FUSION of CULTURES

Abstracts of the XXXVIII Annual Conference on Computer Applications and Quantitative Methods in Archaeology,

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F. Javier Melero · Pedro Cano · Jorge Revelles

Editors

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Fco. Javier Melero, Pedro Cano & Jorge Revelles (Editors)

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A novel approach to 3D documentation and description of archaeological features

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1. Introduction

3D technologies applied to archaeological research have been the scope of intense experimentation carried out by different scientific groups. The activities have concentrated in particular on the use of devices for the acquisition of 3D geometries and the reconstruction of ancient monuments or sites.

So far the researchers' interest was aimed mainly at exploiting the potential of 3D technologies for the virtual reality and the navigation of archaeological landscapes. Often the reconstruction targets prevailed over the scientific purposes; we have many good models, but we don't often have the chance to understand the information which characterizes the virtual objects (artifacts, buildings, sites or landscapes).

We have two ways to manage 3D data: a traditional and an alternative way. On a geographical scale 3D data are geo-referenced information within a GIS platform; on the other side 3D objects are simple alphanumerical information managed by a specific DB. The query performed by DBMS gives lists of data corresponding to the searched string or strings, but in this way it is impossible to infer cultural deductions. As far as the database is concerned, a Ionic capital is simply an architectural element, because the researcher recorded the information this way. Nevertheless the background is greater, as the attribution "Ionic" is linked to a specific architectural style characterized by particular elements and widespread in a specific geographical area.

It is possible to extend the concept to geographical information and to landscape analysis. In a classical GIS the information related to the spatial object is stored in a dbf file. Although we can have different layers corresponding to different thematic information, if we select a spatial feature the system gives back data from the DB. The greater and richer the DB, the more accurate, precise and relevant the software reply will be. The GIS system is not able to distinguish geometrical features and spatial objects if these alphanumerical data are not kept in the DB.

Thanks to technological advancements in the framework of digital content management, now we have an innovative approach to the registration, organization and retrieval of digital archives. This method is based on the ontological description of the digital objects which analyzes the semantic relationships of the elements.

In this paper we will show how it is possible to manage 3D data according to a description of the geometrical features of the objects. In particular we will illustrate the GML standard and the profile CityGML, well-suited for the analysis of complex monuments. We will try to point out how it is possible to use a subset of CityGML in order to describe an archaeological 3D context concerning different structural and architectural objects.

2. The language

CityGML is an open data model and XML-based format for the storage and exchange of virtual 3D city models. It is an application schema for the Geography Markup Language 3 (GML3), the extendible international standard for spatial data exchange issued by the Open Geospatial Consortium (OGC) and the ISO TC2.

The aim of the development of CityGML is to reach a common definition of the basic entities, attributes, and relations of a 3D city model. This is especially important with respect to the cost-effective sustainable maintenance of 3D city models, allowing the reuse of the same data in different fields of application. The modeling principle is based on a taxonomical approach and on the semantic decomposition of the spatial features: from the whole city to the city objects, from buildings to smaller components like balconies.

The semantic model consists of class definitions for the most important features within 3D city models, including buildings, DTMs, bodies of water, transportation, vegetation, and city furniture. All classes derived from the basic class 'Feature', defined in ISO 19109 and GML3 for the representation of spatial objects and their aggregations.

The feature class comprises spatial and non-spatial attributes mapped on GML3. Every class of CityGML is represented by an xsd schema including a subset of attributes shown according to four different levels of details (LoD) (fig. 1).

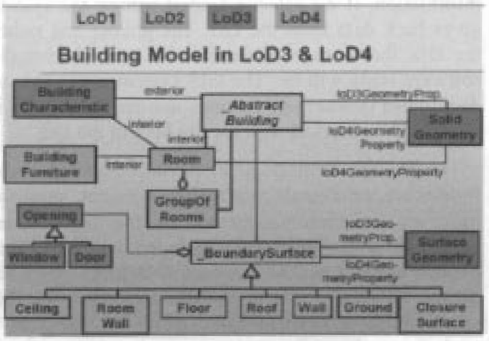

Figure 1: *CityGML schema*

Although CityGML has been developed for the conceptual description of a modern city, some features, such as the topological relationship is_part_of, can easily be transferred and applied to an archaeological context.

We tried to apply the CityGML schema to the archaeological site of Uchi Maius in Tunisia. In particular we chose the forum area characterized by many detailed zones with a lot of precious elements. The area, after the Vandal occupation, was restructured and reused as an oil mill.

2.1. Case of application

Uchi Maius is located about 100 Km south of Tunis in a hilly region; the site is in the lowland of Mejerda in the area called Hencir ed Douamis on the left bank of the Oued Arkou river.

The archaeological area was discovered by a French soldier in 1882 and was identified with the city of Uchi Maius quoted by Pliny the Elder.

The site was founded by Numidian people in the V sec. A.C.; after the Bellum Iugurtinum the veterans of Mario were installed in this area. In 230 d.C Uchi obtained the autonomy and the title of Roman colony. During the V sec. D.C. the city was still flourishing; in this period there were many manufacture installations created by reusing the roman objects.

The archaeological investigations were conducted by the Universities of Pisa and Sassari since 1995; the excavation was carried out in three different locations: in the Islamic Oppidum, in the Forum and in the oil mills (fig. 2).

3. Method

In order to overcome the traditional attitude to 3D management, it is necessary have a new methodological approach based on semantics.

Figure 2: *Installation of the vandal's oil mill in the forum.*

In this way it is possible to extract both the implicit information like the contexts of the 3D objects and the geometrical and topological relationships. The project was characterized by two different phases: the creation of the ontology and the reconstruction of the 3D model of the forum area.

3.1. The semantic structure

The ontology was developed by importing the hierarchical schema of CityGML into the Protegé editor. First of all, as City-GML represents a sort of taxonomy of the urban objects within a modern settlement, we selected only some classes suited for the description of an ancient site. The use of only the CityGML profile for our archaeological case-study showed some limits and for this reason we enriched the starting schema with new semantic definitions. We created new sub-classes for the description of historical objects and new categories like temples, basins, oil mills, sarcophagus, mortars etc. As far as the topological features are concerned each one has been been linked to the other one through the relation "is part of"; to each spatial element an attribute was then assigned as a different part of the object or of the objects.

The first class of the schema comprises the concept "Building" a subclass of root class CityObject containing every geometrical element of a complex. Other descriptive features are included into the class "AbstractBuilding" which include different values like "function", "usage", "type", "years of construction", "years of demolition", etc. The class "AbstractBuilding" is more specialized than Building. To define other components of the building we created some new features like "opening", "floor surface", "wall surface", etc. Each feature was then joined as a chain to another feature through the relation "is part of". In order to specify other topological aspects the relation "is_utilized_like" was created.

The hierarchical schema implemented for our casestudy is shown in Figure 4.

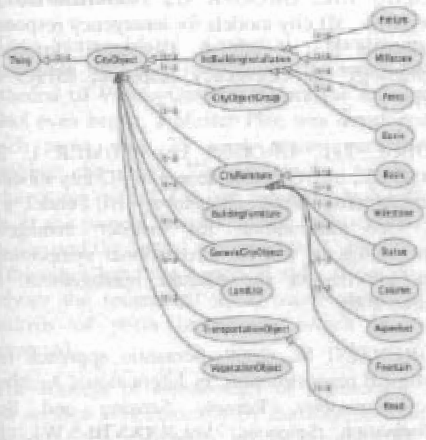

Figure 3: *Ontological schema for the archeological subset modeled on the CityGML profile.*

3.2. The 3D Model

As far as the 3D reconstruction of the forum is concerned, the 3D model was carried out in 2002 by means of a total station (Fig. 5).

The .dxf file was then imported in Blender for the development of the 3D model. Blender is the most powerful open-source software for 3D modeling and, thanks to the plug-in Procad, it is possible to use a typical CAD system for the 3D modeling. During this phase we selected the CityGML classes to define the different layers of the 3D objects. The model was then exported in X3D format and then imported into GRASS for the geo-refencing and the conversion of the dataset into GML. At the end of the process the file can be imported once again into Blender for its management.

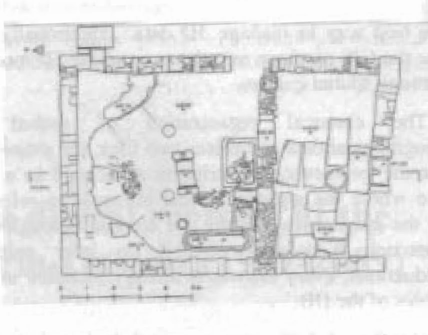

Figure 4: *2D relief of oil mill.*

4. The semantic Management of the 3D Model

The architecture of GML language is very flexible and allows the management both alphanumerical and graphical information; every objects of the model are store in a specific class defined by the information inside the tag relate to the class.

In my project, the semantic management of the data exploit the flexible architecture of GML language; the data and the relations between different classes are stored inside the model and visualize in Blender with hypergraph module present inside the software. The Hypergraph shows a graphical relationship between components of a scene. You can display two kinds of graphs in the Hypergraph: the scene hierarchy or dependency graph. in fact, besides seeing the model, we are able to interact with him. By this way, if I select an object of the model, in hypergraph I can see the information of the object and his relation with the other model (Fig. 6)

Figure 5: *3D model of the oil mill. This figure shows the object "base" identified by the relation "is utilized like"*

5. Conclusions

The 3D representation of different cultural objects and the management of the related data is one of the most important arguments debated by the scientific community. Nowadays the archaeological research is characterized by many different opinions regarding the best way to manage 3D data. Traditionally we use the GIS platform in order to examine 3D models through spatial queries.

The classical organization of spatial or geographical data comprises two files: the shape file for the geometrical description associated to a dbf file where the alphanumerical information referred to the geometrical feature are stored. Through this approach it is not possible to infer cultural deductions; every answer is already included in the tables of the DB.

On the contrary, our proposal is based on the integration of the different levels of information: geographical data, alphanumerical descriptions and, finally, semantic relationships. Through a GML file it is possible to keep all these informative strata in a single file and, thanks to the CityGML profile, each spatial feature can be organized according to a conceptual schema. By means of specialized software we can manage and interrogate any element, as we show in Figure 4.

We carried out an experimental test in the archaeological area of Uchi Maius characterized by a long-term occupation with numerous re-occupations and alterations of the original settlement.

In the future we will prepare a more precise and accurate conceptual schema for the description of archaeological features compatible with the forms and tables adopted by numerous excavation teams. For this scope it will be necessary to create a mapping tool and a graphical interface to make the tagging of spatial elements more simple. Some positive tests have already been carried out by an Italian group (Scianna et Alii, 2005) for the realization of a plug-in in AutoCAD.

Only a complete archaeological ontological model could show the potential of the 3D models which until now were limited to virtual navigation. Managing a real 3D world will be on the contrary the real challenge for the future 3D applications.

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