

House of the Skeletons – A Virtual Way

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Abstract. The archaeological site of Conimbriga, in Portugal, yields the ruins of an ancient city of the Roman Empire. This paper introduces a project made with the cooperation of the Monographic Museum of Conimbriga, which aims the developing of a virtual reconstruction of a particular house (the House of the Skeletons), mainly because of its architecture and relevance to the city itself. The model intends to be as realistic as possible, up to scale and available to a wider audience over the Internet. That justifies the use of the Virtual Reality Modelling Language (VRML) to develop the tridimensional model. It is consensual that the apparent incompatibility of the three main factors -realism, file size and performance - is responsible for the inexistence of more examples of archaeological reconstructions in a virtual format, over the Internet. The work developed in this project, and now presented, tries to make a small contribution to this matter.

Keywords: VRML, Optimization, Realism, File Size, Performance, Virtual Reality, House of the Skeletons, Conimbriga

1. Introduction

The virtual environment concept has emerged with the birth of the Internet. The main objective of generating a virtual environment is to allow people to interact with a specific environment without leaving the comfort of their homes. Such environments can be as varied as an important monument, or a beautiful landscape. Allying this concept with the massive use of the World Wide Web and the demand to evolve the web to a tridimensional level has provoked the creation of VRML (Virtual Reality Modelling Language).

However, the initial enthusiasm that this technology has brought up, have been diminishing, and nowadays VRML is a technology that has fall in disuse.

Regarding that there aren't other technologies that can be considered a solid alternative to the VRML (in the Web), one can ask: what motivated the disuse of this technology? Probably is due to the apparent incompatibility of these three main factors: realism, file size and performance.

Realism: without it, the virtual environment loses interest and the end user, which can be seen as a visitor, will not have the correct perception of the space and will not feel compelled to visit the virtual scenario again.

File Size: should be as smaller as possible to allow a short transference time from the Internet to any domestic computer.

Performance: if the scenario doesn't offer a fluid movement to the visitor in any domestic computer, it will limit its access and the richness of the experience to the end user.

We think that the disuse of the VRML is in part due to the incorrect conciliation of these three factors. In this perspective, they should be considered as critical success factors in any project of this nature. It is our belief that if we try to establish a compromise between these three factors we can achieve all the advantages that VRML can offer.

2. Study Case

In its reduced dimensions (945 m²) the House of the Skeletons can be taken as a paradigm of the residences of quality of Conimbriga: quality of the architectural plan, economy of means, emphasis in the ornamental program of the mosaics, intelligent use of the autonomous part of the construction. The analysis of the house comes across, though, with some inherent difficulties because the façade was destroyed by the construction of the late-imperial wall.

The main part of the house is articulated by an axis of canonical drawing (guided E / W), of the small atrium to the great triclinium going by the axis of symmetry of the central peristyle. The peristyle gives access to six service dependences, to the North, besides which an open space would exist, as a deadlock, that would probably belonged to the house (although with independent access for the street, effectively working as service entrance). A small corridor in the Southeast corner gave access to a great cubicle, with mosaics, and to a secondary entrance; besides this there just one other a small division near the entrance. A substantial part of the area of the building was occupied by autonomous units three of them probable cauponae or popinae opened for the lane that divided the house from the Baths of the Wall, serving as access to the services of these, and another one more complex, of three divisions in row. The main objective of this project was to offer anyone who has access to the internet, the possibility of visiting this cultural and architectural patrimony of the ancient Roman Empire. To accomplish that, a tridimensional model of the House of the Skeleton was built at 1:1 scale.

We would like to leave a note of gratitude to the Director of the Monographic Museum of Conimbriga - Dr. Virgílio Correia, without whom this work would have been impossible.

3. Technology

One of the main objectives of this project was to allow the largest number of people to access the House of the Skeletons through the Internet, which is one of the most powerful means of communication. The VRML is the tridimensional standard for the Web, which makes it the natural choice to accomplish this objective. With the investigation process, soon we've noted the importance that optimization issues would have in accomplishing a compromise between realism, performance and file size. That's the reason why the optimization techniques were the main concern during the development of the project.

4. Development Process

In this point, we want to present and explain the main stages of the development process of the virtual House of the Skeletons. With the exception of the optimization stage, all the other steps are presented in a chronologic order.

In theory, building a world consists of cycling through a series of steps, in order, and repeating the whole series as necessary. In practice we jump back and forth among the various steps, especially after the first time through the cycle Silicon Graphics 1998a.

4.1 Investigation and Planning

In this step, it was made a deep research concerning the characteristics and potential of the VRML. This research has allowed us to collect information about the optimization techniques that we could apply to the model without compromising its appearance. We've investigated the Roman architecture too, namely Vitruvius rules. This allowed us to create the rooftop model and helped in determining the walls height.

4.2 Development Tool

VRML is a simple text language, which is interpreted in real-time by a web browser. However, to develop a complex animation without an authoring tool is a complicated process that may slow down the development time. That is the reason why we've chosen Silicon Graphics Cosmo Worlds 2.0 to develop this project. This software let us model the world in an intuitive way and generates the VRML code, allowing the developer to use all the optimization techniques that can be applied into VRML.

4.3 Modelling

To modulate the House of the Skeletons, it was necessary to study the only existing plant of it (Fig. 1). In this study we followed some of Vitruvius rules concerning the walls height, the rooftop disposition, and the peristyle's columns height and composition.

To build the house walls, we used three cubes of different profundities, which were cloned and then resized, rotated and

translated to its specific location. This has allowed us to build the entire house walls with only 3 pieces of 12 polygons each. This has been a major contribution to the final result. Some specific and complex components such as the great triclinium window were modelled in 3DS-Max. After that this parts were converted into VRML components.

4.4 Assembling

Throughout the modelling process, all the components were disposed in the scene. This simultaneous process allowed us to visualize the house's aspect and simultaneous enabled us to make some corrections to the model in real time. The assembling process has taken into account the displacement of the objects in the virtual scenario; witch has helped to hierarchize the model.

4.5 Textures

The textures are extremely important to the final result. Not only because they cause the visual impact of the scene, but

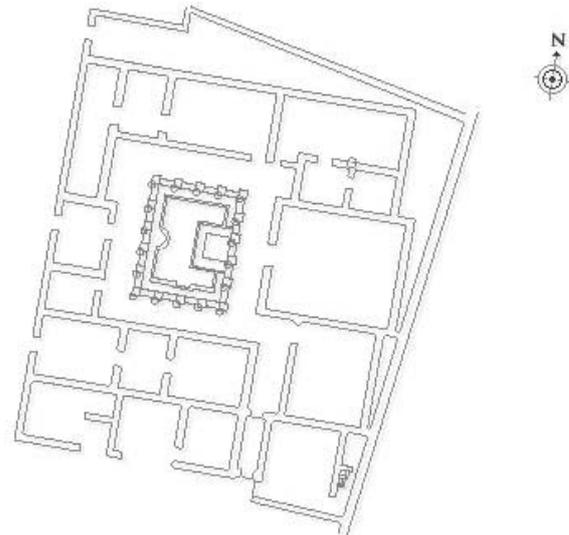


Fig. 1. House of the Skeletons plant.

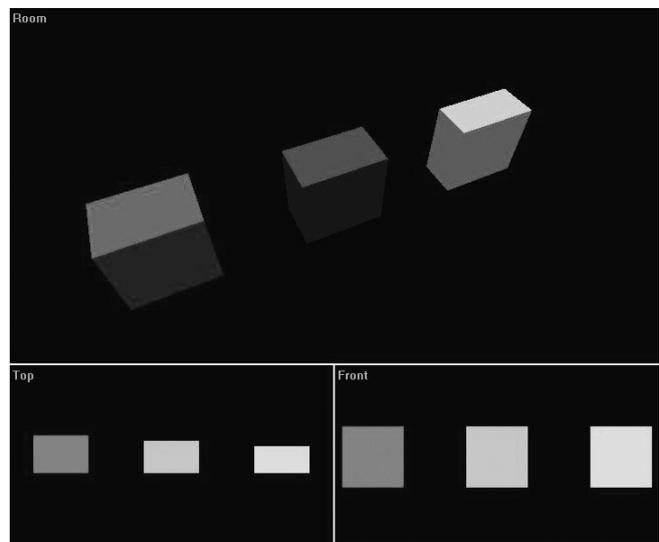


Fig. 2. Blocks used in the walls virtual reconstruction.

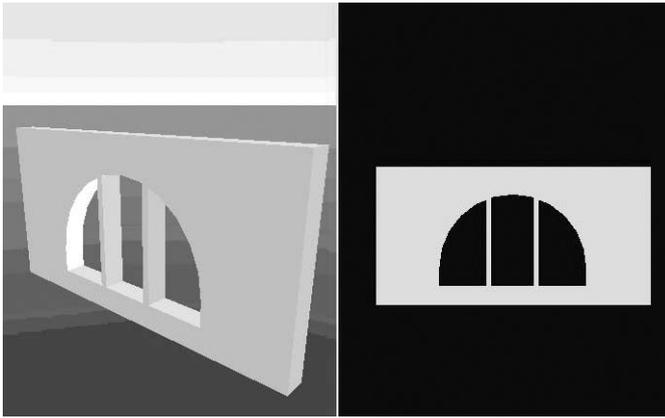


Fig. 3. Great triclinium window.

also because they can act as an optimization to the project. For example they can simplify the representation process of some complex elements like the columns. Using a detailed texture, transparencies and repetitive patterns is a way of simplifying the modelling process.

Next, we describe some of the most important textures used in the House of the Skeletons.

4.5.1 Column

The column that was used in this project was the result of combining a simple model of a half-pipe and a box with a texture. This combination has provided a very realistic representation, maintaining all the reflexions and lighting effects of the scene. This has allowed a representation that makes use of a reduced number of polygons, maximizing the performance of the virtual scene.



Fig. 4. Texture used in the representation of the Tuscan column of the House of the Skeletons.

4.5.2 Floor

As it is of the common knowledge, the Roman constructions are characterized by the detail presented in the mosaics that coat its soil. In this case, despite the mosaics of two rooms being in perfect state of conservation, it was not possible to get its image. In the remaining divisions of the house there are some incomplete mosaics or none at all.

What the museum considered was that the soil should be represented with an identical repetitive standard for the entire house. The aspect of the mosaic should be in accordance with some models conserved by the museum, representing simple geometric forms in tones of blue dark with deep white, having an exterior decorative bar to the central drawing. Photographs to a mosaic with characteristics that allowed arriving at the intended texture, through techniques of graphical composition had been taken off.

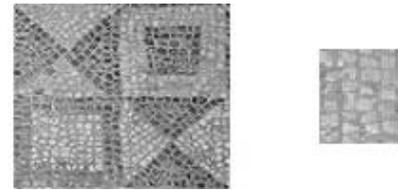


Fig. 5. Mosaic used to create the floor texture.

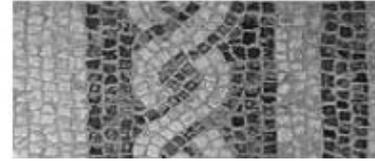


Fig. 6. Textures used in the peristyle floor.

4.6 Colouring

Although we used digital photography to try to get the most realistic textures possible, it was necessary to proceed to a correction of its colours to the standards of its time. This was due to natural erosion that occurred along the centuries that in such a way provoked alterations in the tones as in the original colours. With the aid of the connoisseurs of the Monographic Museum of Conimbriga, we've been able to find the original colour of the materials in the scene, being applied in the corresponding textures.

4.7 Lighting

The main objective of lighting is to simulate the visual effects of the emitting sources of light, natural or not. Its correct use adds realism to the virtual scene; however it must be used wisely to not prejudice the intended performance.

Considering the different existing types of illumination in VRML, the ones that had been chosen have little implications in the performance - the Directional Light and the Point Light. With the right positioning in the scene we achieved the intended effects.

4.8 Optimization

The aspect of optimization in VRML is basic to reach the performance levels that the technology allows. In one project with this nature and having counts to the critical success factors, optimization is an essential aspect that must be considered. Given its importance for the global success of the project, the optimization has followed its entire life cycle, since the early stages of modelling, until the phase of publication.

5. Optimization Techniques

In a technical analysis, this is the key factor of the developed work, because the optimizations techniques were decisive in the final results.

Next we present some of the most relevant techniques used in the development of this project.

5.1 Hierarchy

A VRML file is established by nodes. These nodes may contain other nodes, that by its turn it may contain other nodes and so on. This type of organizing files indicates the use of a hierarchic structure. The concept of hierarchy on a VRML file has to do with the way how the objects that constitute the virtual scenery relate between themselves.

One of the tests made by the browser through the representation of a virtual world, is the test of visualization (culling), that is to say, verifying which objects are completely out of the volume of the vision of the avatar, so it can be determined which ones are visible at the moment. The test consists in intersecting the volume of vision with a representative bounding box of the object and if those two volumes don't intersect, we conclude that the object is not visible, therefore it can be ignored through the rendering of the scene (Silicon Graphics 1998a). As you can imagine, this intersection process of the volumes is a heavy calculation in the internal processing, because it implicates very accurate mathematical calculus, at a tridimensional level.

The all process can be simplified and optimized by defining a hierarchic structure for the objects disposition, in the way that the visualization tests start to be done just by the bounding box of the node that it is on the top of the hierarchy that can, and must, contain several associated objects.

In this project we can see the whole file as a hierarchic structure, in which each node includes other nodes.

- The larger volume objects were divided in smaller objects to turn its representation more optimized in the virtual world. A remarkable example is the floor of the house, because we don't need to represent it totally when we are just visualizing the garden
- The objects were assembled by its proximity, as we can see in the following image by the assembling of several components that constitute the grass in the garden

In virtue of the used structure, the mathematical calculi made and related to the, bounding boxes were reduced, maximizing the optimization.

5.2 Collisions

By being made in a tridimensional space, the collision detecting tests are, generally, heavy. To simplify this process two rules were executed, using for that VRML properties:

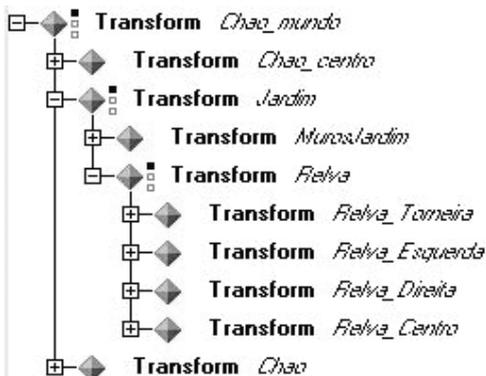


Fig. 7. The hierarchic structure stated in the Cosmo Worlds.

- Inactivate the surface collision test with which is impossible to collide. The visitor is just allowed to “walk around” the house, so he will never collide with many of the existing surfaces, as for example, the roofs.
- To facilitate and simplify the collision tests, less complex geometrical forms were defined, as simple primitives, to be used in calculus to detect the collisions, in the exchange of the original forms, which were more complex and generated heavier calculus. This method allows us to reduce, in a significant way, the tests we have to make when we verify a possible collision between the avatar and any other solid surface. This was a procedure used as much as possible, in the whole space of the House of the Skeletons. On figure 8 we can see an example: the all lateral side of the house, marked in red, is composed by innumerable single “pieces”. However, the collision tests are made just to a one simple parallelepiped that contains all its length.

5.3 Instancing (cloning)

VRML offers two ways to include more than one of a particular object in a virtual world. One is the standard copy/paste approach, which makes a copy of the selected object and then lets us paste the copy into the scene. Another way is to use cloning. This doesn't make a copy of the object; instead it allows to place a single object in more than one place. This technique saves space in the VRML file, because cloning an object re-uses the original object's geometry instead of creating a whole new object, which happens when we use the copy/paste method (Silicon Graphics 1998a).



Fig. 8. Collision proxy is the name of the field that allows to execute this procedure.

Clones share appearance and geometry, but can be resized and placed independently (Silicon Graphics 1998a), by means of translation, rotation and rescaling operators. For example, any change made to the texture, color or geometry of any clone affects the same characteristics of all the other clones of the same object.

However, it is possible to use the translation, rotation and rescaling operators through the transform node, increasing the number of situations in which this technique can be used. It is

possible to modify dimensions, disposition and localization of an object by using this node, and not affect the other objects. All the walls of the house were built based on blocks to whose were applied translation, rotation and rescaling that allowed to adapt it to all the other walls. The walls around the garden were also built based in one only object, that once changed, allowed the elaboration of the kitchen step.

The column is another object where the cloning advantage is clear. Only one column was modelled, the others were achieved by instancing. This allowed significant gains on the performance and size of the file, because the geometrical characteristics of the column are far from being simple.

The roof with the two waters structure (excluding the tiles plane) it was also reproduced with the resource of clones, it was not totally applied because of the rescaling compromised the aspect of the tiles.

The doors and the stair were also reproduced through this technique. As we can see, instancing is present in almost the totality of the project, which confirms its viability.

5.4 Billboard

Although the VRML essentially has the vocation for the 3D, it also allows the use of bidimensional objects. The use of these objects it is inclusively recommended to increase the performance or the realism. For that purpose we use the billboards. These association nodes allows us to show the associated objects always in a frontal position for the user, independently of its position in the world, resorting to rotations over a certain axis. Analysing the functionalism of a billboard it is possible to conclude that they are advised to represent symmetric objects, whose observation from different angles won't have major variations.

In the House of the Skeletons, the use of the billboards was just reserved for the columns used to sustain the central peristyle. Due to the mould of the column and to the considerable number of columns that it was necessary to present, this object was the right one for the use of this technique, considering its symmetric aspect, its resemblance in all the visualization angles and the use of a texture for its representation.

To add realism to the object, the application of the billboard was not done as usual on a simple side, but on a cylindrical object to which polygons were removed.

The achieved improvements with this commitment consisted on a more realistic lightning, once applied to a curve surface, and not to a plane, and a more factual visualization of the mould of the object.

This commitment to realism did not have consequences in the performance, as checked after a few tests.

Figure 9 certifies the realistic effect made possible by billboards.

5.5 Spatial Organization

The way the moulded objects are disposed in the scene and in the file it is determinant on the performance of the world.

A right spatial organization is achieved when the objects that are close in the scene are also close in the file's code. In that

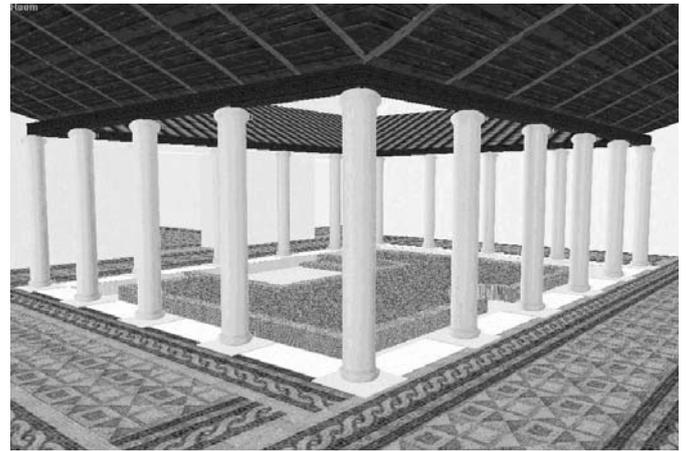


Fig. 9. Columns achieved using instancing.

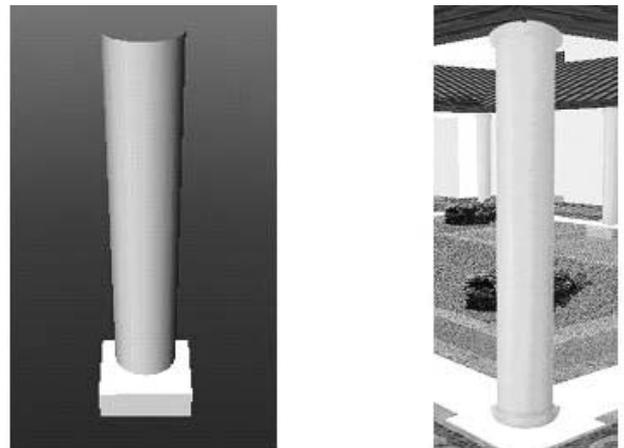


Fig. 10. The use of billboards for column representation.

way, the reading of the file by browser is optimized, once that to represent adjacent spaces it is not needed to realize big jumps on the code. This optimisation is clearer when files are of big dimensions. (Silicon Graphics 1998b).

In the House of the Skeletons we tried to optimize the most this relation between the spatial and physical disposition of the files, as it can be seen, for example, in the kitchen placed near the public-houses, in the thermal street.

5.6 Publication / Compression

One of the greatest problems that cibernauts have is the scarcity of bandwidth. Even with the technological innovations of the physical means of access to the Internet, as the DSL or cable, the time that conditions the wait for a download dictate the success, or unsuccessful, of the sites or applications. The VRML is not immune to this and because of



Fig. 11. Internal position of the objects on the Cosmo Worlds.

that since its beginning that the size of the files has been a preoccupation factor for the developers.

Nowadays, most part of the VRML browsers dispose the gzip uncompressing algorithm, in real time, allowing the immediate and easy reading and visualization of the compacted file.

In our case, the compression process was very easy, because the work tool (Cosmo Worlds) has a command that automatically does it without major difficulties.

6. Results

Here we have the results of this work:

- Realism: confirmed by experts, especially by the Director of the Monographic Museum of Conimbriga;
- Performance: it works in any domestic personal computer acquired nowadays;
- Dimension of the files: the main, and only VRML file just possess 17 KB, and the totality of the work (with the textures), does not exceed the 300 KB.

By the final results achieved, this work can be appreciated on the Web in: <http://www.casadosesqueletos.web.pt>.

7. Conclusion

The potentialities of VRML have exceeded all our first expectations. The relation between performance and realism that it is offered will hardly be surpassed by any other graphic computation technology. For this to be clear we need to recognize several optimization aspects, to know them, to have of them self conscience, to turn to them as often as possible

through all the developing process. Not to know and not to use the optimization factors ends up very often in unrepresentative models of the VRML qualities not showing the features that makes it superior when compared to other more popular tridimensional representations - for example, the ones proportioned by 3DS-Max.

An author who uses VRML has the responsibility to use it in the right way, or it won't take any advantage of all its potentialities, wasting significative resources and gains, comparing it to competitor technologies. To be able to use correctly the VRML it must be made an effort on the research and self conscience of the optimizations. Although studying these factors takes much time, once we control them they allow surprising results, with timing performance identical to other technologies.

In conclusion, we believe that in part this technology viability is in the power of who uses it, and it must be used with the knowledge so it won't misconstrue its value.

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