

A Photogrammetric Project in Brazil: the Use of the PhotoModeler Software

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ABSTRACT

This abstract presents the results of an architectural photogrammetric project using the PhotoModeler software, developed and distributed by Eos Systems Inc., Vancouver, Canada. Prof. Dr. Klaus Hanke has already tested its accuracy at the University of Innsbruck, Austria. This project is part of a search for techniques allowing the recording and measurement of the Brazilian architectural heritage with costs compatible with the economic reality of the country.

Compared to the conventional photogrammetric procedures, PhotoModeler allows even greater reduction of time and costs for the production of models, since it does not require positioning and measuring of targets and stereoscopy to produce suitable photographic documents.

Tolerances observed are perfectly compatible with those accepted in architectural restorations and are not far from the accuracy obtained with metric cameras and following traditional methodology.

Two samples of Brazilian architecture of the colonial period have been chosen. The first one was the Santa Barbara Chapel at Santa Cruz Fortress located in Niteroi, Guanabara Bay. It is an example of the religious architecture of the Jesuit period, built in 1612, reconstructed by the Swiss military engineer Jacques Funck in 1763. It has suffered severe damages during the Navy Rebellion at the end of the XIX century. It has been restored in 1995.

The second example is the São Luiz Fort gate, also located in Niteroi. This gate is the only remaining of the old fort dated 1775.

1. Introduction

Architectural Photogrammetry is a powerful tool for the preservation of the built heritage unfortunately unknown of the majority of historians, architects and restorers.

Having photographs as originating documents, architectural photogrammetry permits that every detail of a building should be precisely documented. Accurate examination of each detail may be undertaken latter with no hurry, and this is not always possible when the measurements are

manually done. Thus, there is no risk of losing details that are kept preserved to the future.

Architectural photogrammetry is also an excellent method of:

- following-up restoration of buildings, allowing costs estimations more realistic than speculative;
- reduction of direct cost of the works, as well as some administration costs.

It also has the possibility of facilitate the follow-up and the evaluation of flow sheets.

For all these reasons ant with the intention of searching simpler, swifter and low cost photogrammetric methods involving less sophisticated groups of professionals, the authors decided to undertake this project using the Eos Systems Inc.'s PhotoModeler software.

2. The Models

The objects of this first experience are the Santa Barbara's Chapel at the Santa Cruz Fort, and the gate of the São Luiz Fort, both situated at Niteroi. These buildings are listed as Brazilian cultural heritage and are Brazilian Army historic monuments.

The local in which the Santa Cruz Fort was erected have been used in first place by the French admiral Nicolas de Villegaignon when he established in 1555 a fort to defend his positions inside the Guanabara Bay where, under the French King's orders he set a commercial operation to extract the brazil wood (*Caesalpinia echinata*).

The "Antarctic France", as they called this colony was active till 1567 when the French have been expelled by the Portuguese. From this date on the fort have been expanded, became the principal defense of the bay and the city of Rio de Janeiro and was named Nossa Senhora da Guia. In 1632 was named Santa Cruz da Barra Fort and have been restored. Restoration continued till 1870 and the blocks of rocks have been cut, numbered and shipped from Portugal.

Santa Barbara's Chapel is an example of the religious architecture of the Jesuit period. Erected in 1612 and restored in 1763 by the Swiss military engineer Jacques Funck. It has been attacked in 1893 during the Rebellion of the Brazilian Navy and its last restoration is dated March 1995.

The construction of the São Luiz Fort began also in 1567 with the installation of an observation and surveillance post to the battery of the Nossa Senhora da Guia Fort (Santa Cruz Fort). But the fort itself began to be constructed only in 1769 and have been concluded in 1775. Its command have been extinguished years later, and reactivated in 1863.

In 1913 a new fort was constructed on the upper part of the hill and the work have been concluded in 1918 and incorporated to the Barão do Rio Branco Fort, is situated at

the base of the hill. The gate is the sole construction remaining from the old 1775 fort.

3. Photographic equipment

Photographic equipment used was a Mamiya RB 67 ProS camera, medium format 6x7, with a Sekkor C 50 mm lens.

3.1 - Camera's characteristics

Focal distance $f = 50$ mm
 Aperture 1:4.5
 Format a x b mm = 68 x 56 mm
 Coverage angles a: 68.4°
 b: 58.5°
 Diagonal: 82.8°

3.2 - Camera calibration

Measurement of the coordinates of the chosen fiducial marks has been made at the Wild AVIOLYT BC2 analytical restitution equipment of Aerofoto Cruzeiro S.A., at Rio de Janeiro.

As the camera used is non-metric thus not having fiducial marks, the four corners of the negatives has been chosen as fiducial marks as per Kraus (1997).

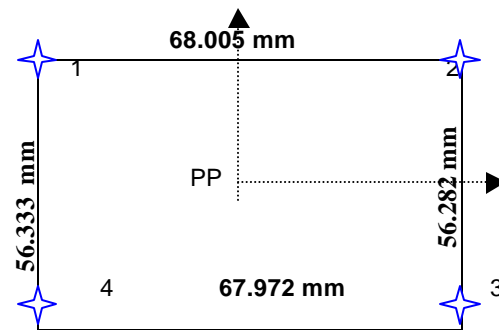


Fig. 1 – Negative format and Chosen fiducial marks

Fiducial marks coordinates (in mm)

Mark	X	Y	
Principal point	pp	33,994	28,154
	1	0,000	0,000
	2	68,005	0,000
	3	67,972	56,282
	4	0,000	56,333

The calibration of the focal distance and the determination of the distortions are not yet available.

3.3 - Photometry

We used a Minolta IV flash meter, with spherical diffuser to measure incident light.

3.4 - Film

KODAK TMX 120,125 ISO black & white negative film was used. It is a panchromatic fine grain film, high resolution and high definition. Four films were used, producing 10 (ten) negatives each.

4. Photography

4.1 – Method

At least three photographs were taken of each façade, one perpendicular to the object and the other two from each side making an angle of about 90° (see Chapter 5 “Taking Photographs” of the PhotoModeler’s user manual). The central photo was used to identify the object as well as to measuring, preparing sketches and the production of an orthophoto. From this experience the authors have noticed that the ideal is to take photos from a mid-height position adding others photos from higher and lower points when possible, to get a good overall coverage of the building, including the roof. Details in the façade, if any, may be covered with other series of photographs taken in close-up range.

4.2 – Control Measurements

It is very important to determinate the distances between two vertical and two horizontal points of the façade to avoid any doubts about the scale of the model. The use of a four meter stadia was very helpful.

5. Camera calibration

5.1 – PhotoModeler’s calibration method

The camera have been calibrated by means of the precise measurement of the focal distance - as we were using a non-metric camera – and recording the objectives resolution and its distortions.

5.2 – Digital import of the photographs

Photographs have been digitally imported to the software by means of a SHARP JX-610 scanner.

5.3 – Coordinates and fiducial marks

Coordinates and fiducial marks have been obtained by measurement undertaken on a monocomparator.

5.4 – Models

The photographs have been imported to the PhotoModeler software in high-resolution mode (600 dpi non-

interpolated). Common points have been marked on each of the three photographs of the models. The internal orientation has been done by means of the camera file and measurement of the fiducial marks.

Relative orientation of the models have been obtained by marking and measuring at least ten (10) common points identically referred on all three photographs of each model. Absolute orientation of the models have been obtained by:

- scales and rotations;
 - latter, by coordinates of thee control points.
- Some arbitrary systems of coordinates have been created as follows:

X axis: from left to right

Y axis: from the object to the rear

Z axis: from base to the top (heights)

As an example: the system’s origin at the principal facade of the Santa Barbara Chapel is at the #34 point.

$$x_{34} = 200,000 \text{ m}$$

$$y_{34} = 50,000 \text{ m}$$

$$z_{34} = 100,000 \text{ m}$$

5.5 – Check measurement of the absolute orientation

Rotations:

1) Z Axis vertical: $x = \text{constant}$

$$\begin{array}{l} X \\ 1.1) 77 \ 196,679 \text{ m} \\ 76 \ 196,666 \text{ m} \\ \text{Diff.} = 0,013 \text{ m} \end{array}$$

$$\begin{array}{l} 1.2) 36 \ 201,339 \text{ m} \\ 69 \ 201,355 \text{ m} \\ \text{Diff.} = - 0,016 \text{ m} \end{array}$$

2) X Axis horizontal: $z = \text{constant}$

$$\begin{array}{l} Z \\ 2.1) 79 \ 101,219 \text{ m} \\ 80 \ 101,221 \text{ m} \\ \text{Diff.} = - 0,002 \text{ m} \end{array}$$

$$\begin{array}{l} 2.2) 34 \ 100,000 \text{ m} \\ 36 \ 100,015 \text{ m} \\ \text{Diff.} = - 0,015 \text{ m} \end{array}$$

$$\begin{array}{l} 2.3) 7 \ 101,478 \text{ m} \\ 10 \ 101,468 \text{ m} \\ \text{Diff.} = 0,010 \text{ m} \end{array}$$

3) X-Y Plane vertical: $y = \text{constant}$

Point	y	Diff.
76	50,009 m	0,009 m
30	50,000 m	+/- 0,000 m
34	50,000 m	+/- 0,000 m
36	50,000 m	+/- 0,000 m
79	49,998 m	- 0,002 m

4) Scale = Δx or Δz

x
34 200,000 m
36 201,339 m
$\Delta x = 1,339 \text{ m}$ in field: 1,33 m

x
52 198,645 m
58 202,648 m
$\Delta x = 4,003 \text{ m}$ in field: 4,00 m

z
35 100,015 m
69 97,605 m
$\Delta z = 2,410 \text{ m}$ in field: 2,40 m

z
42 100,182 m
23 97,500 m
$\Delta z = 2,682 \text{ m}$ in field: 2,68 m

6 – Measurement on the oriented model

Next, well-defined points have been chosen on the facades such as:

- points on vertical lines:
 $x = \text{constant}$
- points on horizontal lines:
 $z = \text{constant}$
- points at the facades' plane:
 $y = \text{constant}$
- distances approximately horizontal:
 Δx

The absolute orientation of the models in such way has been verified comparing the coordinates listed at Annex # 3.

Results: the scale, vertical and horizontal lines and the plan of the facades are well defined.

7- Production of the orthophotos

Once the absolute orientation have been completed and verified the digital orthophotos of the facades have been produced in a 1:50 ratio. The Aldus PhotoStyler 2.0 software has been used.

8 – Digital orthophotos produced by the classic stereoscopic method

Additional photographs have been taken - others than those used in the PhotoModeler software -, to generate a conventional stereo pair of the same facades. These photos have been used to produce digital orthophotos generated by the Zeiss Phodis software of Aerofoto Cruzeiro company. These orthophotos will be used to be compared to the ones obtained with PhotoModeler.

9 – Conclusions

The method of measuring facades with the PhotoModeler software have shown to be efficient when we have common points easily identifiable at least on 3 or 4 photographs, and this is sometimes impossible depending of the kind of object being measured and the characteristics of its surface and materials.

These first experiences have shown us that the use of clearly identified and well-distributed high-resolution targets over the facades is recommended.

10 - Acknowledgment

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Fig. 2 - Reduced ortophoto of the principal façade of Santa Bárbara Chapel , Santa Cruz Fortress - approximate scale 1:50



Fig. 3 - Photograph of the principal façade of the Chapel with control points indicated



Fig. 5 - Main Entrance of São Luiz Fort with control points indicated