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LABORATORY FOR THE GEOMETRIC DOCUMENTATION OF HERITAGE'S ARCHIVE

Sección de artículos / Papers section

13

Información general / General information		
TITULO:	Problems when generating virtual models representing real objects: Hondarribia walls	:TITLE
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Resumen	
TITULO:	Problemas de los modelos virtuales que representan elementos reales: el caso de la Muralla de Hondarribia
RESUMEN:	Se presenta un ejemplo de modelado virtual aplicado a un elemento patrimonial: las murallas de Hondarribia (Gipuzkoa). En este caso se trata de un reflejo de su estado actual, lo cual supone diferencias respecto a los modelos 3D de edificios que ya no existen y que han sido reconstruidos virtualmente a partir de hipótesis. Se parte de una documentación topográfica que obtiene la geometría y sobre la que se proyectan las texturas fotográficas reales. El modelo generado es de gran tamaño, lo que genera problemas de gestión, a este respecto, se comentan algunas estrategias que permiten realizar un manejo más eficiente de modelos 3D de grandes dimensiones.
DESCRIPTORES NATURALES:	muralla, textura fotográfica, modelo 3D jerárquico
DESCRIPTORES CONTROLADOS:	(Procedentes del Tesauro UNESCO [http://databases.unesco.org/thessp/]) Patrimonio Cultural, Infografía

Abstract	
TITLE:	Problems when generating virtual models representing real objects: Hondarribia walls
ABSTRACT:	This report shows an example of virtual modelling applied to a heritage construction, the walls of the city of Hondarribia (Gipuzkoa, Spain). Therefore, it is not a model recreating a building upon hypothetical data obtained from archaeological remains but a true representation of the walls, as we know them today. To accomplish the model, first of all, it is necessary to create a three-dimensional geometric model using surveying techniques in order to guarantee the metric accuracy expected in order to meet further cartographic and restoration needs. After bringing together the necessary documentation, a mesh covered model is obtained which is prepared to be draped with real high-resolution photographic textures, which in turn must be geometrically corrected to eliminate the distortion accentuated by perspective and consequently position the pixels as close as possible to their real place. The process we have just described had been tested in previous projects and yielded satisfactory results. However, more extensive projects as the one in Hondarribia become almost unfeasible due to the huge amount of information involved. The following paragraphs will show the tips used to solve this handicap.
NATURAL KEYWORDS:	wall, photographic texture, hierarchical 3D model
CONTROLLED KEYWORDS:	(From the UNESCO's thesaurus [http://databases.unesco.org/thesaurus/]) Cultural Heritage, Computer Graphics

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PROBLEMS WHEN GENERATING VIRTUAL MODELS REPRESENTING REAL OBJECTS: HONDARRIBIA WALLS

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Abstract: This report shows an example of virtual modelization applied to a heritage construction, the walls of the city of Hondarribia. Therefore, it is not a model recreating a building upon hypothetical data obtained from archaeological remains but a true representation of the walls, as we know them nowadays.

To accomplish the model, first of all, it is necessary to create a three dimensional geometric model using topographic techniques in order to guarantee the metric accuracy expected to meet further cartographic and restorational needs.
After edition job, a mesh-covered model is obtained prepared to be draped with real high-resolution photographic textures which must be geometrically corrected to eliminate the distortion accused by perspective and consequently position the pixels as close as possible to their real place.

The process we have just described had been tested in previous projects yielding satisfactory results. However, for greater extension projects as the one in Hondarribia becomes almost untackleable due to the huge amount of information involved. Next paragraphs will show the tips used to solve this handicap.

Key words : Real object, wall, photographic texture, mesh, hierarchical model.

1- Introduction

Virtual models representing real objects such as historical buildings, monuments and archaeological remains are an excellent tool for supporting historical researches, maintenance jobs and restoration projects. The main issue when endeavouring in the geometric documentation of an object (monument) is to measure every part of its surface with the accuracy and level of detail that will make the resulting model useful for the above-mentioned purposes.

The present lecture shows the process of documentation of the Hondarribia walls. The kind of model required for this project was a true representation of the walls, as we know them nowadays. Therefore, geometric and aesthetic fidelity were of utmost importance, which in turn brought about difficulties.

To achieve the level of accuracy required for the model its scale was determined taking into account the size of the smallest object that had to appear in the model. But bearing in mind that data amount increases in the same proportion to accuracy and also the size of the object of our model (the ancient walls of the city) data management problems had to be solved in order to fulfil our task satisfactorily.

The next paragraphs show every step taken: metric, and aesthetic accuracy establishment, model creation as well as the difficulties found in the process and the solutions taken.

2- Model generation

As we have previously said, our aim in this project was to create a true representation of the Hondarribia walls as they were preserved at the moment the job was done. We will name description model to this kind of performances to distinguish them from recreation models. The difference between them is that in recreation models the aim is to create a hypothetical model from a few remains and historical researches. In recreation models metric questions are not important because in most cases they are unknown, as for example in the picture the height of tusculum church's columns that cannot be obtained from its remains. What is prioritary in recreation models is its aesthetic evocation.

Fig 1: Tusculum church's remains and Tusculum church's recreation model.

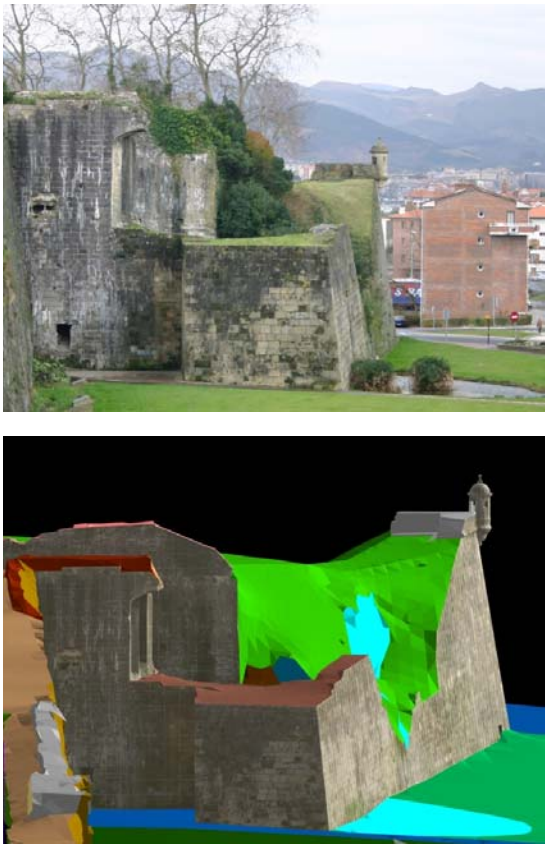

Fig 2: Hondarribia wall's remains and Hondarribia wall's description model.

The following table summarizes the difference between both kinds of models:

	Available data		Purpose		
	Preserved remains	History	Hypothetic appearance	Current real appearance	History
Recreation Model	✓	✓	✓		
Description Model	✓			✓	✓

When the aim of the model is representing the existing reality a description model is developed. In that case it must carry out some accuracy requirements. In the present case, the scale of the model was fixed in 1: 200, so the accuracy between every point of the geometric model should be less than 4 cm at worst.

The following flow chart shows every stage of the work done. Red boxes are tasks related to fieldwork, blue ones are office work and finally obtained outcome is indicated in green.

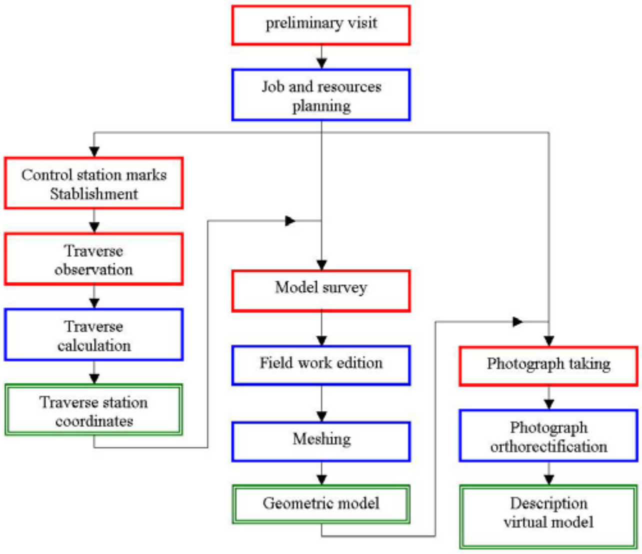

Fig 3: Work flow chart.

The tree-dimensional geometric model is obtained using topographical survey techniques gathering point, line and surface data. Next every surface must be covered by its real high-resolution photographic texture (in its true dimension every pixel must be between 1~2 cm long). These textures must be geometrically corrected to eliminate the distortion accused by perspective and consequently position the pixels as close as possible to their real place before covering surfaces with them. Other elements have to be taken into account too, for instance, the geometric adaptation of the textures, the radiometric variation between textures obtained from different pictures and the deformation produced by lack of data in the process of geometric correction.

When the three-dimensional model is finished the outcome is presented to the customer. A complete documentation of the work is prepared which includes the report of the work done and a set of plans (plant and façade elevation plans, cross-sections...) that could allow another experts involved in the project to use this geometrical information in their investigations and design projects.

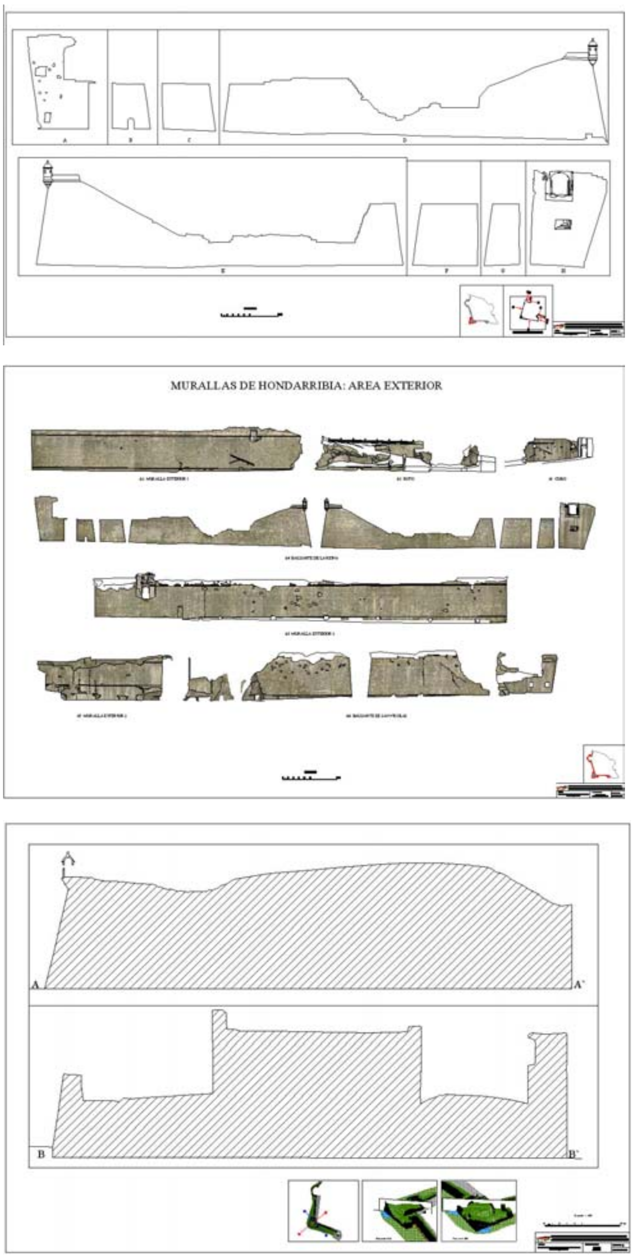

Fig 4: Facade elevation plans, façade orthophotographic elevation plan and cross-sections.

The way that geometric data are gathered on the field (every part of the building is located in the same coordinate system) allows the generation of a three-dimensional photographically real-shape texturized virtual model. This model makes it possible to analyze the function of the different parts of the building and possible relations between them. This is an interesting issue in large sized buildings such as Hondarribia Walls.

The process we have just described had been tested in previous projects yielding satisfactory results. However, for greater extension projects as the one in Hondarribia, creating a high-resolution model became almost untackleable due to the huge amount of information involved.

3- Presentation and exploitation

To make good use of the virtual model, two possibilities are considered:

- Guided exploration: An animation that visits all the building can be done. This choice has as a disadvantage that the object is always and only seen from the same points of view and at the same distance. This possibility doesn't make the most of the model's potential, because if the animation makes a general route, most of the details are not going to be appreciated and in some cases they will be unnoticed. On the contrary, if the animation makes a very detailed route, a too long lasting video will be generated. In this case the animation could lose diligence in choosing the part of the building that wants to be visited.
- Interactive exploration: This choice allows a free exploration of the model by the observer and offers the possibility of choosing the most meaningful point of view and distance to observe the different parts of the building for archaeological researches and architectural or restoration projects.

Taking into account both model's accuracy and the purpose it is generated for, we consider the second choice more suitable.

To develop this option VRML has been chosen, due to the following reasons:

- VRML is a standard language that can be subsequently treated with several computer tools. This allows the customer, the owner of the model, freedom to handle and even modify the virtual model regardless of both the owner of the used format and the model producer. This modifying freedom results highly limited using another virtual reality formats and browsers.
- VRML language has ASCII format, which gives control to the model producer to manipulate and modify easily the model.
- VRML language allows the possibility of browsing virtual models through Internet contributing to make the object represented known and gives the chance of including the model in a multidisciplinary multimedia about the documented building.
- It is a free software, both for the model producer and for the user (the one that navigates through it) reducing production costs. This makes it interesting in low budget projects and makes easy its integration in multidisciplinary jobs where the virtual model is a work tool and not the aim of the project.

However, VRML language shows some disadvantages and can't be considered the perfect virtual reality format: on the one hand it has a very limited lightning and shadowing rendering which yields a poor performance. This is not a handicap when photographic textures are used because they have their own lightning. On the other hand VRML browsers which at least have to handle 5000 triangular shapes in most cases hardly handle more than twice as much of this quantity and the more powerful ones can hardly manage a model with 86000 faces which is the case Hondarribia walls model.

4- Solutions taken

We propose three options to browse interactively a big model, meaning by big one such as cannot be downloaded straight forwardly:

- Partial models.
- Route models.
- Hierarchical models.

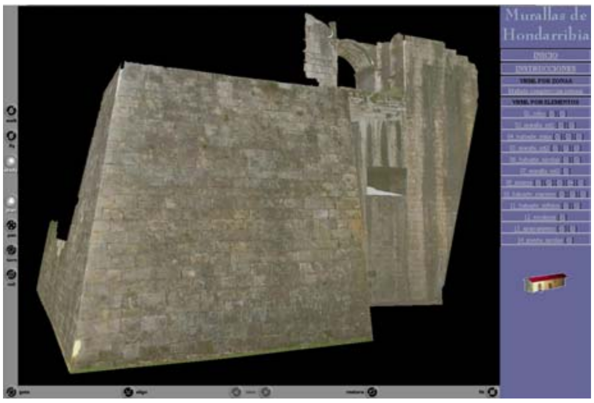

Fig 5: In the first picture the building can be seen in parts, selecting them in the right menu. In the second one, a hierarchically organized model is shown, the parts of the model that are closer to the viewer appear with photographic rendering and the other ones with colour rendering.

The first option, that is, creating partial models, implies dividing the general model in smaller sub-models that can be handled by the system. The overall unity of the model must be preserved in such a way that the user can know at all time what part of the general model is being visualized and can download the next of the partial models. This is an adequate solution whenever the observer is positioned outside the model and moves the objects in his/her field of vision.

Route models are a best option for models that cannot be explored satisfactorily from the outside but are better suited to be visited making a journey through the virtual surroundings. Consequently only part of the objects is within the vision field at a time. As browsers only take into account whatever they have in their visual field, the information to be processed is considerably reduced.

Finally, hierarchical models download the information using different degrees of resolution depending on the distance at which the observer is positioned:

- High resolution only for the closest elements.
- Low resolution for distant but yet visible items.
- Avoid downloading the areas not visible at each stage.

There are various possibilities to reduce the degree of resolution of the model: The size of the textures can be reduced, the geometry of the objects can be simplified or even both things can be done at the same time.

Reducing the size of the textures is a simple task, not so simplifying the geometry. There are mesh reducing algorithms, however, they cannot be applied straight forwardly as they should also incorporate the textures reprojection which means that extra information like the point from where the pictures were taken and the features of the cameras must be born in mind.

Another hindrance is the fact that the external boundaries must be preserved in order to be able to match them to the rest of the parts of the model, regardless of the resolution at which they are being visualized. Hierarchical models can give problems of continuity whenever distant elements have not been downloaded that are within the vision field.

5- Conclusions

This document describes virtual models that due to their purpose demand highly detailed geometric definition and the use of high-resolution photographic textures. These models are used to obtain orthophographies, detailed analysis of structures, general studies of the historic evolution and function of the object represented by the model, analysis of non-accessible areas that have been temporarily reached (using cranes for instance) or as a historic register previous to modifications.

The size of these models renders them inadequate to interactive browsing for touristic or educational purposes. Nonetheless, their technical use makes it necessary for them to be interactively visited which can be done resorting to techniques that present the information in a hierarchical way. The user will not be able to visualize the whole of the model simultaneously but the overall idea is kept.

All this taking into account the shortcomings but also the advantages that using free-use standards like VRML brings.

6- Acknowlegements

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