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This is the published version of a paper published in *DISEGNARE CON....*

Citation for the original published paper (version of record):

Moscati, A. (2012)
Integrated Information Systems.
DISEGNARE CON..., 5: 249-254

Access to the published version may require subscription.

N.B. When citing this work, cite the original published paper.

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Sistemi Informativi Integrati
Integrated Information Systems

Annika Moscati, "Sapienza" University of Rome

Abstract

Attualmente nel campo della gestione e valorizzazione del patrimonio culturale due sono i sistemi informativi che offrono strumenti significanti: GIS (Sistemi Informativi Geografici) e AIS (Sistemi Informativi Architettonici). Il primo gestisce dati a scala urbana e territoriale, il secondo amministra dati a scala architettonica. Per una completa gestione e analisi del patrimonio entrambe le scale (territoriale-urbana e architettonica) sono essenziali. Ma nonostante i numerosi tentativi fatti negli ultimi anni, attualmente nessun sistema è realmente capace di una loro gestione simultanea. Questo studio mira a creare un sistema ibrido, una nuova interfaccia che consenta la contemporanea visione e gestione di AIS e GIS e che presenti una finestra per effettuare analisi spaziali. Gli obiettivi finali sono stati: risolvere il passaggio di scala (dall'analisi alla sintesi); consentire analisi spaziali e creare un sistema accessibile tramite internet.

Currently in the field of management, enhancement, territory and cultural heritage analysis, two types of information systems offer significant tools: GIS (Geographic Information System) and AIS (Architectural Information System). The first one manages urban and territorial scale data, the second one administers architectural scale data. For a complete management and analysis of heritage both scales (territorial-urban and architectural) are essential. But despite numerous attempts made in recent years, currently no system is really able to manage them simultaneously. This study aimes to create a hybrid system, which is a new interface that allows to simultaneously view an AIS, a GIS and a window for management of spatial queries. Considering the profound differences between the two systems, the ultimate goal is to integrate them by proposing a new hybrid system (HS) to solve the problem of scale change (from analysis to synthesis) using a new data structure and a new interface. To achieve the ultimate goal it has been studied mainly: a) the possibilities of implementation of the two systems; b) spatial analysis and 3D topology.

Keywords*:* GIS, AIS, Web, Topology, 3D Models, Cultural Heritage / GIS, AIS, Web, Topologia, Modelli 3D, Patrimonio Culturale.

Introduction

This work is part of the PRIN2008 (1) research, but also of a Ph.D. thesis in Representation and Survey carried out at La Sapienza, University of Rome (Department History, Design and Restoration of the Architecture) and at the Laboratory UMR 3495 CNRS / MCC-MAP Gamsau of Marseille, France (2). The main goal of the research was to work on systems to the enhancement and information dissemination about the architectonic / urban cultural heritage. To include both scales, a general scale for the urban and a particular one for the architectural, we need two system: Geographic Information Systems (GIS), that can manage cartographic data, and Architectural Information Systems (AIS) to use 3D models like tools to access at the architectural information. From these premises, specific objectives of the research were:

• investigate the possible implementations of Geographic Information Systems (GIS) and Architectural Information Systems (AIS);

• try a connection between the two systems and create a new hybrid systems that allows the concurrent menage of cartographic and architectural data;

• verify queries on 3D models studying the 3D topology;

• work with free and open source and web available systems.

The main research phases were five:

1) state-of-the-art study about 3D GIS, Web GIS, AIS and topology;

2) 1st experimental phase: choose of the case study;

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3) data capture (cartographic and architectonic data found through research in archive and survey);

4) 2nd experimental phase: informatics architecture and information architecture;

5) 3th experimental phase: Hybrid System, i.e., connection between the two systems (GIS and AIS) and 3D queries.

State-of-the-art

The state-of-the-art's study shows that there is a great interest around 3D GIS and Web GIS implementation, but, unfortunately, there are not yet complete and not yet online usable systems. It's the same for the AIS, there is an important interest around this topic, but poor literature and few web available systems can be found. Normally, the experimentations concern the extension of GIS with 3D interfaces, but the inserted models are de-connected at the database, i.e., it is impossible to query the database or to make spatial analysis through the 3D models.

Instead, the 3D models are described in an AIS through data inserted in a database, and, vice versa, the database can be queried from the 3D models. On the other hand, they are not a spacial collocation, to be more exact, they haven't any georeference.

The AIS used for this research is Nubes (3), a web platform, available online, that allows to manage and query 3D models in real time.

At last, a reflection was conduced about the difference between an Information System and a Geographic Information System. The result was that the main characteristic of a GIS is its geographic meaning (geographic, i.e., geometric and topological) and the consequent possibility to make spacial queries. So, we deduced that the only possibility to query a 3D model is to work with the 3D topology.

The case study

The case study must be urban and architectonic, so we needed a part of a city and its building. But we also need a connection to skip from the urban to the architectonic scale. Therefore the choice fell on a square, exactly on Piazza del Popolo of Ascoli Piceno. A square because it is a connection element between the urban scale (a square is an urban element) and the architectonic scale (a square could be described through the buildings that form its perimeter). This specific square because it has modular elements that are perfect to compare modular elements (columns, bays, windows' mouldings, Fig. 1).

Data capture

To achieve an urban / architectural analysis it was necessary to acquire data for both scales. Cartographic data was found in various archives, in particular the digital archive of the Architectural Faculty and in the Public Records Office of Ascoli Piceno. These historical maps and orthoimages of the centre were used to improve the GIS, to build a historical description of the city, and especially to be a georeferenced base for the 3D models.

Architectural data, used to build the 3D models, was created through different surveys (topographic and photographic survey and laser scanning). The idea was to create several models at different scales, so we needed various surveys and instruments.

The laser scanner and the topographic survey were used to capture the whole square and to rebuild the exact position of the edifices. The laser scanner, with other settings, and the photographic survey were employed also to capture architectural details.

Informatics architecture and information architecture

For Informatics architecture we intend the complex of system, software and informatics languages used to reach our goals. In this case we used as much as possible free and open source instruments, to its flexibility and to work on low-cost. For the Web GIS the work was conduced entirely in Linux using QuantumGIS, p.mapper and MapServer. The database was created with PostgreSQL and PostGIS. The 3D models were made with Maya and elaborated with Virtools because Nubes needs

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specific formats. The information architecture is most complex and it depends on the final objectives. GIS and AIS have two different information architectures, but in both cases the first step was a project. For the Geographic System a good design of the database and the connection between it and the cartographic data is essential.

Before the realization of 3D models, a reflection about the semantic decomposition is important, i.e., how many architectonic parts form the entire architectonic complex. The second step was the realization of 3D models according to a hierarchical decomposition. The results of these operations were a Web GIS and a new project in the AIS (Fig. 2).

In the Web GIS it is possible to see various cartographies regarding Ascoli Piceno. There is also a layer piazze (squares) and a layer perimetri (perimeters).

From the layer piazze it is possible to query the database, that was designed to describe a square, and, consequently, the buildings that are the square's perimeter. In Nubes we created a Project (Piazza del Popolo) with three pov (point of view) (3), in each pov we can upload 3D models and describe them semantically. The three pov have models in three different scale: a pov has the 3D models of each building around the square. They are not much detailed to preclude a too heavy pov (in Mb). In another pov there is a building, one of the renaissance edifice, detailed and broken down to many parts (columns, windows, façade, etc.).

A last pov regards two detailed bays made up columns, volts and arcs.

Hybrid System

The Hybrid System was designed to allow the contemporary access to both systems (Web GIS and AIS) and to make spacial queries (topological analysis) through a query editor. Therefore the new interface is split up into three windows: the AIS on the left, the Web GIS on the right and the query editor at the bottom of the page (Fig. 3). The 3D models and the cartographic information are connected through the two databases, a MySQL database (Nubes' database) and a PostgreSQL (Web GIS' database) with php script.

More exactly the buildings' 3D models are connected at the layer building into the Web GIS. That allows to set a one-to-one relation and clicking on one element of the layer buildings in the Web GIS, the 3D scene moves in real time and puts the 3D representation of the selected building into the centre of the scene (Fig. 4).

The query editor allows to query the 3D models and to make spatial analysis. One of the most difficult parts of the research was to imagine spatial, or topological queries in three dimensions. We individuated the following analysis, useful for the study of architectural objects (5):

- vertical alignment;
- horizontal alignment;
- hierarchy;
- solid / empty;
- geometric informations.

To explain the vertical and horizontal alignment a remark is necessary: in Nubes the 3D objects are imported creating a vectorial point (writing the x, y, z coordinates) that is the barycentre of its representation that is the 3D model. That means that every 3D model exists in Nubes' database like a vector point and its representation. For this reason a good decomposition the the architectural objects is very important.

So, to verify that two objects have a vertical or horizontal alignment, it is necessary to check if the barycentres have one equal coordinate. In the query editor it is possible to select the two objects and the coordinates that we want to know. The system answers writing the coordinate values and highlight the request information (Fig. 5).

The hierarchically aggregation is another Nubes' property that we used. We can upload, for example, a capital, a shaft and a base and then select all and indicate that the three elements are a column. Nubes writes three dimensional graphic and creates a hierarchical report between the three objects.

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We did this operation for each element uploaded in Nubes, so, in the new hybrid system we can select an object an in the query editor we can read its hierarchy.

For geometric informations we intent the geometrical comparison between two objects. In Nubes we can measure the 3D models and enter the measures in the database. Through the query editor it is possible to select elements and mathematical operations, to do a geometrical comparison between the selected elements, for example compare two bays to know if they have the same dimensions or not.

Conclusions

The main aims of this thesis were to investigate the possible implementations of Geographic Information Systems and Architectural Information Systems, to try a connection between the two systems and to verify spatial query on 3D models.

Regarding the first objective we reached the conclusion that it is impossible, or really difficult, to have a single complete system that can manage 2D and 3D information, also due to the databases' complexity and the limits that common computers have to manage too much Mb.

For this reason we connected two systems through the connection of two databases, instead of creating a new system. The result is a Hybrid System that allows to visualize and to manage at the same time and in real time 2D and 3D data. The last aim was attained studying the 3D topology and creating a query editor in the new Hybrid System.

The 3D topology is the key to reach this goal and there is still much work to do. The most difficult is to imagine useful analysis in the three dimensions and to generalize, i.e., found geometrical primitives that could represent the so complex architectural elements.

The research could be continued carrying out a deeper study about the 3D toplogy and the geometric primitives and working to obtain graphic answers to the spatial queries and not only alphanumeric ones.

Notes

1 - PRIN2008 (Research Project of National Interest) in Integrated information models to learn, enhance and share the urban and environmental heritage, co-funded by MIUR (Ministry of Education, Universities and Research, Italy).

2 - The thesis was defended at Rome on June 11th, 2012. The tutor was Prof. Elena Ippoliti (La Sapienza University of Rome) and co-tutor Livio De Luca (Director of the Laboratory UMR 3495 CNRS / MCC).

3 - NUBES is a project developed by a research team of the Laboratory UMR 3495 CNRS / MCC-MAP Gamsau of Marseille, France.

4 - Pov, point of view, describes in Nubes the possibility to create different visualizations in a same project. To build a Nubes' project we need to create vectorial points writing the x, y and z coordinates and assigning a name to each one. Every point can have one or more 3D representations, and sometimes in a project we need to view some points and not others. Therefore in Nubes it is possible to have several points of view for a project, to manage easily the visualisation.

5 - The analysis that we imagined could be useful to study architectural objects, but to test it it was necessary to adapt to the systems we used.

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Figure 1. Piazza del Popolo in Ascoli Piceno.

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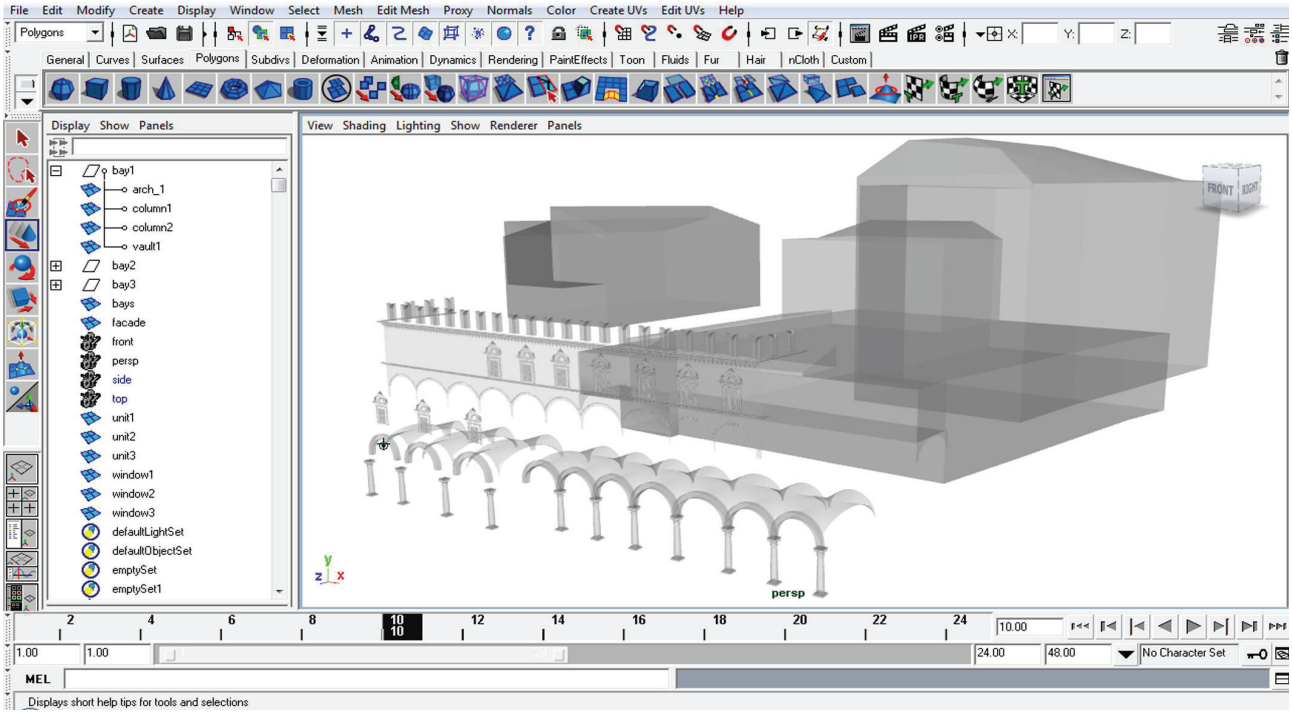

Figure 2. 3D model semantically decomposed.

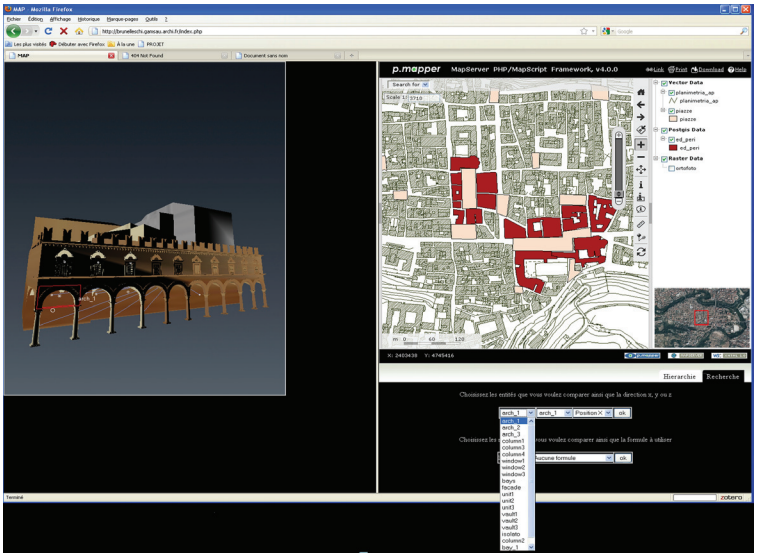

Figure 3. Hybrid System.

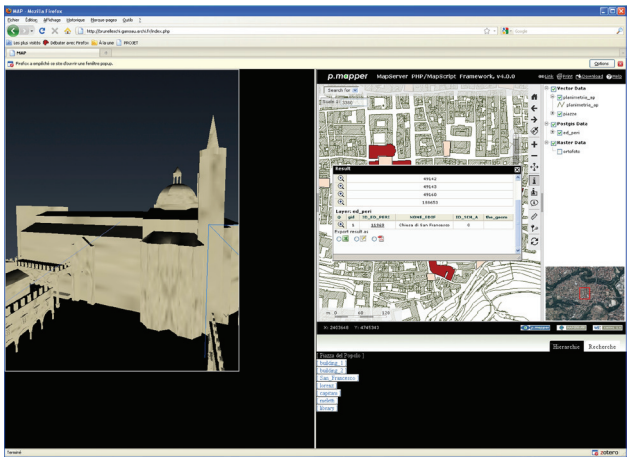

Figure 4. Connection between the Web GIS and the AIS.

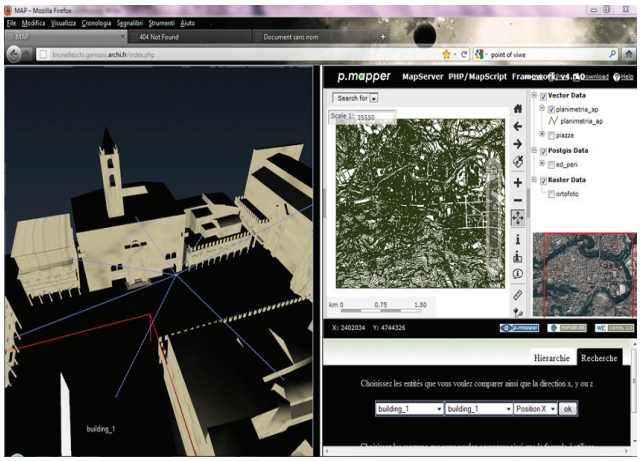

Figure 5. Verification of vertical and horizontal alignment.

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