GIS contribution to urban history and to the reconstruction of ancient landscape

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Abstract: This project is part of a PhD research (in History and Computing) carried out with the department of Historical Disciplines of the University of Bologna. The aim of the research is to investigate the structure of the Roman city of Bononia through the reconstruction of its surface and access to excavation data. Recognising the importance of the immersive experience, in the case of Bologna, the project attempts to answer two questions: "How did the city change from Roman period to the present?" and "What was the nature of its ancient landscape?".

Far from pretending to exactly reconstruct the ancient landscape, the reconstructed three-dimensional model tends to offer some suggestions related to distribution of urban space, in relation to its morphological structure.

Key words: GIS, Virtual reality, Ancient Landscape Navigation, Urban history, Bononia

Introduction

This work is part of a PhD research (in History and Computing) carried out with the department of Historical Disciplines of the University of Bologna.

An important research project, involving many themes related to the history of Bologna city, was started in the 1990s[1], involving mainly the department of Historical Disciplines (Prof. Francesca Bocchi) and an interdisciplinary group (CINECA Supercomputing Centre and Carpi Research Centre). The aim was to sort out the historical events that characterised the city, in term of urban structure and evolution, which led it to have its current form, through the construction of a four-dimension digital model.

The success of this project, is due mainly to the large number and accessibility of historical documents preserved in archives, as well as to the hard work of numerous historians, in meticulously analysing the information, keeping and digitising the most reliable and useful in order to reconstruct the different historical urban phases.

The city centre has been modelled in this way: modified and built following the evidence from those historical sources (documentary and iconographic) allowing the reconstruction of crucial urban phases, starting from the present, back to the 13th century[2].

A possible approach has been studied to more ancient times, but obviously obstacles were found in treating and recovering information prior to the XI Century . Historical sources are in fact quite scarce for this period and often unreliable, not allowing a proper identification and understanding of the evolution of Bologna city, between the fall of the Roman Empire and the X-XI centuries. Archaeological excavations cannot help much either in recovering the historical and urban memory.

The research project

The present research started precisely at this point - from the end of the Roman Empire, backwards - using a different approach to the mainlyarchaeological sources, but with a similar aim: the reconstruction of the ancient Roman landscape.

The first step was the development of as reliable a cartographic base scientific knowledg scientific knowledge as possible, in relation to the current form of the territory under study.

After a few attempts with Regional Technical Maps (CTR - 1 : 5000), detailed maps were chosen (1 : 2000 scale) for the city centre and less detailed for the surrounding areas (Fig. 1), used together to maintain the relationship between city and suburban zones, for both morphological aspects and human interactions.

After some verification and corrections to the digitised data, due to discrepancies between the maps at different scale and adjustment by comparison with terrain observations, a three-dimensional digital model of the territory was obtained. This model was good enough to be used as a continuous reference where necessary, particularly where documents failed to record elevation data in units above sea level.

Vectorial information, such as rivers, streets, railways and built-up areas, was overlaid on this model using ArcView GIS (Fig. 2). Aerial photographs were rectified and georeferenced in order to complete the present day 3d model.

The aim was to reconstruct a good model of the actual landscape so as to highlight the changes which occurses between Roman times and the present day[3].

In order to obtain as accurate as possible a model of Roman landscape, it was necessary to study bibliographical and archive sources in detail[4].

Data have been systematically arranged in a relational ODBC database, consisting primarily of three tables for SITES, REMAINS and BIBLIOGRAPHY information. We now have almost 500 remains and 400 sites.

To start with, the database was interrogated for referenced points belonging to particular categories of contemporary sites. Some data couldn't be used, such as records referred to spread remains and underground remains (such as sewers, water courses and canals).

Using these points a three-dimensional model of the Roman surface has been calculated using the *krig* interpolation method.

On this new model have been placed a few themes took out from the database, through crossed-queries based mainly on the typology of the remains, their chronology and building materials. Main Roman streets (*cardines* and *decumani*) were added, as well as observations related to the presence of *domus*, suburban *villae*, industrial structures, dumping places, *amphorae* storages and building's pavements (3).

Information relating to public places was also added: the *forum*, the *basilica*, the theatre and a few temples.

Finally, remains relating to the urban water administration were placed on the surface. These included pipes (*fistulae*) belonging to Roman aqueduct and drain-pipes, and vectors representing known and hypothetical rivers[5].

Every object *geo-placed* on the model has been assigned an ID number, used as the main reference to connect with the ODBC database tables, through a *join* operation, called of in the GIS system through SQL instructions. This also allowed relations between different tables of the external database to be maintained.

The next step in the project led to a twofold direction and to a different approach to data and problems.

There's, indeed, another possible point of view, likely to be examined. Analysing the urban history going backwards - starting with known elements of modern and Medieval city - we arrived at a point were we just have spread information that cames from a few excavations. At this point lights fade away and the scene is deprived of buildings, constructions and daily life. The manuscripts are silent, leaving us with just a disturbed surface. Thanks to the reconstruction of this surface through a mathematical calculation, is it possible now to keep on working on the city, looking at the natural events and human activities that have marked it. This surface begins to be populated at *domus*, *villae*, temples, markets, theatres, industrial and commercial activities.

But the reasearch should not stop at this point. It goes on, backwards, to a time before the Romans decided to quarter the colony of *Bononia* here, before the Etruscans had left traces of their *Felsina*. It is possible to have a quick look at the large territory that the Villanovians chose as their residence in the Iron Ages[6].

Following this approach we are working in two directions: on the one hand we are now exploring the great potential of GIS, on the other developing its new potential in terms of visualisation and realtime navigation.

Analysis

GIS cannot be considered just a useful tool to visualise geo-referenced two- or three-dimensional geographical data. We can experience its real value with spatial and crossed analysis of data collected in the initial phase, characterised by archival research and informatisation. This is the crucial stage, when there is direct confirmation of the validity of our project plan and the quality of the problem definition. We also have to consider that we are not dealing with simple numbers and mathematical problems, but with historical and archaeological data, sometimes so multifaceted and so difficult to interpret that there has to be room for a certain wastes to be retained, as possible, since the beginning, inside a definite range[7].

The analysis that will be carried out mostly consists of operations such as buffering, visibility, density and neighbourhood statistic, distance mapping, slope and aspect functions. The goal is to answer questions such as: the distribution of different typological elements in relation to terrain morphology and natural resources; the distribution of certain building materials; analysis - through deeper examination of relations between remains and their morphological location - of two or three macro-situations highlighted by the generation of the digital model; and analysis of the relationship of remains connected with Roman hydrographic management with soil drainage characteristics.

3D visualisation

Some analysis is related to the later phase of this project, whose final aim is the realisation of an interactive (even with data acquired) and three-dimensional navigation virtual system.

We cannot claim anything new when we talk about *archaeological landscape navigation*[8]. I think we have all witnessed years of discussion and case studies on these topics. Today, thanks to the laborious work (and information dissemination) of some researchers, it's possible to recognise that something has been achieved. Perhaps we can say that there is a common awareness of the importance of three-dimensional and immersive approaches to data. There are new opportunities for these applications together with the creation of interdisciplinary work-groups and the identification of needs and new solutions in this field.

Recognising the cognitive importance of the immersive

experience, in the case of Bologna, the project attempts to answer two questions: "How did the city change from the Roman period to the present?" and "What was the nature of its ancient landscape?".

Far from pretending to exactly reconstruct the ancient landscape, the reconstructed three-dimensional model tends to offer some suggestions related to the distribution of urban space, in relation to its morphological structure.

In this first approach the particoular software was used: *Terravista*[9]. It works with input data such as vector *shapefiles*, DEM, 3D objects and raster images (such as *geo tiff*) and it produces 3D real time navigation as output in **flt* format. Even if it cannot be considered as 'geographic' modeling software, Terravista has good characteristics of compatibility with commonly used GIS tools (ArcView, ErMapper, ...) and has the great advantage of producing perfectly georeferenced 3D scenes.

Thanks to this kind of software, a project to navigate on the actual territory (with aerial photographs) is in progress, together with the construction of a virtual model of Roman landscape displaying (and possibly interacting with) the data acquired (Fig. 5).

End notes

[1] Nu.M.E. project (New Electronic Museum for the city of Bologna)

[2] "Atlante storico delle Città Italiane": Emilia-Romagna, 2, Bologna, a cura di F. Bocchi, voll. 4, BO 1995-98; Vol. V (Atlante Multimediale di Bologna) in formato CD ROM, BO 1999; F. Bocchi, L. Calori, F. Fraticelli, A. Guidazzoli, M.Mariani, The 4 Dimensional City, Science and Supercomputing at Cineca, 1997 Report; F. Bocchi, Nuove metodologie per la storia della città: la città in quattro dimensioni, in "Medieval Metropolis", Proceedings of the Atlas Working Group, BO 1997; M. E. Bonfigli, Implementazione del progetto Nu.M.E., in "Medieval Metropolis", Proceedings, BO 1997; F. Bocchi, Medioevo Virtuale, in "Medioevo" n.11, (22) Nov. 1998; F. Bocchi, M.E. Bonfigli, L. Calori, A. Guidazzoli, M.C. Liguori, M.A. Mauri, M. Melotti & D.Vasetti; "Virtual Reality and Cultural Heritage: Some Applications"., in "Proc. of EVA 2000" , (V .Cappellini & J. Hemsley Eds.), Florence, March 2000, Pitagora Editrice Bologna, pp.162-165.

[3] For a bibliographic reference of Roman Times: Bergonzoni F., Bonora G., Bologna Romana, I, Fonti Letterarie - carta archeologica del centro urbano, Bologna, 1976; Ortalli J., Bononia romana; in 'Bologna I. Da Felsina a Bononia, dalle origini al XII secolo', "Atlante storico delle città italiane." Vol. I, a cura di F. Bocchi, Bologna, 1996; Ortalli J., Bologna città romana; in 'Atti e memorie della regia Deputazione di storia patria per le province di Romagna' vol. 47; Bologna 1997, pp. 141 – 193; Scagliarini D., L'insediamento residenziale e produttivo nel suburbio di Bologna romana; in 'Atti e memorie della regia Deputazione di storia patria per le province di Romagna.', Bologna 1969

[4] Part of the documentation was taken from Soprintendenza archives (ASAER), kindly granted by Sopritendente Dr.sa Calvani and Dr. Ortalli.

[5] Every object was always connected with its bibliographical references

[6] Forte M., La pianura bolognese nella prima età del Ferro. Note sulla topografia degli insediamenti, in "La pianura bolognese nel Villanoviano", Catalogo, Firenze, 1994, pp. 9-20; Morigi Govi C., Tovoli S., La cultura villanoviana a Bologna (IX – prima metà del VI secolo a.C.), in "La pianura bolognese nel Villanoviano", Catalogo, Firenze, 1994, pp. 46-48; Sassatelli G., Morigi Govi C., Felsina etrusca, in "Atlante storico delle città italiane." Vol. I, a cura di Francesca Bocchi, Bologna, 1996

[7] A clear example can be the case of excavation and documents without the definition of a precise dating: this led us to calculate a surface model with a generic assignment to the Roman Period (between II-I BC and III AD), considering in any case the absence of significant increase of the ground for the considered period.

[8] MOLINEAUX, B., 1992, From virtuality to actuality: the archaeological site simulation environment, In 'Archaeology and the Information Age' Edited by P. Reilly and S.Rahtz. London: Routledge, pp.312-322; FORTE M., Un esperimento di visualizzazione scientifica per l'archeologia del paesaggio: la navigazione nel paesaggio "virtuale", in "Archeologia e Calcolatori" 4, 1993, pp.137-152; BARCELO J., FORTE M., SANDERS D., 2000 (eds.), Virtual reality in archaeology, Oxford, Archeopress (BAR International Series S 843), 247-263.

[9] With the co-operation of CNR ITABC and Dr. Maurizio Forte.

Figures

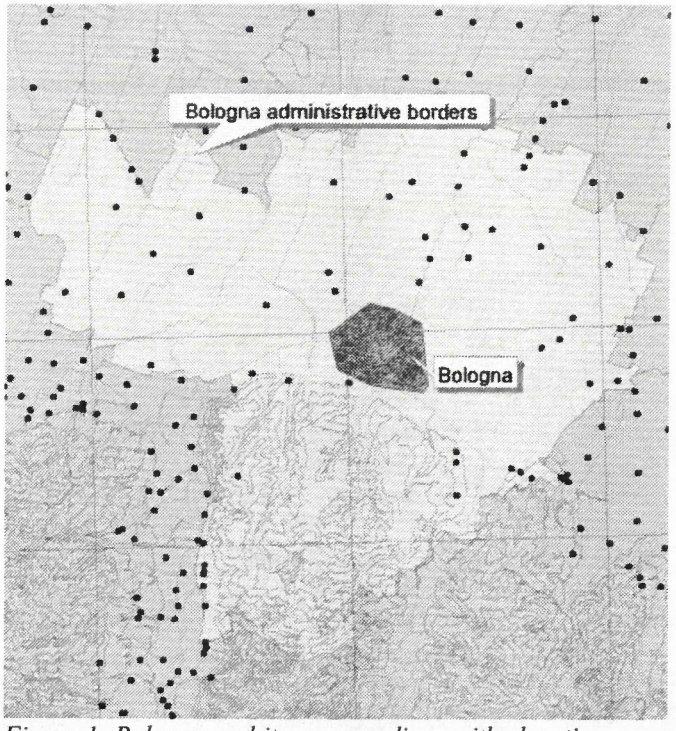

Figure 1. Bologna and its surroundings with elevation information

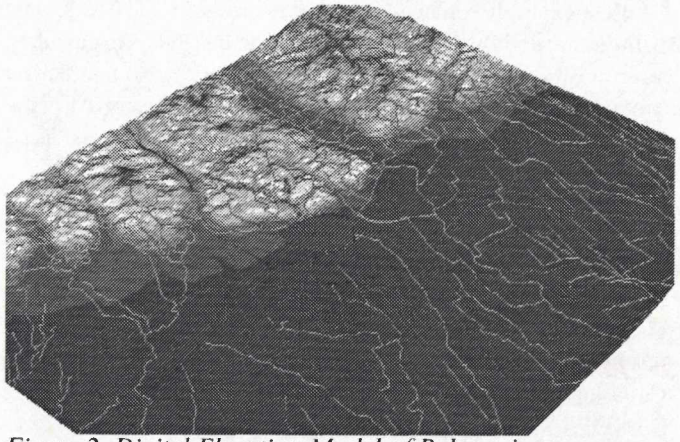

Figure 2. Digital Elevation Model of Bologna's area.

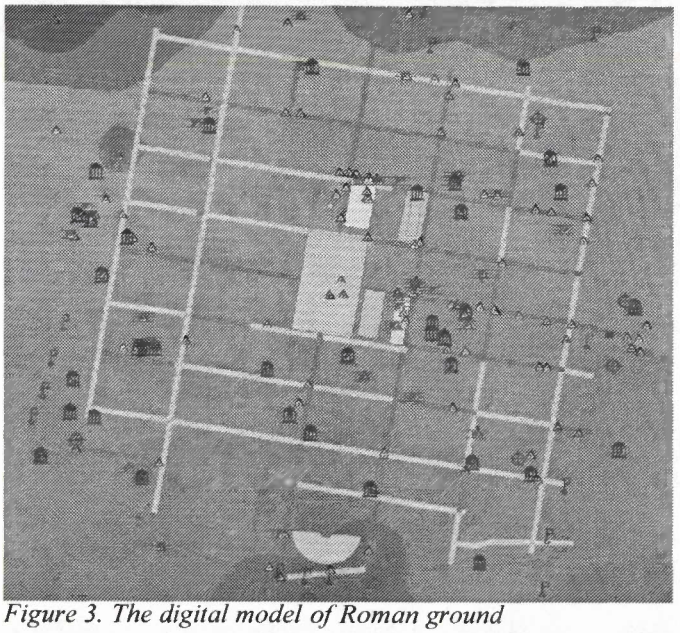

Figure 3. The digital model of Roman ground

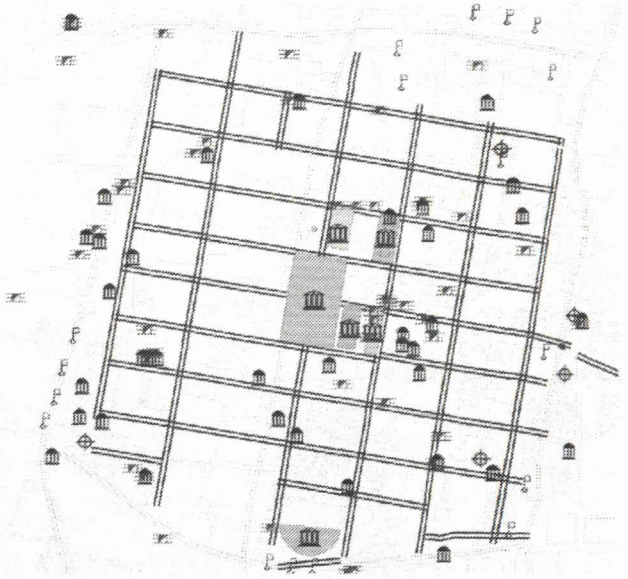

Figure 4. Themes of Roman Bononia*: mosaics (red), public buildings (blu), storages (violet), streets (brown), river (ipothetical: light blu; assumed: dark blu)*

Figure 5. A snaphot of the real time navigation in the roman virtual environment.

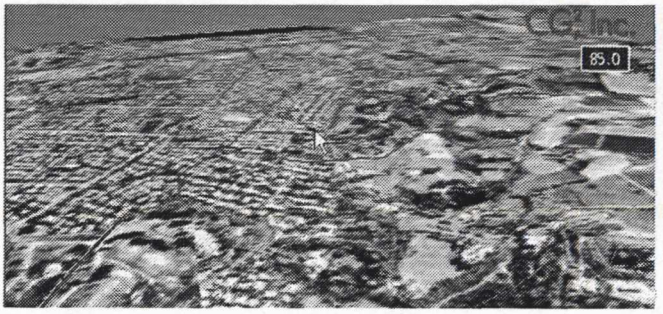

Figure 6. Snapshot of the real time navigation in the actual landscape