DOCUMENTING ARCHITECTURAL HERITAGE IN BAHIA – BRAZIL, USING DIGITAL TECHNOLOGIES

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ABSTRACT:

This paper shows the experience that is being developed by the Laboratory of Computer Graphics applied to Architecture and Design (LCAD), at the Architecture School of the Federal University of Bahia (FAUFBA), in documenting architectural heritage in the Bahia state, in Brazil, using a set of digital technologies. The research is happening in Lençóis city, an old mining city, located at the Chapada Diamantina region, in the middle of Bahia state, distant 420 kilometers from the state capital, and in Salvador, the oldest city of Brazil, its first capital, and also the state capital. The Pelourinho, located in Salvador, is an impressive set of baroque constructions which lies at the historical center, where the city was founded. The Pelourinho neighborhood is considered World Heritage by UNESCO. The research aims to present a critique analysis of technological platforms, like Digital Photogrammetry, Digital Cartography, Spatial Databank, Geographic Information Systems, Three-dimensional Geometric Modeling, CAD technology and 3D Laser Scanning technology, for the apprehension, validation, and dissemination of these technologies against testing and reformulating the used methodology. Besides, it creates a digital iconographic databank of satellite images, terrestrial and aerial photographs, drawings and all kinds of three-dimensional geometric models, including urban cadastral plans, topographic surveys of the sites and its metadata. By the end of this project, it is expect that all this data and information will be available at the project website on the Internet. Finally, with this public divulgation of this architectural heritage, we hope to contribute for its preservation and call attention for the urgency of a heritage education.

1. INTRODUCTION

This paper shows concisely two experiences on heritage documentation using a set of digital technologies in developing phase, in Bahia state, in Brazil. This research has been made by the Laboratory of Computer Graphics applied to Architecture and Design (LCAD – Laboratório de Computação Gráfica Aplicada à Arquiteura e ao Desenho), at the Architecture School of the Federal University of Bahia (UFBA). The first experience was in Lençóis, a town located in the Chapada Diamantina region, in the middle of Bahia state, distant 420 kilometers from Salvador, the state capital. The second is in Salvador, the oldest city of Brazil and its first capital.

1.1 Lençóis

Lençóis is an important historical site that was raised and consolidated about the middle of the 19th Century, when diamond mines were found in that region (BAHIA, 1980). The town was developed in the narrow valley of the Lençóis river, located directly on the sandstone, a sedimentary rock. It had a fast and exuberant development and it became the second most important town of the State, at that time. Soon, the mythic diamond reserve's exhaustion caused its decay, and the town grew down. The economic decline caused a population exodus that was probably the reason of the old housing preservation.

The sprouting of a new tourism based economic cycle in the Chapada Diamantina, urges the extensive documentation and preservation of this precious and delicate urban tissue. As well as Lençóis, there are several others cities in that region, like Igatú, Andaraí, Mucugê, Palmeiras and Rio de Contas, which keep yet more important architectural heritage. For example, Igatú's diamond seekers district is now a ghost neighborhood. Even the roofs, doors and windows of these houses no more exist. There only remains the cold stone walls covered by lichen and the shadows of a vivid past. These historical places must be preserved, and an important step toward this direction is its documentation.

Today the Chapada Diamantina region is world-widely well known for the dramatic beauty of its natural landscapes, and for being a fantastic place for adventure sports, rather than for its historical cities, or its cultural and architectonic heritage.

1.2 Salvador

Salvador da Bahia, is a historic city with 2.7 million inhabitants, located in a peninsula on the Atlantic coast in the northeast region of Brazil. Salvador was the first city in Brazil and its first capital too. It was founded by Tome de Souza, the first General Governor, in 1549. Initial it was located in a strategic place, in the All Saints Bay (Baía de Todos os Santos), on the top of a scarp of the geological fissure that origins the bay. A place with painful accessibility, but very good for defense.

The colonial city was constructed on a plateau on top of the scarp, and the harbour, at the bay, on the graben. This situation originated two places and the expressions: lower city e upper city. Around the governor's house, and the municipality square, the upper city was raising and forming an impressive baroque architectural set. On the harbour, successive landfills were made conquering land from the sea, and some beautiful buildings were raised. Due to its powerful commerce, Salvador was for many years the most important city in the Americas. During the colonial period, Salvador was the capital of Brazil and the most important center of the sugar cane industry.

With the decay of the sugar cane cycle, and, the transference of the capital to Rio de Janeiro, in 1763, Salvador lost its status and begins a stagnation process. Due to the strong slave presence during that period, Salvador has a strong African cultural influence that is notable in many ways, like its typical cuisine, folklore, arts (dance and music), besides religious and spiritual practices.

The lower city and the upper city conserve their colonial bucolic affair until the beginning of the 20th Century, when the modern urbanism started, the city had 120 thousand inhabitants.

The modern city shelters yet other architectural sets, and a large number of isolated buildings, with meaningful cultural and historical importance. One of these sets is the Pelourinho neighborhood, a "city within a city," which is located at the historical center, where the city was founded. This impressive set of baroque constructions, with its architecture from the 17th and 18th centuries and its cobblestone streets, are considered the largest colonial set in the Americas and figure at the world list of UNESCO as humanity heritage.

1.3 Lençóis Project

The documentation project was named Lençóis Project because it begins at this city, but Lençóis and Salvador are only the pilots of this project. Besides the previously named cities of the Chapada Diamantina region, there are many others important historic cities in Bahia, like Cachoeira and Porto Seguro, for the example, that will be considered.

Sidely with the production of the documentation data, this project intends to divulgate this precious heritage, through publishing its photographs, orthophotos, data and geometric models, in books, inventories, catalogs, magazines, journals and the Internet. The LCAD intends that the project data collection will be available to be used by architects, researchers, professors, students, even tourists and travellers.

Thus, these are the project purposes:

- To present a critique analysis of the technologies and software used, for the apprehension, validation, and dissemination of this technologies against testing and reformulating the used methodology;

- To create a digital iconographic databank of satellite images, terrestrial and aerial photographs, drawings and all kinds of three-dimensional geometric models, besides urban cadastral plan, topographic surveys of the site and its meta-data. All data and information will be available at the project site on the Internet;

- To form and qualify personnel for the employment of technologies, such as: Digital Photogrammetry, Digital Cartography, Spatial Databank, Geographic Information Systems, Three-dimensional Geometric Modeling, CAD technology and 3D Laser Scanning technology, and

- At least, but not less important, there is the divulgation of this architectural heritage, as a contribution for its preservation and call attention for the urgency of a heritage education.

The project has no specific subvention or grants for the field works. Only two or three scholarships, and it has been developed with the collaboration of some volunteer students of the Architecture School of the Federal University of Bahia, Brazil. And it had received some specific help from time to time, that will be registered soon.

2. ANTECEDENTS

The state of Bahia, and more specially, the city of Salvador, are known internationally for the beauty and richness of its historical and cultural heritage, and also for the wideness and importance its architectural heritage. The colonial group of houses of the Pelourinho, the palaces, churches, convents, monasteries, fortifications, the sugarcane factories on the Recôncavo Baiano, the historic cities of seaboard, like Porto Seguro or still the cities in the heart of the country, like Lençóis and Rio de Contas, are incontestable proofs of this cultural heritage.

Therefore, Bahia was a pioneer in large initiative on documenting its cultural heritage. In 1974, it was created the Inventory of Protection of the Cultural Collection of Bahia, called IPAC (Inventário de Proteção do Acervo Cultural da Bahia), which divides the state in five regions, for inventory purpose. This work was sponsored by the Bahia State Government and it was published in six books, printed in black & white. The first one was finished in 1975 (BAHIA, 1975).

Another pioneer initiative in 1970s, was the surveying with short range photogrammetry of the ruins of the Garcia D'Ávila castle (OLIVEIRA, 1979), also known as Casa da Torre (House of the Tower). This construction gives name to one of the most famous place in Bahia, the Praia do Forte beach.

It is unnecessary to say that these works were made using traditional techniques and without computer aids. Despite of this important efforts in documenting this heritage, the IPAC has a comprehensive collection, but it only represents the first step towards a systemic knowledge at this heritage and, it is insufficient for its studying and effective protection (BAHIA, 1980).

In spite of the recognized importance of this architectural collection, still unique and significative, alone, has proven to be insufficient for guarantee its preservation, for its wideness, and in some cases, by the abandonment they were submitted during many years, except for some rare exceptions. So, it is important to perform an extensive documentation of this architectural heritage, not only to preserve its memory, but also as a safeguard in case of any kind of accidents.

This documentation project with digital technologies was proposed as a pilot of a huge project that aims to explore the potential of these technologies, in documenting meaningful buildings and sets of buildings in some of Bahia's historic cities, and make this database available for research and others applications.

It is important to point that this is a pioneer work in Brazil, and these kinds of data are inexistent for historic brazilian cities, even for the famous ones, like Ouro Preto, in the state of Minas Gerais or Parati, in the state of Rio de Janeiro. The cities of Lençóis e Salvador were chosen to start the project.

The Architecture School of the UFBA has tradition and a precursor job in this field, in conservation and restoration of

monuments and historic sites, through enterprises like the Center of Studies of Architecture of Bahia (CEAB), since the 1960s and the Course in Conservation and Restoration of Monuments and Historic Sites (CECRE), which is supported by UNESCO. For instance, with Lençóis Project, all of the initiatives in heritage documenting in Bahia, mentioned before, contributed with its professors.

3. TECHNOLOGICAL APPROACH

For the project purpose, documentation is considered as a single process that involves data capturing, handling or processing, indexing, storage, recovery, management, availability and the distribution of graphics and non graphic data and information, about the buildings, for all kinds of uses.

In addition to the plain applications usually made, the architectural documentation plays an essential role in preserving the memory of this documented heritage set. This is vital aspect, due the impossibility of physically preserving all significant examples. Factors like accidents, usury and abandonment have contributed to damage significant ones.

For the urban and architectural documentation purpose several digital technologies have been tested and used in this research, like:

- Topographic Automated Survey;
- Digital Cartography;
- Digital Terrain Modeling;
- Digital Photogrammetry;
- Spatial Databank;
- Geographic Information Systems;
- Three-dimensional Geometric Modeling;
- CAD technology, and
- 3D Laser Scanning.

3.1 Lençóis

The field action were planned taking as a "start" point an existing city plan that was supplied by the water and sewer Company. This plan allows pick up a set of points from the contour curves, to make the DTM, and the geometric model of the road structure of the site, over which were be placed the geometric models of the buildings.

The first mission on field, occurred in May of 2004, employing a group of 30 people, among professors and students, with the purpose of collecting the first data set, which were used as a database for the project.

One activity consisted in indexing photos taken of the buildings, simultaneously with the measurement of their façade width, or the land parcel. These data were important for the restitution of the photographs. Then, some sketches of the streets were made with its grades, for the assembly of the squares elevations and the reference plan. Once these data sets were processed, the orthophotos and restitutions drawings were generated, as seen on Figure 1. Each one put side by side to generate the square elevation.

Figure 1. Lençóis: photo, orthophoto and drawing

At the same time, another activity took place. It was the filling out of the inventory report called INBI-SU, for about 60 buildings of Lençóis' historic city center, in addition the schematic survey through direct measurement.

Finally, the third field activity was the topographic surveying, with a total station of a previously defined area, including five closer squares and nine other partially contiguous, including street widths, buildings and parcel widths, façades or roof ridge heights. All of this, to support the geometric modeling of the buildings and to proof-check the existing city plan. So, the RN transport and the UTM coordinates were made using geodesic GPS receivers.

Recently, other field missions were made to fulfill and amplify the data collection, including 3D measured sketches for modeling the volume of these buildings, as shown in Figure 2.
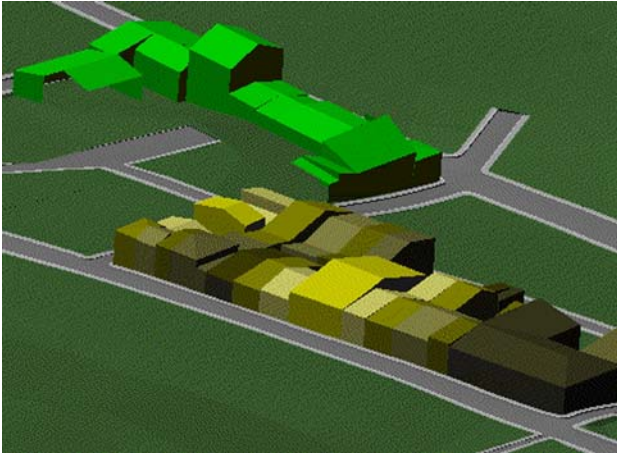
Figure 2. Lençóis: road structure and geometric models of the buildings

For some buildings that have the register drawings, there were made the detailed geometric models, such as the Church of Nosso Senhor dos Passos, as shown in Figure 3. This model is available in VRML format.

Figure 3. Lençóis: Church of "Nosso Senhor dos Passos", in VRML format

The work was done using AutoCAD 2000 for modeling the constructions and Easysite 2.0 for modeling the terrain and road structures, and PhotoModeler Pro 4.0 for the buildings' façades and orthophotos generation and then AutoCAD 2000 for vectorizing these orthophotos. Adobe Photoshop was used to retouch and clean the orthophotos.

The urban site relief, the road structure and buildings of some squares have been modeled. The orthophotos of some buildings' façades were generated and then vectorized. From the façade's drawing and its concerning orthophotos some square elevations of the city were mounted.

Three-dimensional geometric models of the urban site and its buildings were generated, and the digital restitution, through photogrammetry, of the buildings façades of the Historic Center of Lençóis was made.

The final products obtained were:

- The Digital Terrain Model of all urban site of Lençóis;
- The Three-dimensional Geometric Model of part of the road structure;
- The Three-dimensional Geometric Model, artless, of some squares with its buildings;
- The orthophotos (raster format) façades of some buildings;
- The register drawings (vector format) of these façades, and
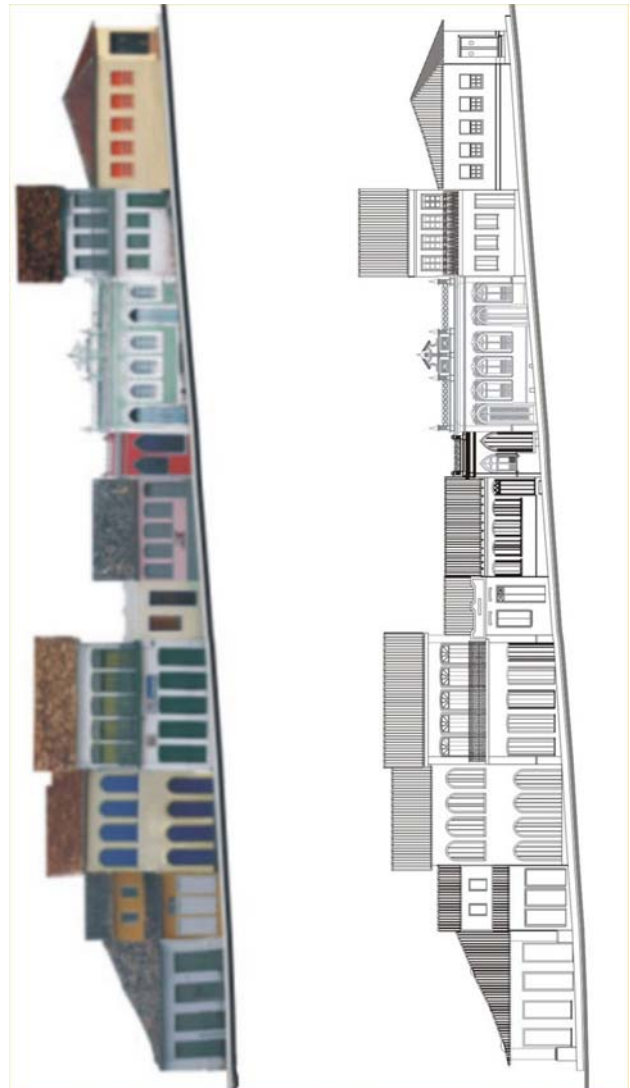- The elevation of some squares in raster and vector format (Figure 4).

Figure 4. Lençóis: square elevation on "Avenida Sete de Setembro", orthophotos and drawings

3.2 Salvador

The initiatives on documenting Salvador began with Digital Protogrammetry on an isolated monument, like the "retabulos" of the Basilica Cathedral of Salvador (GROETELAARS, 2004b) and register of the Chapel of "Nossa Senhora de Escada", constructed about 1536 (GROETELAARS, 2004a).

Following, it was initiated the project "3D Virtual Pelourinho: a laser scanning approach", with the goal of registering this neighborhood with this technology (CHUDAK and AMORIM, 2004). This project began during the 1st International Conference on 3D Laser Scanning for Heritage Documentation (1st CyArk), which happened, in July of 2004, in Salvador.

This conference focused on showing and discussing up to date technologies and methodologies in architectural documentation and similar applications, from important international research centers, in the use and development of 3D laser scanning technologies. The conference held talks given by recognized experts, and it was organized to support the conceptual, theoretical, technological and practical knowledge for the surveying work on Pelourinho. There were professors, students and a large variety of correlated professionals.

The process generates a High Definition Documentation (HDD). The main objective of this kind of register is to promote wide and precise documentation of this heritage, an essential way for promoting protection, comprehension of its historical significance in addition of conservation and restoration applications.

This technology is also called High Definition Surveying (HDS), which utilizes a 3D laser scanner to capture the physical features of a site and displays them in a "point cloud" model, where each point represents the precise location of where the laser beam was reflected at the object surface (BALZANI *et al*, 2004). When high resolution photography are integrated with the laser scanning, providing additional material and chromatic information to the 3D point cloud model, a new and very simple kind of 3D geometric model. During the event were surveyed part of the "Terreiro de Jesus" square and its surroundings and the interior of the San Francisco Church, in the Pelourinho area (AMORIM and CHUDAK, 2005).
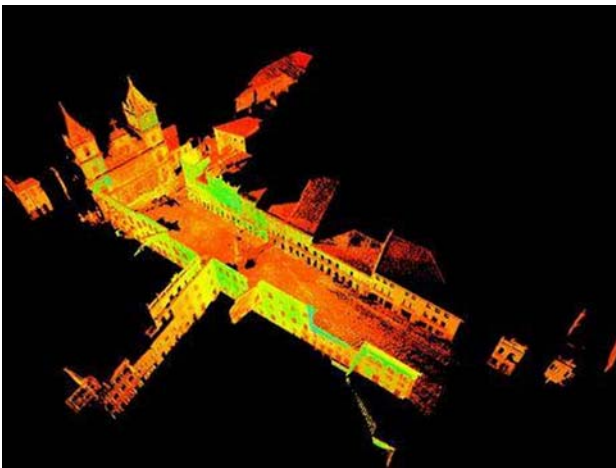

Figure 5. Salvador: Cross of San Francisco area, the church on the upper left corner

There were chosen two spaces for the field practices: one at open sky and another inside of a building. The places were inside the "Terreiro de Jesus" square, located in front of the San Francisco Church, known as San Francisco's Cross. The façades of the buildings in those places were scanned, as shown in Figure 5, and the interior of main nave of the church, as shown in Figure 6.

The surveying was made by professors of Ferrara University with technicians of Santigo & Cintra staff, besides professors and students of the Federal University of Bahia.

It is important to remember that this survey was a first experience, and it doesn't have the completeness or the richness of the survey that was made for Istanbul Hagia Sofia by Bianchini and Paolini (BIANCHINI and PAOLINI, 2003).
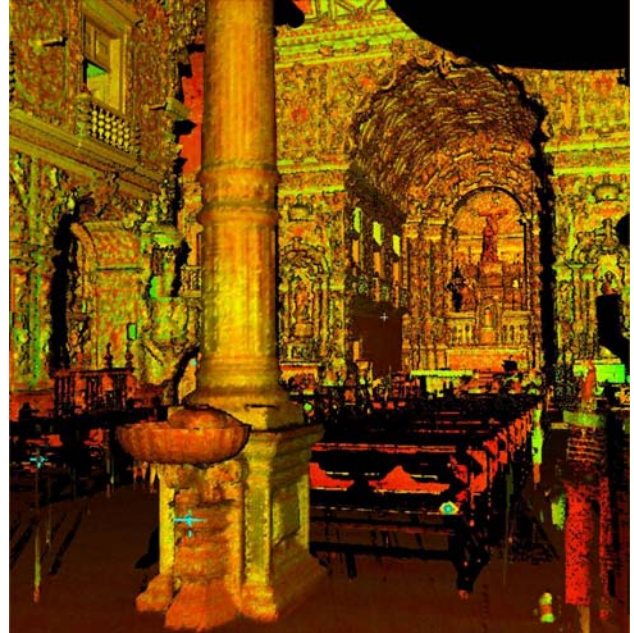

Figure 6. Salvador: main nave of San Francisco Church, in rococo style

The used hardware was the Cyrax 2500 with a sampling rate of 1000 points per second, with a range of 100 meters, covering a solid angle of 40 x 40 degrees. The software used for the scanner control and for processing the point cloud was the Cyclone 4.1.

Finally, the point clouds were processed, thus generating the products that can be seen at the Cyark website (http://www.cyark.org). On these images the accuracy and detail richness of the survey could be seen.

Now a day, the LCAD is currently surveying and restituting this area with digital photogrammetry, and some façades are shown on Figure 7.

4. CONCLUSIONS

This paper shows the surveying phase and the first results and products of the project. Although the complete restitution of the historical façades and the three dimensional geometric models have not been concluded, the tools and methods used have revealed to be adequate to the purpose and the resultant models constitute an important document, beyond an instrument of study and apprehension of the urban reality. But, the work continues persecuting its purpose.

Figure 7. Salvador: orthophoto and drawing of a "sobrado"

All of the technique and technologies that have been used reveal themselves useful and suitable, and were used in a complementary manner. In few aspects or cases, only one technology could be chosen as unique, such as non planar or very detailed forms for which is suitable the use of 3D laser scanning technologies.

Finally, at the moment the LCAD is implementing the first version of the website of the project, and its next phase will comprehend the data modeling of the Information Systems of these surveyed sites.

REFERENCES

AMORIM, A. L.; CHUDAK, D. *Patrimônio Histórico Digital: documentação do Pelourinho, Salvador – Ba, com tecnologia 3D laser scanning.* in: Congresso Iberoamericano de Gráfica Digital. Lima, 2005.

BAHIA, Inventário de Proteção do Acervo Cultural da Bahia. Monumentos do Município de Salvador. V. 1. Salvador, 1975.

BAHIA, Inventário de Proteção do Acervo Cultural da Bahia. Monumentos e sítios da Serra Geral e Chapada Diamantina. V. 4. Salvador, 1980.

BALZANI, Marcello, et al. *Laser Scanner 3D Survey in Archaeological Field: the Forum of Pompeii.* in: International Conference on Remote Sensing Archaeological. Beijing, 2004.

BIANCHINI, Carlo; PAOLINI, Marinela. *Rilievo per il restauro e la messa in sicurezza de Hagia Sophia a Istambul: prime sperimentazioni.* in: **Disegnare**, Roma, anno 14, n. 26, p. 20-31, Luglio 2003.

CHUDAK, Daniel; AMORIM, Arivaldo. *Notes of 1st International Conference on 3D Laser Scanning for Heritage Documentation*. Salvador, 2004. (snt)

GROETELAARS, N. J.; AMORIM, A. L. *Levantamento Fotogramétrico Digital da Capela de Nossa Senhora da Escada*. in: CONGRESSO IBEROAMERICANO DE GRÁFICA DIGITAL. São Leopoldo, 2004.

GROETELAARS, Natalie Johanna. *Um estudo da fotogrametria digital na documentação de formas arquitetônicas e urbanas*. Dissertação (Mestrado em Arquitetura e Urbanismo) – Universidade Federal da Bahia, Faculdade de Arquitetura, 2004.

OLIVEIRA, Mario M. Na Bahia uma experiência de fotogrametria de monumentos. **Planejamento**, Salvador, v. 7. n. 1, p. 5 –69, jan./mar. 1979.