenSimulator. *Journal of Virtual Worlds Research*, 6 (1).

Silva, A.V. (1900). *As Muralhas da Ribeira de Lisboa*. Lisboa: Typographia do Commercio.

Smith, L. and Campbell, G. (2015). The elephant in the room: heritage, affect and emotion. in Blackwell, Wiley et al (ed.). *A Companion to Heritage Studies*. Wiley Blackwell.

Sousa, L.P. (1909). *Efeitos do terramoto de 1755 nas construções de Lisboa*. Imprensa Nacional.

Sousa, L.P. (1928) *O terramoto do 1º de Novembro de 1755 em Portugal e um estudo demográfico*, Vol. III- Distrito de Lisboa. Serviços Geológicos.

Styliani, S., Fotis, L., Kostas, K. and Petros, P. (2009). Virtual museums, a survey and some issues for consideration. *Journal of Cultural Heritage* 10: 520–528.

Vries, J. (1981). Patterns of urbanization in pre-industrial Europe 1500-1800. In *Patterns of Urbanization since 1500*, ed. H. Schmal, 77- 109. Croom Helm.

Witcomb, A. (2013). Understanding the Role of Affect in Producing a Critical Pedagogy for History Museums. *Museum Management and Curatorship*, 28: 255-271.