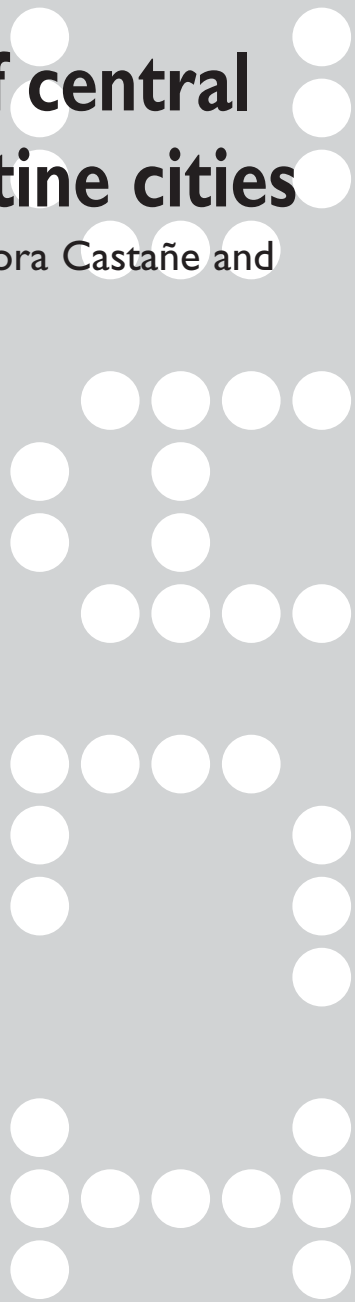
Hypermedia urban models in virtual environments: Case studies of central areas of Argentine cities

Diana Rodríguez Barros, Dora Castañe and Alfredo Stipech



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The virtual models of urban fragments recreate environments of simulation and analysis with a great degree of realism. This paper addresses a review of case studies in which Argentine researchers from three different university centres have worked jointly. We examine spatial databases from a representational and communicational perspective as virtual 3D, walk-through, and interconnected urban models. Our aim is to explore, recognise and analyse advances in this direction, and to apply them to the development of virtual models of central areas in the Argentine cities of Buenos Aires, Rosario, Santa Fe and Mar del Plata. We present the methodology used to analyse the design, production and management processes of the virtual model as well as the results of our research. We acknowledge that these models are consistent non-traditional instruments of analysis which complement the knowledge of the city and facilitate spatial comprehension. Finally, we review predominant tendencies.

1. INTRODUCTION

The virtual models of urban fragments (consisting of spatial, hypermedia, and interactive databases interconnected to telematic networks), recreate environments of simulation and analysis with a great degree of realism. These models are supported by efficient storage, information retrieval in multiple formats, and a diversity of visualizations for review and analysis. They are integrated by geographical, historical, economic, social, environmental and urban variables. The use of different strategies to convey information makes these models consistent and apt three-dimensional instruments for understanding the city and making decisions related to space and design. Their applications in the fields of urban planning, evaluation and visualization, whether existing or offering new proposals, are possible for both expert and non-expert users alike [1, 2].

A virtual 3D urban model is a digital representation of the interlinked physical objects that make up the complexity of a city. It generates a three-dimensional artificial environment whose referent is an existing or modified real environment. In it, several ways in which architectural objects or urban interventions are incorporated and linked can be simulated, visualized and verified. The GIS (Geographic Information System), CAD (Computer-Aided Design), pseudo-realistic modelling programs and VRML (Virtual Reality Modelling Language) digital technologies contribute to the creation of these spatial databases [3, 4].

In broad terms, the generation of urban models starts with the production of 2D databases, simultaneously with the production of 3D databases with hyper-realistic effects. After this, incorporating possibilities of real time walkthroughs to recognize, navigate, and manipulate information according to a program, to eventually adding the possibility of their transformation with the user's interaction when the virtual models are integrated into networks, especially into the Web2.0 dynamics.

2. PRECEDENTS

We are presenting the developments and studies of the project "URBAMEDIA. Urban databases of central areas of Argentine and Latin American cities," developed at the CAO FADU, Universidad de Buenos Aires, Argentina. It started in 2002 under the direction of Architect and Consulting Professor Arturo Montagu, promoter of the initial ideas and developer of the first stages of the project [5, 6], which ended in 2006.

The group was originally composed of a team of researchers from the FADU Universidad de Buenos Aires, later enlarged by other members from the CEAC FAUD Universidad Nacional de Mar del Plata, the CID FADU Universidad Nacional del Litoral, and the FAPyD Universidad de Rosario.

During the first stages, there were joint international projects completed with the ABACUS Centre, University of Strathclyde (U.K.), under the

direction of Professor Thomas Maver. Subsequently, other studies were conducted in collaboration with researchers from PROURB, Universidade Federal do Rio de Janeiro, under the direction of Professor José Ripper Kós, and with the Graduate Studies Division FAD, Universidad de Zulia, under the direction of Professor Jane Espina. We have exchanged our experiences and the results have been published and tested at SIGraDI (Sociedad Iberoamericana de Gráfica Digital).

Some precedents to these studies were the DATARQ "Modern and Contemporary Architecture Databases" (1996) and ARQUIMEDIA "An Experimental and Pedagogic Vision of Cultural Media Integration" (1998) projects run by Arch. Montagu [6], as well as pioneering developments on digital urban models and later studies [7, 8, 9, 10].

3. OBJECTIVES

In our study, the focus of interest was inquiring, from a representational and communicational perspective, into spatial databases as virtual 3D, walk-through and interconnected urban models, with the aim of exploring, recognising and analysing advances and developments.

First, we inquired conceptually into the nature of these spatial databases.

Second, we analysed operatively the generation and visualization of spatial databases that include and link three-dimensional models generated by the GIS and CAD technologies, models and mappings of photo-realistic image texture, and VRML. We also analysed instances of interaction and interconnection among networks.

Third, we interpreted the conclusions and results of previous studies to draw categories that would allow us to design methodologies readily applicable to the stages of analysis, management, design, production, optimization and systematization of medium- and low-complexity 3D virtual urban models, in correspondence with reduced budgets, standard equipment and commercial programs.

Fourth, we formulated simple predictions about trends oriented towards advances in the realism of the created morphology in a virtual city project and in the integration of applications, to be translatable into design rules.

Lastly, we set out to transfer these findings to develop virtual models in the context of architecture and the city in regional contexts. Therefore, a network was set up to carry out work in collaboration with research groups located in different Argentine universities.

4. DESCRIPTION OF STUDIES

A 3D virtual model of an urban fragment is a digital representation of the physical objects that are part of the complexity of a city, expressed in an artificial three-dimensional environment having an existing or modified real environment as its referent. In that representation, several ways in which architectural objects or urban interventions are incorporated and linked can

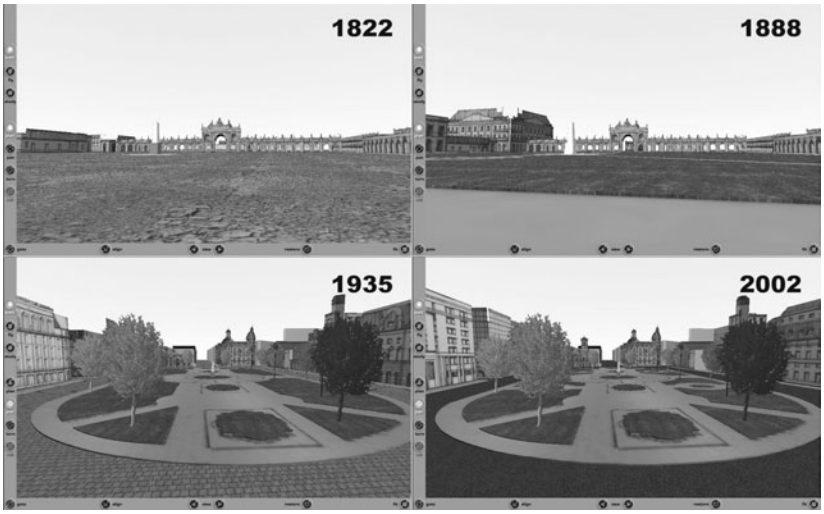
be simulated and visualized; in addition, the influences they have and the degrees of impact they cause can be verified in an accurate and economic fashion. Our premise is that such virtual environments are oriented towards generating significant knowledge of the city, as they are suitable instruments for the users to intervene from several dimensions, depending on the users' profile and diverse applications, whether their interests are architectural or urban.

Broadly speaking, the models depict a sequence that has been completed through a morphology with the addition of geometrical information and information geo-referenced to the scale of the whole urban sector involved. Architectural information is also added, so that the resulting pseudo-realistic model can be explored interactively, connected to networks and destined to the recognition of significant areas.

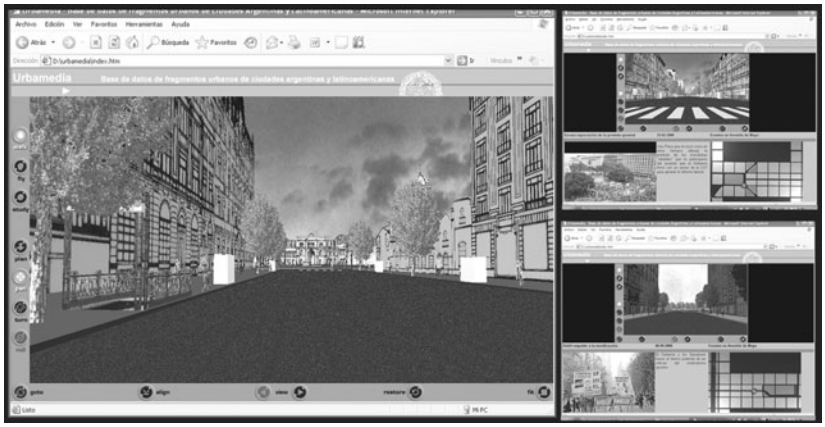
What follows is a description of the methodology used and the results obtained in four case studies of the Argentine cities of Buenos Aires, Rosario, Santa Fe and Mar del Plata [11].

As regards to the cities of Buenos Aires and Rosario, studies and applications were developed at the CAO Centre (FADU UBA) within the framework of the Urbamedia project. The first case corresponds to the area between Plaza de Mayo, Plaza Dos Congresos and Avenida de Mayo in the city of Buenos Aires. The second case corresponds to the area between Plaza 25 de Mayo and the National Flag Memorial in the city of Rosario.

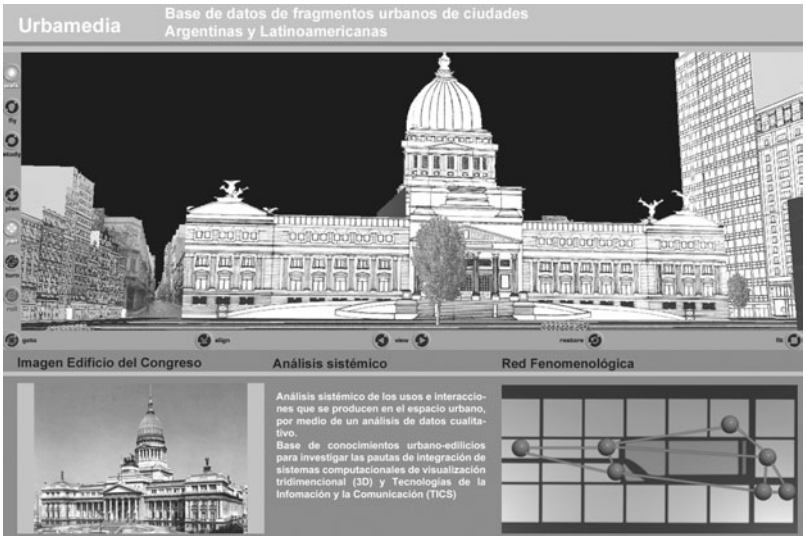
At first, the historical precedents were studied. This was done in four stages. In the first, a pilot study was conducted in the city of Buenos Aires in the Plaza de Mayo area. We experimented with 3D models of significant moments of the city's history, namely 1820, 1880, 1935 and 2002 in VRML environments, with the aim of producing simplified realistic simulations of the area and measuring different types of environmental, visual and noise impacts, and new urban codes (Figure 1). At this stage, we had the support of the Abacus Centre, and we applied developments adapted to the limited computational equipment of the CAO Centre. In the second stage, we extended the modelling by including Avenida de Mayo, from Plaza de Mayo to 9 de Julio Avenue. We enquired into the city dwellers' various uses and appropriations of this urban area, which were instrumental in defining nodes and communicational hypermedia links (Figure 2). In the third stage, we extended the modelling further by including the Avenida de Mayo area up to Plaza Dos Congresos (Figure 3). We incorporated 2D visualizations to our experiments, which complemented the urban space and were simultaneous with 3D models and VRML walkthroughs. Several design options of integrated interfaces were explored. In the fourth stage, the experience incorporated the city of Rosario (Figure 4) [12].



◀ Figure 1. Buenos Aires, Plaza de Mayo urban area. VRML models and significant moments of the city's history.

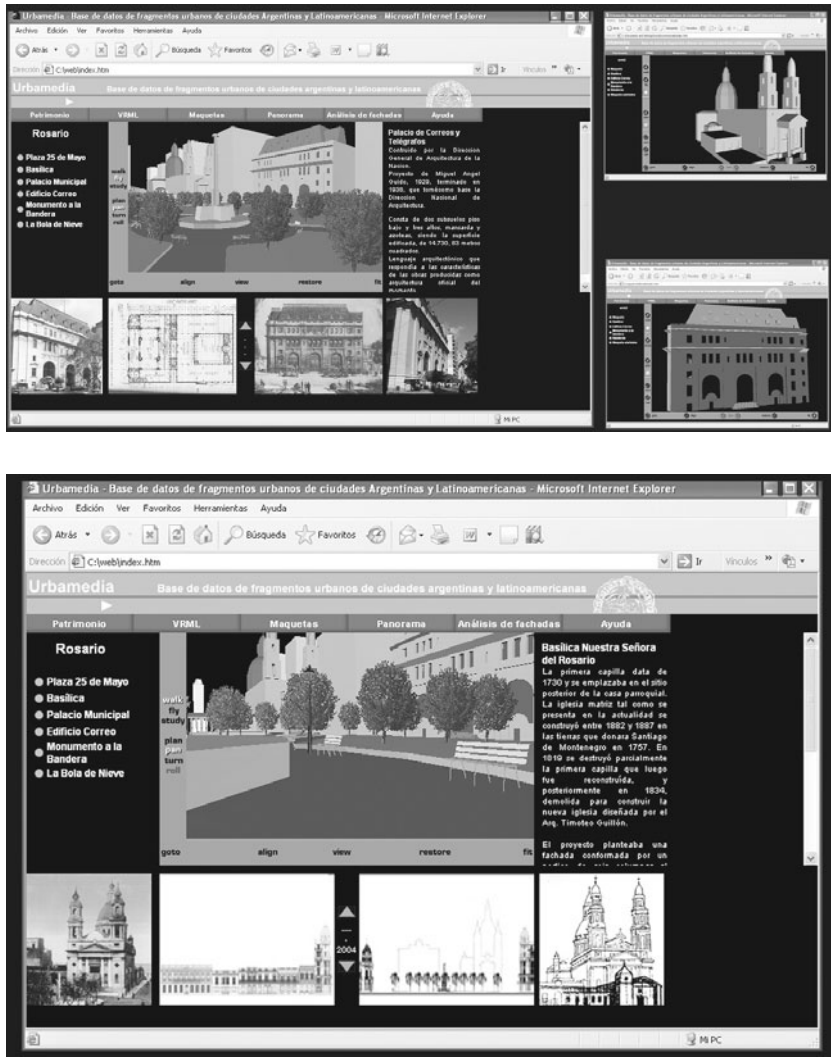


◀ Figure 2. Buenos Aires, Avenida de Mayo. VRML model and city dwellers' various uses and appropriations.



◀ Figure 3. Buenos Aires, Plaza Dos Congresos and Congress building. VRML models.

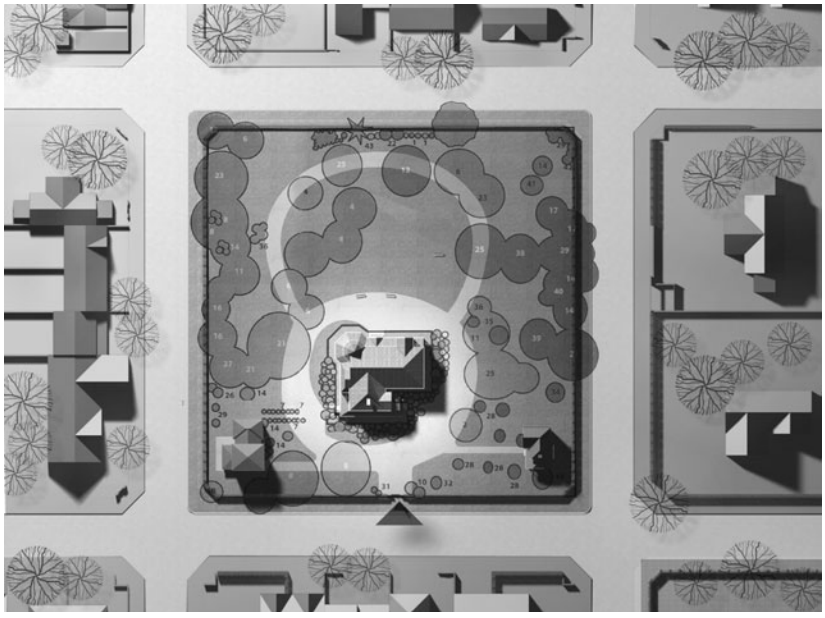
► Figure 4. Rosario, Plaza 25 de Mayo and National Flag Memorial. 3D and VRML models.



The city of Mar del Plata's studies and applications were developed jointly with the CEAC Centre (FAUD UNMdP) and the Urbamedia project on the design of a three-dimensional virtual model whose referent is a real environment of historical heritage value from an urban fragment of the city of Mar del Plata. It is bound by the diagonal axis linking Villa Silvina, Villa Victoria, Villa Mitre and the Divino Rostro Chapel. They are located on the Divino Rostro Hill, characterized as a low density residential area at the city's highest point above sea level. At the end of the 1900s, some of the most outstanding residences were recycled and refunctionalized, which generated a great deal of cultural activity around them (Figure 5). The purpose was to turn the complex web of the sector into a didactic site, as an object of knowledge, from urban, architectural and landscape design dimensions, as well as historical, cultural and social dimensions. Within this

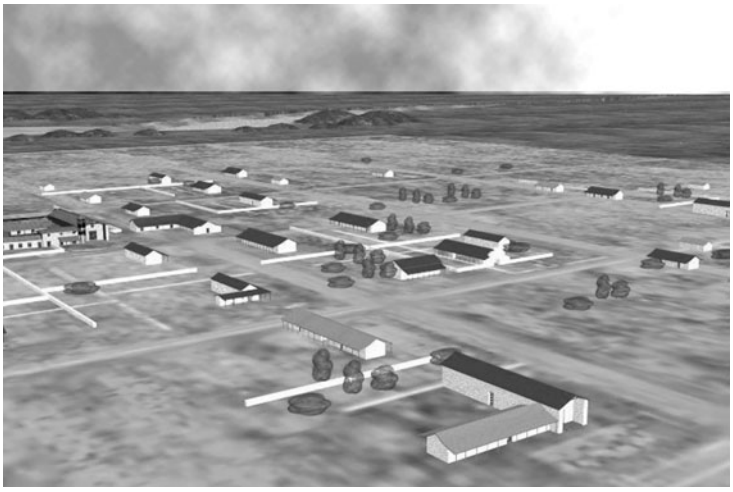
sector, in order to continue the experiment, the modelling work of the unique buildings and the VRML walkthrough were developed with greater details (Figure 6) [13].

◀ Figure 5. Mar del Plata, Divino Rostro urban area.

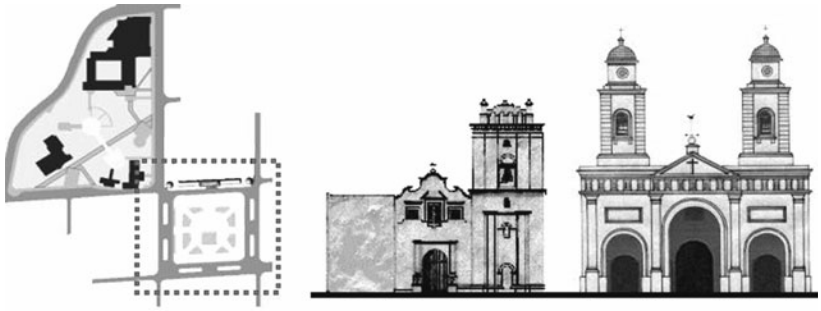


► Figure 6. Mar del Plata, Villa Victoria cultural center. Hyper-realistic 3D model of the main house.

As regards to the city of de Santa Fe, studies and applications were developed in collaboration with the CID Centre (FADU-UNL) and the Urbamedia project regarding the design of the city's foundational area. First, Santa Fe's original settlement on the banks of the San Javier river was analysed (now called Cayasta) (Figure 7), and then its present location since it was moved southwards. The original city enclave was worn out by negligence and the erosion by natural agents while the present city was affected by constant urban renewal, and, as a consequence, lost most of its original buildings. Based on a work hypothesis, we created the 3D model of the reconstruction of both enclaves, first as part of the Digital Reconstruction of the Cayastá Ruins Buildings Project and then of the present city. Layers of information were juxtaposed where the models of existing or no longer standing objects could coexist, thus showing either the evolution or involution of the landscape in certain places (Figure 8). We have focused on the developments of planar, cylindrical, and spherical panoramic visualizations and VRML walkthroughs (Figure 9) [14].



◀ Figure 7. Santa Fe "La Vieja", Cayastá colonial city. Digital reconstruction.



◀ Figure 8. Santa Fe, foundational area. Study facade proportions, textures and mapped.

► Figure 9. Santa Fe, Metropolitan Cathedral and San Francisco church. Pano-spherical interior.

5. METHODOLOGY

We have systematized strategies and methods to the above mentioned case studies, based on similar cases [15], where different steps in the design, production and management processes of the virtual model are analysed.

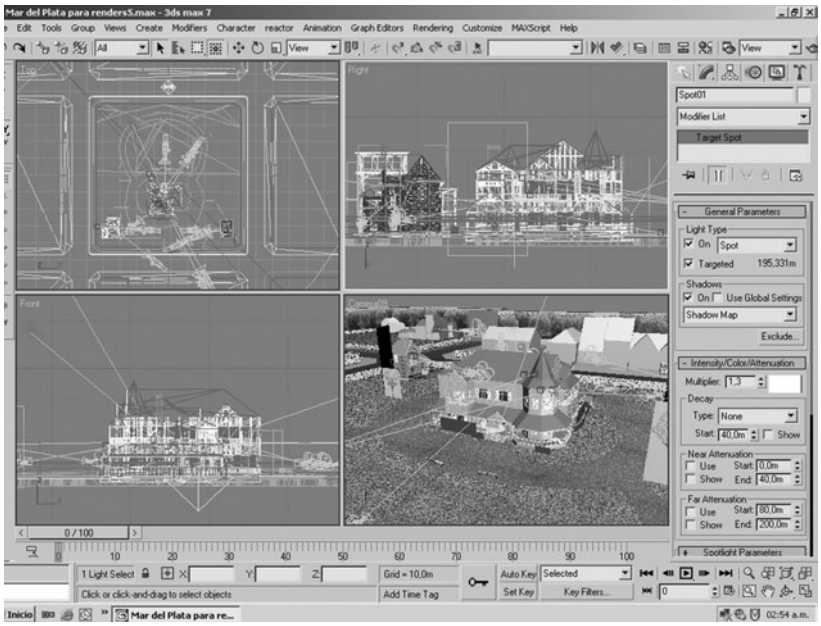
We divided this process into four steps. The first step comprises acquisition, evaluation and validation of data about the plot, the main buildings and the surroundings; the second step refers to the three-dimensional mesh modelling of the plot, unique buildings and the buildings surrounding them; the third step includes the optimization of the models, as well as rendering and setting operations; the fourth step consists of the walkthrough, exploration and navigation of the models as well as instances of interconnectivity, interactivity, and usability.

During the first step, it was necessary to face and solve issues such as the acquisition, evaluation and validation of data drawn from GIS technologies and from traditional sources (e.g., aerial and terrestrial photographic records, zoning of topographical property registry and hand drawn sketches) (Figure 10). At first, data management included the specification, implementation and compatibility management of different data formats, geometrical characteristics and control of inconsistencies in the operations of visualization and navigation.

CAD three-dimensional visualization and photorealistic presentation programs are resources too limited to analyse urban planning interventions in all their complexity. Therefore, the use of GIS technologies was necessary. Thus, these virtual models, in so far as they can link data of a different nature, allow us to relate in a more accurate way different sources of information such as spatial analysis and topologic associations with project, environmental, statistic, legislative and infrastructure data.

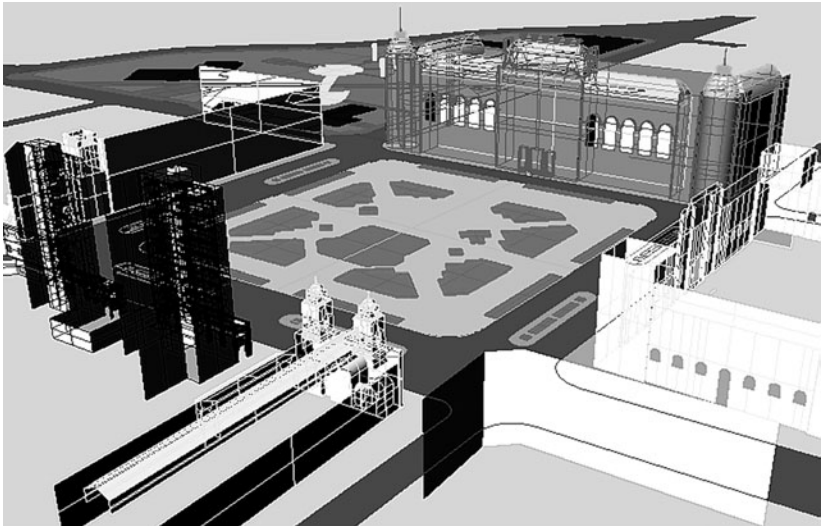
◀ Figure 10. Buenos Aires, MGCBA cadastral map and postcards historics.

During the second step, we had to manage, design and produce the virtual model and the optimizations that allowed us to simplify its complexity, with the resulting increase of visualization performance. In particular, the modelling of the plot, of the unique and repetitive buildings, and the surroundings was solved. We have acknowledged, after Monedero [16], that in 3D building modellings there is a wide range of techniques that can be reduced to three groups from which different combinations arise: either by means of precise geometrical models built with standard CAD programs, or models generated by simple extrusions from 2D plots, or, finally, models generated by false geometry projection as bitmaps on simple faces. The three groups and their possible combinations were used according to each circumstance. We spotted, on one hand, unique buildings that have been documented, which required a precise, accurate modelling (Figure 11); on the other hand, repetitive buildings for which it was useful to define typologies according to height and morphology, using simplified unifications with façades and similar rooftops that were not visible on the virtual model scale. Then, to give the model an appearance of urban setting, it was necessary to include autonomous agents and elements, such as architectural urban equipment and forestation. In addition, backgrounds or 360° image limits of the models were defined to increase their realism (Figure 12).



► Figure 11. Mar del Plata, Villa Victoria cultural center. Modelling, rendering and setting operations of unique buildings. (2)

◀ Figure 12. Santa Fe, Plaza 25 de Mayo. VRML and 3D models.



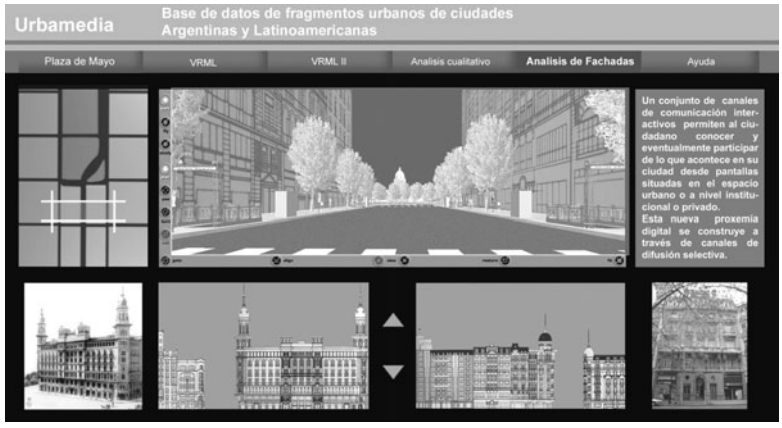
During the third step, it was essential to optimize the model, due to several problems arising from an excess of information. We had to simplify and prune the data, applying the concept of hierarchical structure of the components and reducing geometries and operations in texture mappings on faces (Figure 13).

► Figure 13 - Santa Fe, Palace of Justice. Studies facade proportions, textures, mapped, shadows and overlaps.

Finally, during the fourth step, interactive interfaces associated to model manipulation were designed. We carried out numerous developments and verifications, especially on ways of production, options, uses and procedures admitted by VRML files (Figure 14), a format characterized by a simple syntax that allows compatibility among different low cost applications, as well as among HTML graphic interface designs (Figure 15).

► Figure 14. Santa Fe, Plaza 25 de Mayo. VRML models.

► Figure 15. Buenos Aires, Avenida de Mayo. 2D visualizations simultaneous with 3D and VRML models.



6. FINDINGS

Our findings about the developments of the Argentine cities we selected were published in a book [17], complemented with a hypermedia CD on the experiences. In that book, we offered a detailed description of the compositional processes of spatial databases, we considered different scales and levels of resolution and we linked different kinds of information.

Additionally, we shared the advances and developments of virtual models of other Latin American cities with other research teams: studies on the central area of Rio de Janeiro and urban evolution [18]; virtual model of the central area of Havana and symbolic urban structures [19]; virtual model of the urban sector in the central area of Maracaibo and interconnectivity in multiuser environments for urban interventions [20].

The urban models thus generated store information in several graphic formats, especially about 2D and 3D architectural and urban documentation of the selected areas. We have modelled the emblematic architectural works three-dimensionally, providing easy access to digital planimetry, current and historic-documentary photographs and VRML walkthroughs. Each work can be retrieved on CAD files.

These databases linking graphic, textual and sound information are available to be uploaded on Internet websites and in CD-DVD format. They recognize interactive interfaces on which several evaluative studies of usability and functionality were conducted.

We admit that, even though there are other experiences that use high cost equipments and advanced technologies with optimal results, there are possible and acceptable alternatives, suitable to the conditions typical of the public universities in Argentina and other similar developing countries. These universities use standard PC equipments and generic commercial softwares and have limited resources and budgets.

The network of research groups originally composed of centres from three Argentine universities and then extended to other Latin American universities fostered the development and exchange of databases of the selected urban areas, in spite of significant differences among the groups not only in terms of resources but also in terms of criteria. In addition, team work went beyond mere modelling and representation interventions, inasmuch as it stimulated the experimentation and formation of researchers from several disciplines in all of the research centres involved. Thus, this applied research network broadened its production of knowledge and its influence over people and institutions responsible for the formation of many students.

The application of several techniques and methods, as well as interface and usability designs have demanded that we work jointly with experts from various disciplines and seek their advice, due to the complexity of approaches and developments of the subject. However, although the higher degree of verisimilitude of 3D models with respect to reality guaranteed a

clear interpretation of the represented fragment, we consider that the possibilities of interactive walkthroughs require more sophisticated technologies than the ones within our reach. It was made evident that the possibilities and strategies open to us are countless; therefore, a constant updating and adaptation of these resources was essential.

In this sense, we have addressed methodological and practical issues over rules of integration between graphic computation systems, information technologies and interactive environments, related to the standardization of formats, use of advanced media, compatibility management of three-dimensional models, semi-immersive virtual reality and geo-referenced systems of spatial analysis [21, 22]. We also approached issues related to the improvement of operations of partial automation of the model construction process, optimization routines, demands of compatibility and programs consistency.

7. CONCLUSIONS

We believe that the virtual modelling of urban fragments should not be subordinated to operations limited to just the formalization, representation and communication of spatial data. As Kós [23], claims, virtual urban modelling also offer other ways of exploring the city and its transformations. Thus, we acknowledge that the models we get and the interactive interfaces we design bring forth non-traditional analytic tools that complement urban communication and management. They greatly contribute to the study of phenomena, objects and developments involved in processes of urban consolidation, transformation, expansion and/or restructuring. They also offer alternatives of usability both to experts and non-experts to explore and recognize an urban fragment.

We assume that the three-dimensional hypermedia urban models, after their great initial attraction, are capable of generating motivation and interest, verisimilitude and adaptability to the simulated reality, and multiple pertinent information. Moreover, they are apt for many levels of retrieval, readings and interpretations of information.

We have also noticed the existence of several criteria to systematize and transfer these experiences, confirming the combination of sundry modelling techniques, which has caused, in turn, the emergence of different analysis and visualization resources, developed with dissimilar technologies and initiatives. Consequently, it was our priority to establish broad categories of analysis so that the process of virtual urban modelling can become a reliable tool for the production of knowledge about the city. Hence, the need to incorporate methodological accuracy in the different steps of the virtual modelling, to guide, first, the understanding and systematization in the construction of models and second, the interpretations of the outcomes.

Also, we have identified other features inherent in the virtual models,

such as the three-dimensionality and the possibilities of walkthroughs, which facilitate a spatial understanding that is not available in the two-dimensional information coming from primary sources. In this respect, we realised that the transition from 2D to 3D in the conformation of urban models enhances the intuitive capability associated to the users' spatial vision by facilitating the synthetic approach of the comprehensible thinking of reality as opposed to the analytical approach of abstract thinking provided by the two-dimensional image. Even though we must acknowledge the development of the analytical capability associated to 2D representation, 3D representation does not eliminate the graphic possibilities of 2D, but subsumes them in a superior dimension.

Likewise, we have found that the inclusion of virtual models within websites and the possibility of integration to networks linked to several web pages and files increase and boost the reach, dissemination and efficacy of the models.

Nevertheless, we admit that this field still remains at an experimental stage with an interest in achieving both conceptual and technological improvements, provided that we acknowledge the limits imposed by the economic situation of our workplace and study facilities.

8. FINAL REMARKS AND IMPLICATIONS

Finally, we have detected, as predominant tendencies, lines of study oriented to the complex multi-layered resolution of the synthetic city model/ analytical urban model, with the purpose of recreating present or future urban scenes, with possibilities for representing and analysing several kinds of impacts [24, 25].

These studies propose improved instances oriented towards the generation of synthetic, analytical and interconnected virtual models where 3D information updated in real time, can be linked. We have particularly acknowledged the advances and setbacks of studies on automated, real time construction of 3D models interconnected with the development of 3D GIS.

We have also noticed the way cross relations among 3D CAD, 3D GIS technologies, photogrammetry, pseudo-realistic interfaces, VRML and communication and information technologies are established and reformulated, with instances of visualization and real time interaction. These productions interconnected online would be able to detect a sequence capable of linking directly 3D information captured by high quality remote sensors. These sensors feed and update the database and statistical resources obtained through 3D GIS, which are compatible with standard 3D modelling, capable of generating consistent and efficient models, and with the possibility of specific resolutions. Thus, it would be feasible to associate precise geometric information obtained through 3D CAD, linked to data obtained through 3D GIS that can be renewed and stored easily.

All these studies point to directions that will allow users to interact with the models since they make participation easier, as well as to receive and establish links among multidisciplinary knowledge from several fields, such as remote sensors, photogrammetry, geo-computation, graphic computation, virtual reality, artificial intelligence, architecture and environmental and urban planning.

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