Virtual Heritage Reconstruction: The Old Main Church of Curitiba, Brazil

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ABSTRACT

The "virtual reconstruction of vanished heritage" is now a widespread practice around the world, due to the growing capacities of digital media to replicate and interpret lost or inaccessible cultural sites. Each effort within this growing industry has its unique technical, artistic, and interpretive challenges. This paper describes the process that led to the virtual reconstruction of the Old Main Church of Curitiba, a demolished structure once located in Southern Brazil. Because there was only a single reliable image of the building and no archaeological data or architectural drawings available, the central focus of the project concerns the documentary and interpretive processes needed by the situation, involving historical research, photogrammetry and computer modelling. The key image was submitted to a digital rectification based on the dimensions of a surviving clock originally positioned in the front façade of the church, generating an orthophoto that allowed retrieving the probable original dimensions of the vanished building. Additional data originated from old paintings, drawings, historical maps, and analogies with existing contemporaneous buildings.

INTRODUCTION

The origin of the Old Main Church of Curitiba goes back to the 16th Century, when the community started raising a new building to replace a crumbling wooden chapel. From the outset of its construction up to the year 1876 when its demolition started, the most significant events of local history occurred inside the church's walls. However, in spite of its eminent role in local events, the available sources about the formal features of the church were reduced to some exterior images and a few written notes left by European travelers. A remaining clock, unique surviving piece of the front façade, and one photograph taken in April 1870 were the central elements in the process to retrieve the dimensions of the demolished church.

1. CONSIDERATIONS

The first task for any virtual reconstruction is "to gather data of existing conditions" (Addison, 2000, p. 1). Architectural drawings of the Old Main Church of Curitiba were not found and no archaeological excavation was conducted on the site. Most of the building images consist of paintings and drawings, which show the building formal evolution in time but are unreliable to supply precise dimensions.

Among all types of historical images, photographs represent a dependable source for documenting building dimensions and formal features, and its use as an architectural data provider is not a recent approach. Historically, photographic methods hold an established tradition for building documentation, as demonstrated by the Meydenbauer Archives in Germany[1].

Different from a three-dimensional model drawn by hand where lines may be freely adapted to match any desired position, a digital model demands precise coordinates. The necessary dimensions may be acquired from images by applying a photogrammetric process, which is "an indirect technique to acquire 3D geometric data without touching, but using images of the object" (Wiedemann, 1997, p. 1). Fortunately, the amount of data acquired from photographs exceeds information derived from drawings, and the task of data acquisition and three-dimensional digital modeling is a "reverse engineering" process (Albertz and Wiedemann, 1995, p. 1)[2] based on an orthophoto of the building[3].

A special type of photogrammetric application refers to situations where a single image comprises the unique source of

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1 Dating from 1885 to 1920, the German collection presents metric images of about 2,000 buildings (many of which have been destroyed during and after the Second World War) and places in 20,000 negative plates (Wiedemann *et al.*, 2000). It represents the introduction of architectural photogrammetry by the civil engineer Albrecht Meydenbauer (Wiedemann, 1997).

2 Albertz and Wiedemann (1995) present a diagram with the digital photogrammetric process data flow in a CAD system, from image acquisition to object reconstruction.

3 Fowler (1998, p. 1) states that an orthophoto is "a fully rectified base map with x and y (or east and north) coordinates for each pixel. This mean that if we measure distances, areas or angles on the image they will be correct".

information about a historical building[4]. Bräuer-Burchardt and Voss (2001) provide a list of several researches proposing mathematical models and algorithms to solve "the problem of metric reconstruction using single images" (idem, 2001, p. 1), and in such cases, a-priori knowledge about usual architectural properties such as "linearity, parallelism, perpendicularity, and symmetry" (ibidem, 2001, p. 11) allows one to complement missing elements as the camera parameters and reference points in the building[5].

Even though digital rectification relies on mathematical equations and geometric rules, the user interpretation plays a decisive and variable role in the procedure. Viewing the process through a logic perspective where a unique solution is suitable for each case is a wrong assumption, as reality delineates an interpretative operation with variable results. Albertz and Wiedemann (1995) comment that "each photogrammetrically derived plan is the result of an interpretation process, where the complex image information is reduced to some simple lines" (idem, 1995, p. 6). Schuhr and Kanngieser (1999) recognize that a "real obstacle for a broad application of single images in Archaeology is the competition between objective photogrammetric mapping and subjective Archaeologic interpretation" (idem, 1999, p. 2). The following is an account of the interpretive decisions and process that generated the probable original dimensions of the Old Main Church of Curitiba[6].

2. GEOMETRICAL REFERENCES

When the building under analysis for an architectural image rectification no longer exists, another source is needed to supply the minimum references to the photogrammetric process[7]. If parts of the building still exist, direct measurements in the façade elements provide scale references, but for the Old Main Church of Curitiba the only existing measurable reference was the clock that appears in the right tower of the church in the historical photograph. As the clock frame appears partially hidden, the dimensions of the internal white ring were chosen as the horizontal and vertical references for the front façade rectification.

In the lateral façade the reference derived from the front façade, as no other data source was available to provide the necessary references. Wiedemann *et al.* (2000) addresses the problem found in situations where "the required data to extract 3D information directly is not available," and considers the use of "additional techniques" as a source of "indirect 3D information"[8]. A historical map from 1857 provided the dimension for the depth of the church once the photograph does not show the ending portion of the wall. For the horizontal reference the average width of columns 'A' and 'B' was applied to column 'C' in the lateral. The necessary vertical dimension for the rectification derived from the projection of the internal white ring of the clock on the façade corner, 'D'.

3. RECTIFICATION PROCESS

The objective of the digital rectification is the production of an image "from which the measurements of the façade and architectonic details can be taken in a desired scale" (Hemmleb, 1999, p. 2). The selected tool to rectify the photograph was Photoplan[9], software which runs within AutoCAD. Photoplan does not require previous knowledge on photogrammetry and, besides providing a user-friendly interface, allowed to quickly test several geometric hypotheses on the image.

The next step aimed at selecting the most appropriate location for the reference points required by image rectification according to geometry in Photoplan. Geometric relations among the elements of the church came to be a major problem, as valid interpretations about the location of the points generated distinct results in the rectified images. For example, depending on the chosen set of points the two towers in the rectified image could have the same height or not. The positioning of the four points turned to be a major variable without historical sources to support any option and the solution needed to derive from the process itself. The most reliable alternative proved to be the placement of the reference points on the central frieze of the façade, clearly a horizontal line.

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4 Ogleby (1999) presents the virtual reconstruction of the ancient Asian city of Ayutthaya, and describes the importance of photogrammetric methods to generate data for digital models of vanished heritage.

5 Among the cited examples, Liebowitz *et al.* (1999) addresses the problem of data acquisition exclusively from photographs in cases where it is not possible to acquire any building reference measurements. Proposes algorithms for establishing data based on proportions and ratios, not on absolute scalable dimensions.

6 El-Hakim (2000) comments about diverse applications for computer reconstructions and concludes that no single solution can solve the technical necessities of all situations.

7 Hemmleb (1999) describes several possible origins for additional data.

8 Wiedemann *et al.* (2000) mentions the acquisition of the façade depth values by using the length of projected shadows.

9 Photoplan is developed by Kubit (http://www.kubit.de).

4. DATA SIMULATION

Heuvel (2000) defines photogrammetric processes that generate a CAD model as 'CAD-based', making a distinction between approaches with different automation levels. This research did not address automated methods, choosing to produce a 'vectorial representation' (Wiedemann, 1997) of the rectified façades of the Old Main Church through a manual edge recognition procedure in a CAD environment.

The rectified images did not provide all the necessary geometrical information to produce a complete set of elevation drawings of the church, as portions of the frontal and lateral façade were hidden or missing[10]. Barceló (2000) points out some issues related to information incompleteness in historical virtual models, affirming that the "archaeological record is most of the times incomplete," and even though some reconstructions consciously target an incomplete model, the usual approach tends to complete the missing historical data through "induction, deduction and analogy."

A method for data completion added information to the elevation drawings, originating from:

- Architectural plans and site measurements from churches with similar construction date and geographical proximity.
- Rectified image of one lithograph published by a local magazine (*Revista do Paraná*, 1887).
- Rectified image of a historical map (1857).

Comparing the dimensions of the church in the map with the drawings originated from the edge detection process, the difference between both is 60 cm, or 2.65% of the building width in the map. The total lateral length of the church was already based in the map dimensions. The obtained dimensions are very close to integer values of the 19th Century measurement unit: 10 by 17 *bracas*[11], or 22 m width by 37,40 m length which is concluded to be the probable external dimensions of the church.

CONCLUSIONS

The goal of the research, to determine the probable dimensions of the Old Main Church, was attained, even though it is difficult to define how precise the final results are in the absence of any substantial measured remnants of the demolished building. The process demonstrated that in image rectification cases when no archaeological remains or prominent architectural elements such as windows and apertures are available, minor elements may supply the necessary geometrical data. The digital model of the Old Main Church of Curitiba is a representation of "the building after a possible reconstruction" (Hemmleb, 1999, p. 5), and as such constitutes a "virtual representation of the reality and the product of an objective deduction process" (Wiedemann, 1997, p. 4), not a "subjective fantasy of the modeler" (idem, 1997, p. 4).

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10 El-Hakim (2000, p. 1) recognizes that "counting on images for modeling is limited because the features that can be extracted are usually fewer then the required level of details".

11 Braca is a linear measurement units used in Brazil during the 19th Century. 1 braca = 2,2 m.

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FIGURES

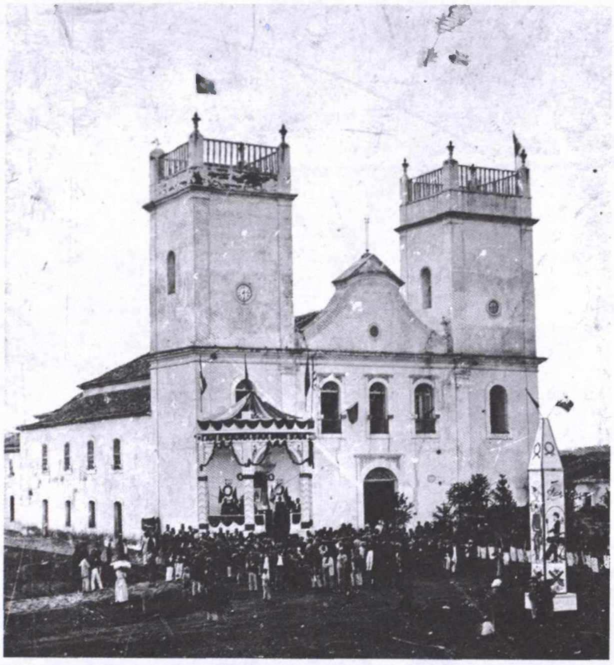

Fig. 1 – Old Main Church of Curitiba photographed by Adolph Volk in April 1870. (Fundaçao Cultural de Curitiba).

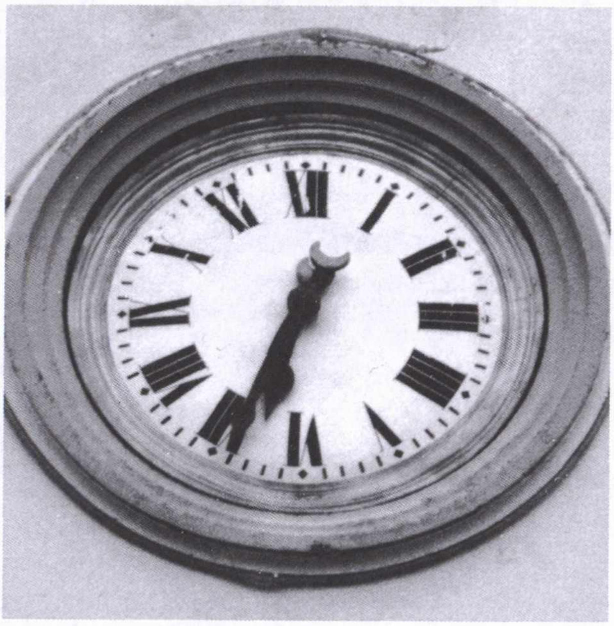

Fig. 2 – The remaining clock as it appears today.

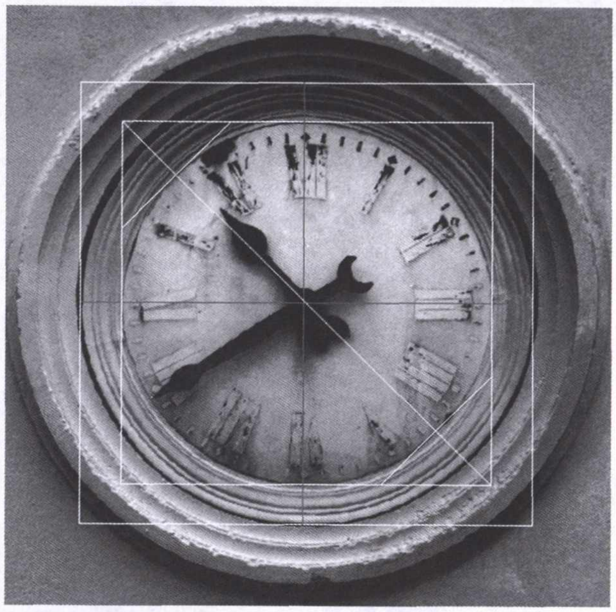

Fig. 3 – Rectified clock image (Composite after Suely Deschermayer).

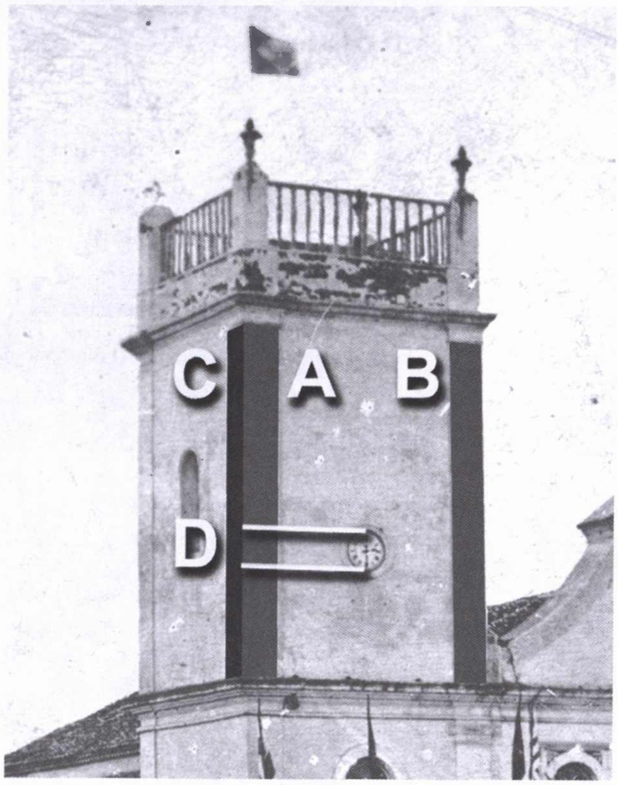

Fig. 4 – References for the lateral façade rectification.

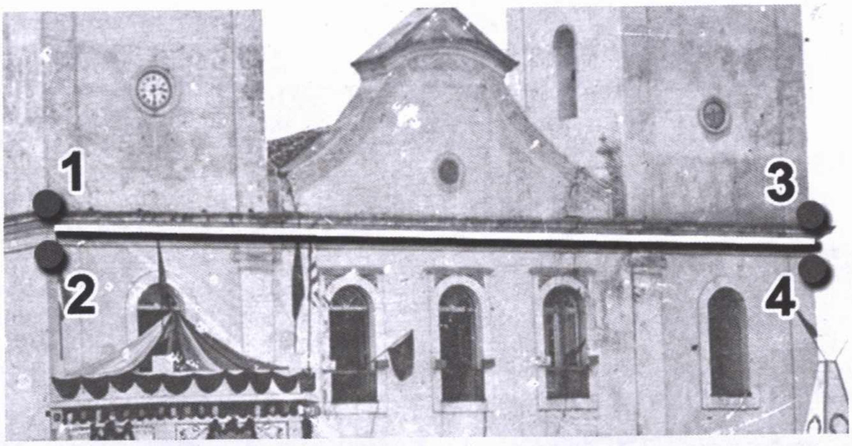

Fig. 5 – The selected horizontal reference and points on the frontal façade.

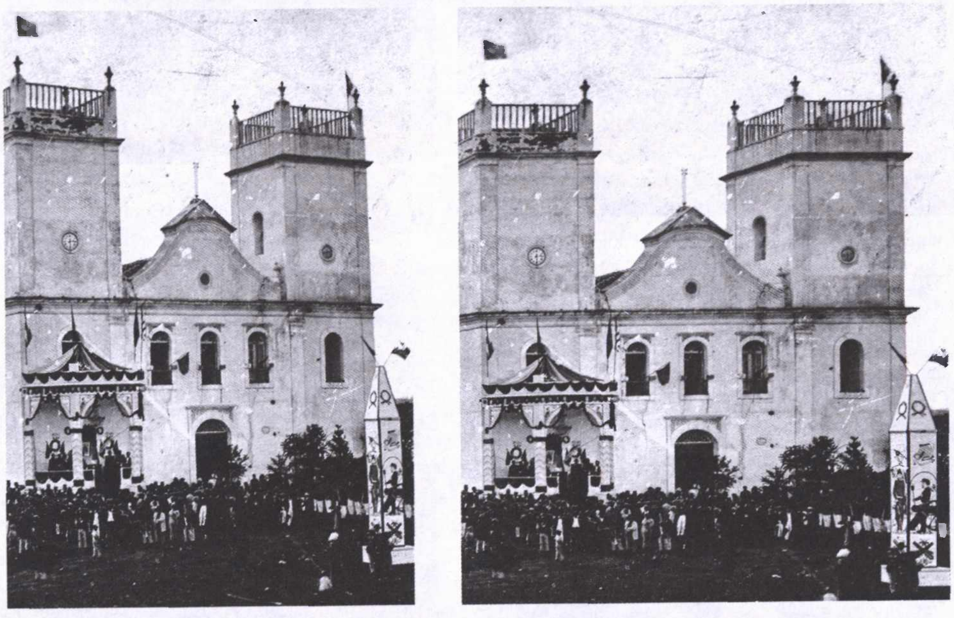

Fig. 6 – Frontal façade before and after rectification.

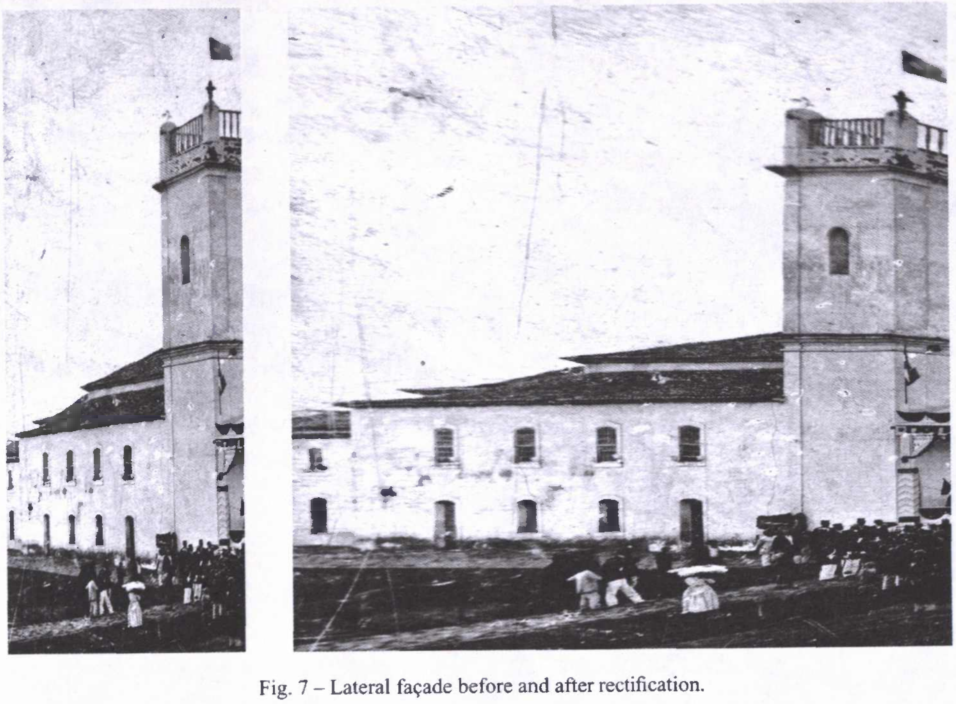

Fig. 7 – Lateral façade before and after rectification.

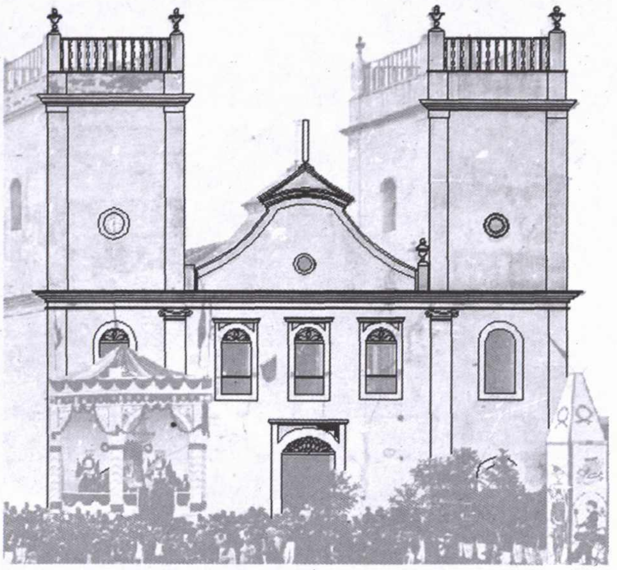

Fig. 8 – Edge detection over the rectified image of the frontal façade.

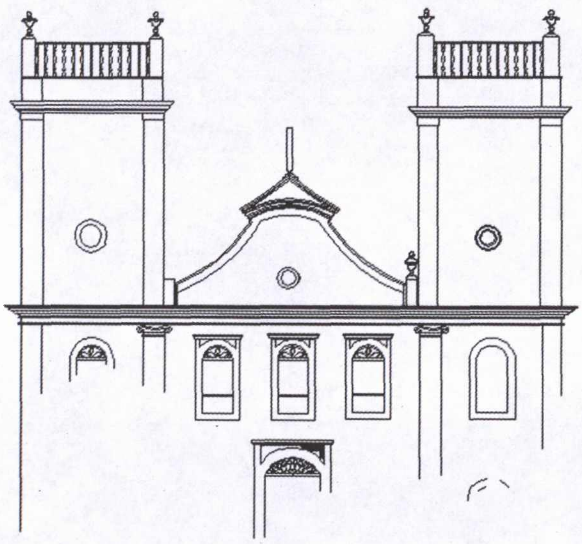

Fig. 9 – Edge detection of frontal façade.

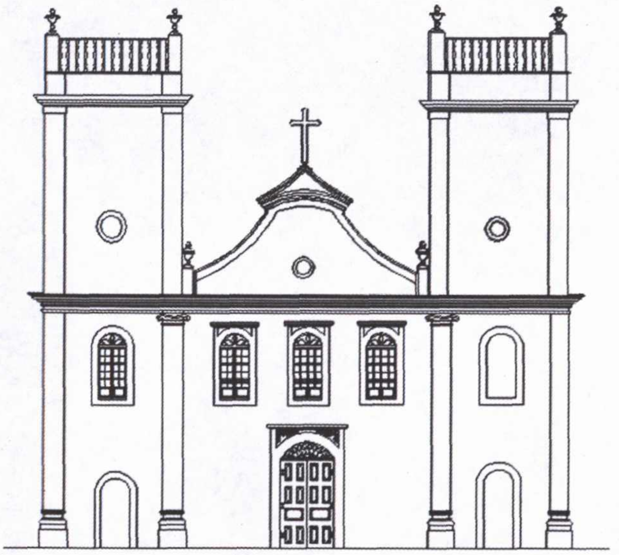

Fig. 10 – Frontal façade with additional data.

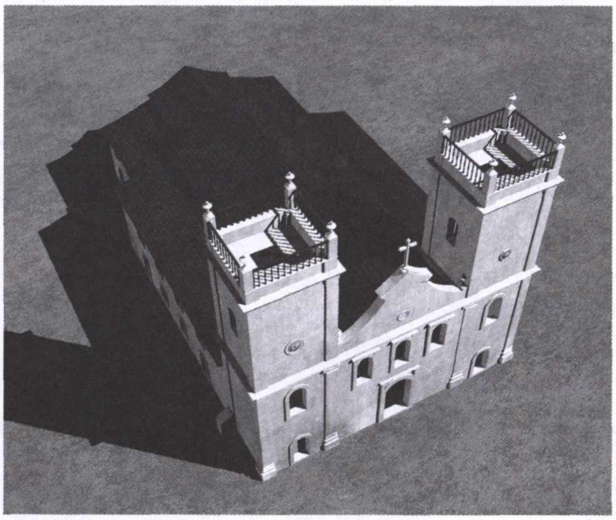

Fig. 11 – Top view of the digital model.

Fig. 12 – Frontal view of the digital model