LOW-COST DOCUMENTATION OF BRAZILIAN HISTORICAL TOWNS: INTEGRATING PHOTOGRAMMETRY TO VIRTUAL REALITY AND WEB-BASED APPROACHES

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ABSTRACT

This is the final report of the binational project to develop low-cost methodology for the documentation of urban ensembles in developing countries, introduced in Vienna, 1996 [LANDES1996]. Since that congress many important improvements and changes have been made in the system's workflow and use cases, profiting from new technologies that became available since then. A multi-purpose database was formed using the analog cadastre of the city of Laguna as its basement, IPHAN's Real State Inventory of the Urban Site, planimetric map sheets and 3D data acquired throughout hybrid photogrammetric approach. Photomodeler was introduced to plot the images. The application's knowledge base was modeled following OO design patterns and implemented with a platform independent, object-oriented programming language. Thematic and geometry data were stored in RDBMS and ORDBMS databases so that the system could achieve the desired interoperability.

The result is a complex system that promotes the integration of photogrammetric content, thematic data that regard cadastre and urban historic ensembles and the urban planning process.

1 INTRODUCTION

For many years only major isolated monuments, mainly of outstanding cultural value, were subjects of documentation and preservation procedures. However, it was realized that it is very difficult to represent and document the value and characteristics of a monument, without a co-joint presentation of the environment it is inserted in. As a matter of fact, if the surroundings („the context“) are impaired, even highly valuable historical monuments lose part of their historical meaning.

ICOMOS General Assembly in Washington (1987), concerning the conservation of Historic Towns and Urban Areas, had pointed out the need for documenting the area before any intervention. Moreover, the Committee suggests applying photogrammetric techniques to accomplish this difficult task. Nevertheless, some questions still open:

- At what cost?
- At what accuracy and precision levels?
- How would this information be stored, retrieved and under which circumstances may it is shared?
- Who demands this information? Who will pay for that?
- How should it be displayed?
- If these questions do not have a standard answer for monuments of outstanding value, which have been documented since decades, even worse is the situation regarding large urban ensembles.

This work addresses the issues presented above, with exception of *ii*. Good references to this last one can be found meanwhile in [HANKE], [HECKMANN1997], [DECHANT1998] and [PEIPE1999]. In addition, we want to represent, model and show this information as to make it understandable and useful for different categories of users, at different demands (conservation, urban planning, cultural tourism etc).

For five years a cooperation project between the Institute for Photogrammetry and Remote Sensing –IPF (Karlsruhe, Germany) and the Laboratory of Photogrammetry, Remote Sensing and Geoprocessing - LSFG (Florianópolis,Brazil) was started, aiming at the researching in the field of architectural photogrammetry for large building ensembles documentation. Developing the culture of monuments preservation in Brazil by means of introducing new tools for data acquisition and processing was also a main objective, that should be accomplished by a close joint work with the Brazilian IPHAN (National Institute for the Preservation of Historical and Artistic Heritage - the Brazilian government agency responsible for managing national heritage).

To reach our objectives we made use of state-of-the-art, freeware and low-cost technologies. Some of them are not yet enough mature, but presenting a shining promising future. They are:

- Java (RMI, JDBC, Swing etc): a pure object-oriented web-based programming language was necessary to manage this project's demands accordingly;
- VRML (ISO/IEC 14772-1:1997), to represent 3D objects and virtual environments;
- Java/EAI: this interface allows the communication between an external application and the virtual world displayed in a Web-Browser;
- Object-Relational Database Management System: PostgreSQL was chosen to manage the geometry database due to its flexibility and powerful features. The database implements important object oriented (classes, inheritance) and provides the user with a powerful extensibility mechanism;
- UML for system (software) visualization, specification, construction and documentation;
- Photomodeler: a softcopy analytic close-range photogrammetric software system, that enables the plotting of 3D textured models from convergent photographs. Attaching the raster image to the 3D-line model was an important issue in this project.

The data model associates information maintained by the IPHAN, the urban cadaster and additional geometric information of the façades that was acquired with a hybrid analog/digital photogrammetric approach.

The result is a 3D-IS that through the integration of the above mentioned technologies enables the user (by means of a Web-based client-server architecture) to:

- interact: a collection of sensors ("time", "proximity", "touch") enables the virtual world to react to events (key pressed, mouse clicked etc) generated by the user ;
- visualize: the virtual world brings 2D flat surfaces into life. Also a tourist sitting elsewhere in front of a computer monitor will be able to made a virtual trip to the city;
- navigate: different navigation paradigms are present in the application. Through them, the user is able to examine, fly or walk in the virtual reality model. Furthermore, it is also possible to customize user defined paths to be routed in the scene;
- scenario prediction and simulations: this is especially interesting when one wants to undergo a significant restoration in a monument or even the revitalization of a whole ensemble. Urban planners may find this specially useful to study the consequences of a new building in the historic site;
- query: there is a seamless connection between the 3D environment and the database, providing the means to query the multipurpose cataster of each building;
- time simulation: so far the information is available, a time simulation showing the changes in the monuments can be presented.

Next we are going through a description of the results against the objectives that were original purposed.

2 LOW-COST 3D DATA ACQUISITION

The cost was and is a very dominant figure in general. "Low cost" is obligatory in case operational tools have to be developed. [WALDHAEUSL1992] criticised this slow advance in mapping historical monuments. Interestingly, high tech leads to low cost [BAEHR1999]. This is different from what we knew in the past. High tech components are related to digital data processing (including imagery), digital data acquisition for instance by digital cameras, digital data processing and digital archiving and, finally, digital data distribution by Internet. All mentioned components today are much cheaper than any analogue tool.

Considering cost vs. spatial resolution and amount of data collected per camera shot for close-range purposes, hybrid systems are still some steps away from fully digital imaging ([PEIPE1999]). The Ektachrome EPR 64 film mounted on a PENTAX PAMS 645 provided us with a system resolution of the approximate order of 100 line pairs/mm. This was far better than the spatial resolution with which we configured the scanner to read the film transparencies (25.4μm x 25.4μm). Such levels of resolution in a 60 x 45mm format could only be achieved by high-end digital imaging systems, which still out of low-cost budgets.

Therefore, a hybrid process still highly recommended for this project, despite the difference between hybrid and digital has decreased since then. The investment in some professional (maybe metric) camera is still worthy, and a camera back chip can further be applied to transform an analog into fully digital camera.

For five years, the decision about which one would be better suited took into account that:

- films are cheap, stable and of great longevity;
- analog cameras are less expensive than digital cameras, if same properties (resolution, accessories, ...) are to be compared;
- with same lenses, analog cameras are able to register much more information than digital ones;
- very fine resolution of films, either spatial or spectral. Slow speed films (for instance ISO 64) for data acquisition permit registering of fine elements in the façade. Professional analog cameras yields many different exposure times

and shutter speed that, if combined with slow films enables the acquisition of photos of excellent spectral and geometrical quality;
- analog cameras capture large areas in one frame, thereby reducing handling costs.

The desired spectral and spatial resolutions where already raised by digital imaging systems, as far as one regards the documentation of large urban ensembles. Systems like Kodak DCS 460 [STREILEIN1998], Jenoptik Eyelike [PEIPE1999] have been successfully used in close-range photogrammetry for monument documentation. Spectral resolution has reached 48 bits, while spatial resolution resides between 3060x2036 till 6144x6144 for the cited equipment.

There are many reasons why fully digital data acquisition is looked forward. Among the main ones are:
- Faster: Data is acquired on-line and attending user demands. Even if a hybrid approach is adopted, many field surveys are necessary, once the quality of the photos can not be controlled in situ;
- Effective: User can control exposure, scale, amount of information per spot, overall quality;
- Manipulation. Digital data can be easily enhanced, compressed and manipulated for better analysis;
- Communication. Data can be transmitted on-line to a remote office. Further office processing can approve or refuse data. In the last case, a new exposure is requested to the survey team and the process is re-started. This is as easy as exchanging “Hellos” by e-mail;
- Storage: digital media demands less space than analog ones, and is in general easier to copy;

3 DATA STORAGE AND ACCESS

In our first approach (see [RENUNCIO1998]) we explored MS Visual Foxpro 5 and MS Access to form a distributed and heterogeneous Relational DBMS, managing information coming from the Municipality of Laguna and IPHAN, respectively. Using Foxpro’s internal programming language, we designed a graphic user interface. Data that was still in analog format could then be digitized.

Remote access to data was provided by means of Java RMI and JDBC drivers (Dyade’s RMIJDBC). Code was then written transforming the system into a multiplatform, heterogeneous, distributed environment, having data being accessed from remote computers through Java stand-alone applications or applets running inside a WWW-Browsers JVM.

In 1999 PostgreSQL was adopted to store and manage the 3D-multimedia files (VRML) coming out of Autocad and Photomodeler. PostgreSQL is an object-relational database that complies with SQL-92 specification, providing also a type 4 JDBC driver and ODBC connection possibilities. PostgreSQL capabilities were tested and then added as a valuable component of the whole system.

The *geometry* and *appearance* nodes of VRML-based files were syntactically and grammatically analyzed by a parser that accomplished the task of mapping these nodes into the database data structure.

4 INTEGRATION OF THE BUILT HERITAGE ONTO THE URBAN PLANNING PROCESS

One of the ambitions of the project was to break down the isolation that uses to occur between preservation of built heritage and city administration. This was accomplished adopting a catastral data model as the foundation for a parcel-based Land Information System, on the top of which we developed our built heritage IS. Additionally, the Complementar Law for Urban Control (Lei Complementar de Controle Urbanístico) of the municipality of Belém (Pará, Brazil) was interpreted and modeled to provide the guidelines for city planning and control.

This process made thoroughly use and took full advantage of object-oriented design patterns (polymorphism, inheritance, ...) and related technologies (visual modeling/UML). The OO model allowed the representation of knowledge existing in this complex multipurpose information system by means of concepts and the different relations they share [MARTIN1996].

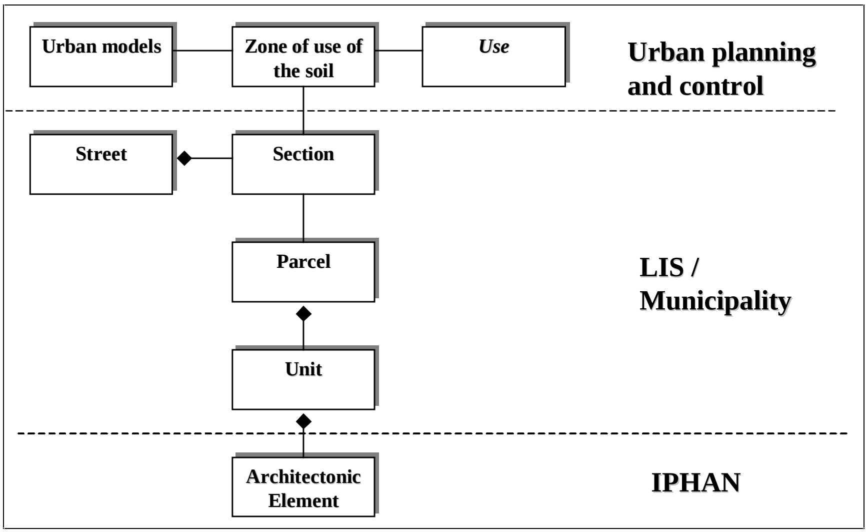

Figure 1 - A strategic view of the integration between the different information systems

Figure 1 shows a strategic view of the complete system. The term *Use* is an abstract concept that will be further materialized in the form of Service, Industrial Use, Commercial Use, Residential Use and so on. A *Use* can be further extended till specific uses are introduced. For instance, Hotel, as a kind of service (Service Use) could be described with properties like *number of rooms*, *sauna (yes/no)*. This is also the basement, for instance, to a tourist information system that could be queried by users through the Internet.

Street, Section, Parcel and *Unit* are concepts we borrow from the land information system. It can be further extended as in [JAEGER1998] and [DEGERSTEDT2000]. The *Unit* is of special interest, because it represents the building itself, thus the common element with IPHAN's IS.

While the land information system has the building as its lower level of detail, the information system for documentation purposes goes further. It holds data about every *Architectonic Element* that composes the monument. This *Architectonic Element* is again an abstract idea, which is further materialized by *cymatium*, *cornice*, *parapet*, *pediment* and so on.

5 COSTS ASSESSMENT

Since reaching lower cost than traditional analytic close-range photogrammetry was one of our main objectives, it is still necessary to present an evaluation of costs involved in data acquisition, processing and general system development. Table 1 summarizes these costs in two categories: fixed and variable (function of the amount of work) costs.

Table 1: Costs assessment.

Fixed Costs	**Amount (US$)**
Equipment: PC Pentium 166+ Pentax PAMS 645 Microtek Scanmaker 45t	12.000,00
Software: Photomodeler 3.1, Autocad PostgreSQL, Java SDK and extensions, Apache Web Server, Cosmo Player 2.1.1, Netscape Communicator	 5.000,00 0,00
Variable Costs	**Unit**
Ecktachorme EPR 64 transparency films, Development of films	4 buildings/film

No inference was made in Table 1 about the technical staff required and their respective costs. That is because we assume a system analyst, an architect and an assistant are already part of the existing staff in an institute that deals with the documentation and preservation of the built heritage.

Such institutes can now profit of the knowledge transferred to the Federal University of Santa Catarina by means of this project, to train their personal staff in acquiring and managing 3D data by means of low-cost architectural photogrammetry.

6 BINATIONAL TEAM WORK

The objective of the project was also to promote the exchange of knowledge and experience between German and Brazilian teams. The fruitful cooperation between the groups lead to the following accomplishments:

- education and professional update: the project performed close interactions with other activities developed by the institutions;
- training: there was a intense technology transfer from Germany to Brazil in the field of close-range photogrammetry. Several training courses in this field were given, as well as on-line support through the Internet;
- participation in international congresses and seminars: SBC/FIG (Rio de Janeiro), SBC/CIPA (Olinda), COBRAC (Florianópolis), Geodata Management (Karlsruhe), ISPRS (Vienna, Amsterdam).

The success of this first ”team play”, lead to the proposal and approval of two other projects that assess the use of low-cost, close-range photogrammetry. This time, the methodology is being tested in the industry (offshore platform) and as a tool to generate *Campi* information system for both universities.

7 CONCLUSIONS AND PERSPECTIVES

This project was specially designed to match developing countries’ needs. Brazil is now 500 years old since it was discovered by the Portugueses. Despite a lot of our built heritage has been lost, it is still a lot to be documented, restored and conserved. The last two task are cost demanding. Documentation is urgent, because it warrants that monuments can be restored when financial resources are made available.

But documentation is not a goal on itself. It should be seen as a subsystem, and included as a component of a wider project, where aspects like preservation, restoration, urban planning and cultural tourism are also concerned.

The methodology developed in this project does not demand a deep knowledge of photogrammetry from the customer. However, when it is needed it can be provided as a service by the university. The joint work between educational institution and public administration helps developing the culture of preservation. The project demands a technical staff composed of architects and preservationists, to determine surveying objectives; a computer specialist for digital data processing; and the help of an assistant for the field work. Most of these human resources are already present in our institutions.

We are looking forward for new developments in digital imaging systems to assembly large building ensembles. Digital cameras will provide architects and other professionals with an on-line imaging system, a key issue to low down the time to plot a built façade. Furthermore, real-time software based systems can also be developed to achieve even faster results by means of close-range photogrammetry.

On the other side is the laser scanning technique. Though it is still much more expensive, on the other hand it provides on-line 3D data with degrees of accuracy that around a cm [RIEGL]. The integration between close-range photogrammetry and laser scanning is a possibility that need to be considered when simultaneously documenting large buildings and small details on them [WEHR1999].

The statement “low-cost is not photogrammetry”, as we have heard sometimes coming from traditional surveyors, ignores that a costumer stands at the end of the line of every photogrammetric product. Whether it is photogrammetry, it is analog, analytic or digital this is for the user irrelevant. What the market demands are cost effective solutions, that are reliable, secure and fast enough to accomplish user needs for data. A key issue here is data accuracy: user wants the technology to be adapted to his needs and not adapt (read here “pay for”) himself to what technological advances can bring. For a discussion of the theme conservation x photogrammetry, please refer to [LAGERQVIST1999].

“Architectural photogrammetry” is a very limited concept in the context of analogue or analytical photogrammetry during the first eight decades of our century. In the digital age the situation has drastically changed. The term "documentation” has to be put in a much broader context. A geometrically “correct” plan of a building, for instance given as a line drawing, is not any more sufficient for describing the concept “documentation”. We have to quote [BAEHR1999] where these ideas have already been put down for the CIPA community. The traditionally weak outfit of financial support for “architectural photogrammetry” may be overcome by satisfying the demands of industry in relation to town planning, telecommunication, navigation systems, facility management etc. On the other hand, “architectural photogrammetry” will virtually vanish if no links to the mentioned areas are established.

At dynamically developing scenario, any applicant wants to show the capacity of the new tools. However, we should remember that the secret of final technical success requires standardisation, which means definition of standard products and standard tools and methods. For architectural photogrammetry based on digital procedures this has not yet been performed. Suggestions had been made for instance by [BAEHR1999] with respect to 3D-city models. The documentation of full urban ensembles in the above-mentioned way will yield value-added products. Planning, tax raising, and operating towns is one of the most important present challenges, especially in countries of high population growth. The documentation of historical towns has to join the community that faces the challenge to organise and administrate town in general. The documentation of historical buildings has to be defined in this context and must not play an isolated role.

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