

A VIRTUAL MODEL OF BARCELONA IN THE XVIII CENTURY

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The project dealing with the construction of a virtual model of Barcelona in the year 1714 was commissioned to the LMVC (Virtual City Modelling Laboratory) by the Catalonia Television, in an attempt to reproduce the events of the battle fought in September 11th of that same year.

Methodology

This methodology started off by gathering a wide variety of data through a historical investigation of the city' s growth. All the cartographic plans from the 16th to the 19th century were approved to be used by recognized Catalan historians.

Gathering of Historical Data

There were three main sources used to gather information from the late 17th century to the 18th century.

The first source was TV3 (Catalan Television), who provided most of the information of the singular buildings and their urban surroundings to be modelled as to form part of the city complex.

The second source was based on a proper investigation directed by the LMVC team, based on the existing documentation of the E T S A B¹ library.

Finally all the gathered information using both sources mentioned above, were approved and certified by Albert García Espuche, a well known architect and historian, expert on this theme.

All this information was used as a basis in the construction of the virtual model of Barcelona in the 18th century.

Gathering Cartographical Data

During the investigation we encountered several city plans dating 1714², providing the urban location of Barcelona in the beginning of the 18th century. Still though the proportion of these plans that had been drawn by hand were not exact, thus they were placed over precise cartographic 21st century maps and modified using Adobe Photoshop, in order to obtain realistic proportions and scale, using the prevailing blocks as a reference.

After obtaining a reliable urban plan of Barcelona in the 18th century, we proceeded to generate a mesh out of the territory corresponding to today's topographical site.

Mesh Generation

The mesh that defines the territory was created using DTM³ files (Digital Terrain Model) provided by the Cartographic Institute of Catalonia.

This information was introduced in Rhinoceros, where the mesh (composed mainly as a 2D faced manifold) was generated from hundreds of existing points that were interpolated by this software in order to create a high fidelity model .

¹ Go to bibliography.

² "Barcelona 1714-1940; 10 Historical Maps selection and texts". Albert Garcia Espuche, Manuel Guardia Bassols. Fecha del plano 1842.

³ Este archivo contiene toda la información de puntos (X,Y,Z) en el espacio con una separación entre ellos de 30m.

Territory Generation

The generation of the territory undergoes two main processes: On one hand there is the geometric elaboration of the mesh as described above, and on the other hand there is the preparation of the texture and the exact city plan that is to be laid upon the mesh as a solid base to virtually construct the entire city, with its non existing great walls among other architectural elements that either remain or not, in today's city.

During this second process, as we placed 18th century drawn plans and adjusted them over precise cartographical plans, we projected nonexistent blocks and isolate buildings along those blocks that remained along the centuries in the precise 21st century city plan. Through means of this process we were able to obtain a complete vector (digitalized in CAD) drawing of Barcelona's urban disposition in the 18th century, as it can be appreciated in the following figures. (See figures 1 trough 3).



Figure I. Superposition of an 19th century City Plan, adjusted and modified to meet the precision of today's cartographic plans.

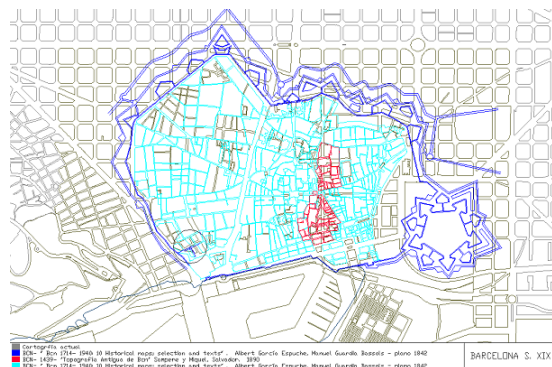


Figure II. 2D CAD drawing of Barcelona in the 19th century.

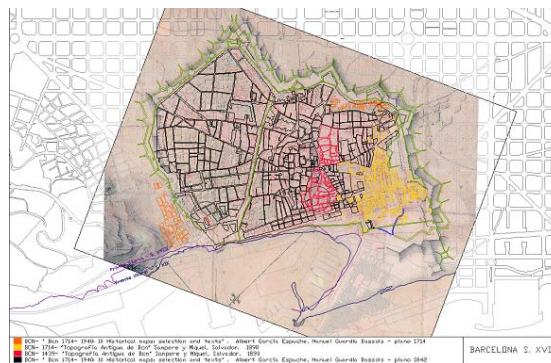
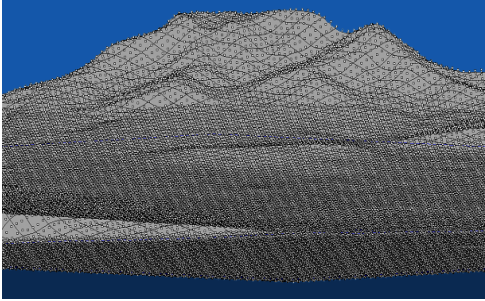


Figure III. Superposition of an 18th century City Plan, adjusted and modified to meet the precision of today's cartographic plans.

Texture Application

The texture applied to the territory is a 1:25000 scaled orto photo, that is a geo- referenced photograph where every pixel corresponds to 2,5 m² .

a)



b)



c)



Figure IV. a) Polygon Mesh of the territory. b) Application of the texture
c) Final result of today's territory .

Once the photograph has been hooked on to the territory's mesh, a restitution process initialises in order to convert the 21st century photograph into an 18th century photograph, using an image treatment program (Adobe Photoshop). All the information that determined the urban form of the 18th century was gathered from former paintings and engravings that were also certified, in order to provide a true context as real as possible as that existing in the 18th century.



Figure V a) b) Substitution process. From Barcelona 21st century to Barcelona 18th century urban form



Figure VI. Final Result.

Geometric Definition of the models

TV3 (Catalonian television) structured the virtual model of Barcelona in the 18th century, in three main parts:

Part A

A simple volumetric model with low resolution textures and geometries of the entire city, where it would be possible to visualize the urban form of Barcelona in the 18th century, as well as the skyline of that specific period of time. In order to obtain the adequate 'skyline' it was necessary to elaborate a 3D model for several singular buildings:

Roman wall, Cathedral, Square of the King, Church of Santa Maria of the Pi, Square of Sant Jaume, Palacio of the Generalitat, City council of Barcelona, Wall of the Ravine, Convent of the Mercè, Church of Sant Pau of the Camp, Monastery of Sant Pere of them Puel.les, Convent of Sant Francesc, Castle of Montjuïc.

Part B

A 3D model of an intermediate level of detail, of the great walls and the Ribera neighbourhood. There were also several singular buildings that were included in this part:

Wall of the Raval and the door of Santa Madrona, Drassanes, Rasher, Palacio of the Viceroy, Door of the Sea, Church of Santa Maria of the Sea, Walk of the Born, Rec Comtal, Monastery of Santa Clara, Tower of Sant Joan, Rampart of he/she Gets up, Convent of Sant Agustí vell, New Door, Citadel (half-filled of the XVIII century)

Part C

A model of great precision of the houses and its corresponding public spaces (adjacent streets and squares) of the archeological remains of the antic Born marketplace. This model has already been described in the previous communication.

Generation of the models

Once the territory model was generated, a new process begins by gathering and selecting all the historical information of the singular models defined in the list, as well as its localization is identified in its proper space. Then we proceed to determine if the buildings have suffered any modifications since the time of their construction until the present year. All this allows us to reconstruct as we assume the modifications that the buildings have undergone during such a long period of time. It is necessary to consider that some of the buildings no longer exist and therefore the historical information is fundamental.

As soon as we determine the geometry of the buildings in the 18th century, we continued by determining not only the constructive system but also the materials used in each of them at that specific period of time, in order to apply the correct texture to each 3d model.

As we completed the models with its corresponding textures, we used a precise CAD drawing containing the exact urban form to fit in the buildings and slightly adjust them in plant, always respecting its proportions. In the case of low resolution models, their geometry was defined from simple extrusions of this CAD basis.

Buildings with complex volumetric parameters, such as gothic churches, that were in need of an intermediate or a high level of resolution, were generated using a different methodology: the architectural elements composing these buildings were reduced to their initial geometric formulas, such as parabolas, to construct a harmonic volumetric models of them.

80% of the entire model was carried out in 3D Studio Max version 5.00 , 15% by means of Autocad2000, and the remaining percentage was elaborated using complex surface generation software developed in the E T S A B, with the use of Lisp programming.

The methodology used to generate models with a low level of detail is summarised in the process used in modelling the King's Square.

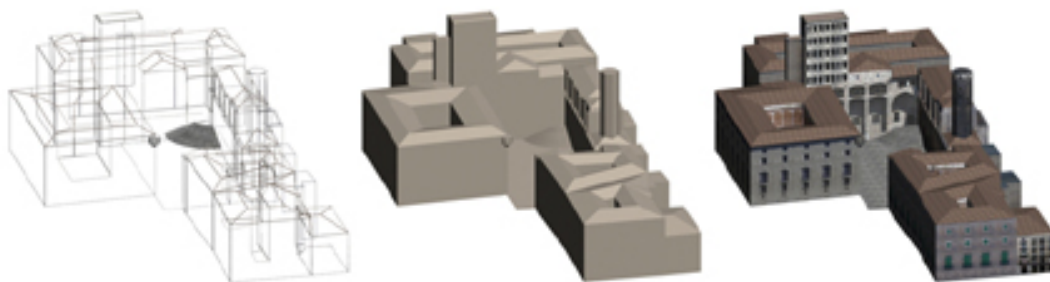
MODELING OF LOW OR SIMPLE RESOLUTION BUILDINGS

The King's Square

This model defined as a low resolution project, required a mesh containing few polygons that would reproduce the building's geometry with a great deal of realism.

Geometric Model:

Since the square does not appear in a first plane, detailed modelling was not required. The generation of the model was reduced to a series of simple extrusions in AutoCAD, lifted as to maintain the main planes that compose the building. A minimum of Boolean operations were needed, as to obtain a simple volume of the square composed by main solids and prisms. Later on, these solid prisms were exploited to eliminate unnecessary geometry, such as inferior faces and to reorganize each composing element in a different layer, as convenient for the application of texture.



It figures 7 Phases of construction of the pattern of the King's Square.

Generation and application of textures:

The generation of textures was carried out starting from digital pictures of the facades of the buildings. This process was based on a series of retouches and corrections of foreshortenings until obtaining right angles representations of the facades. Then, to each a series of colour, saturation, shine and contrast adjustments was applied until achieving uniform patterns in all them. The generation of textures was carried out with (Photoshop version 7.00), while the assignment of textures to each one of the faces of the corresponding volumes was carried out in 3DStudio Max.



It figures 8 Example of the used textures, generated starting from taken pictures" in situ."

- Final result:

The final result was a model with a file size of 971 kb composed by 1587 polygons and texturized with 21 maps in .jpg format whose sizes vary between 42 and 498 kb. These characteristics were ideal to be used as part of the background of the entire Barcelona model, and also suitable to be exported into an interactive navigation format VRML.



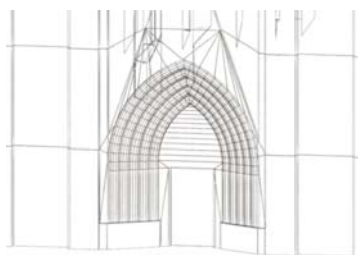
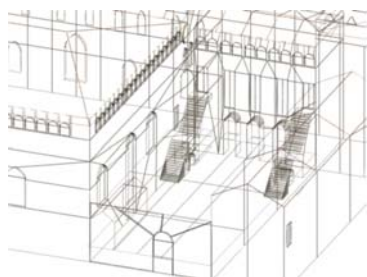
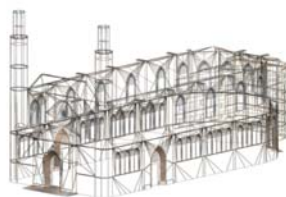
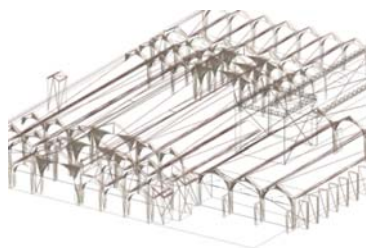
It figures 9 general Views of the completed pattern

MODELING OF INTERMEDIATE AND HIGH RESOLUTION PROJECTS

The generation of this type of models was carried out using more complex techniques, such as the interpolation of surfaces, and nurb and Boolean surface generations, among others. Still though it was imperative that the obtained mesh did not overpass the 10,000 polygons, thus we implemented optimisation methods to reduce the number of faces composing the polygonal meshes, without losing the essence of the building.

Each building had its own package of textures, where every architectural element had its own texture as well. As a result many of them were small in size but presented a high definition.

The following are some of the generated meshes:



It figures 8 Meshes of buildings and singular elements: Drassanes, Santa María del Mar, The Antigua Rasher, Portal de Santa María del Mar



It figures 9 Application of textures: Santa María del Mar, The Antigua Rasher, Palacio of the Viceroy, Environment and Wall of the Ravine.

The result of the generation of the whole model provided a sum of more than 500.000 polygons and a total texture file size of 400 MB. This presented several difficulties due to the excessive rendering time required for every image, and thus there was little time left to edit any video. We also encountered problems when administrating external references in 3D max, due to the size and the amount of files required in every scene. For instance, we generated a '.max' file for every camera and then we inserted all the singular buildings, lights and territory, each as an independent file and as an external reference.

The Laboratory of Virtual Modelling has created a particular methodology for virtual urbanistic complexes that can be transferred, with small variations, to other models of similar span.

RENDER AND VIDEO EDITION

Editing videos was quite costly with respect to time, due to the Ray traced lights applied in each scene; such a decision multiplied by 5 the rendering time of each frame but the quality of the image was worth it, specially if compared to prior try outs where we applied a shadow map modifier instead of ray traced shadows. With the first one the projection of shadows was quite unreal and presented a dented aspect, as if it was composed by enormous pixels.

Still though we used the first modifier, mentioned above in several camera paths (shadow map), to obtain renders more efficiently, but due to the complexity of the model the configuration parameters were sustained in a Size 4000 and a Bias value of 0,1, so that the virtual memory of the standard computer (Pentium 4 with Ram memory 1GB) would not collapse.



Figure 10. Site of the City of Barcelona in transformation during the XVIII century

Conclusions:

The project involved in reproducing a virtual and realistic 3D model of Barcelona in the year 1714, was quite a challenging task due to the difficulty in gathering valid information (specially architectural plans and drawings of the buildings) from a historical point of view. Thus we created a complete database conformed by a wide variety of information, starting off with the cartographic planes, maps, drawings, engravings and documents from past times, until arriving to images taken at the present time.

During the first stage of the project, the information obtained in the bibliography contributed by the library of Architecture of the Polytechnic University of Catalonia, as well as the graphic data provided by the team of TV3, was essential to conform a solid basis supporting the reconstruction of the virtual model of Barcelona in the 18th century.

Maps, engravings and diverse drawings were necessary to have a clear vision of the buildings' and their surrounding tipology.. These singular architectural elements contributed in the identification of city areas that had changed dramatically during these years.

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