

THE METRIC DOCUMENTATION OF VILLA POIANA BY ANDREA PALLADIO WITH SPHERICAL PHOTOGRAMMETRY

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ABSTRACT:

Multi-image panoramas are normally used extensively for virtual tours and documentation of Cultural Heritage for their easiness and completeness. Moreover they have metric capabilities enabling the 3d evaluation of an architectural object provided at least two panoramas (Fangi, 2007, 2008). The procedure already very well tested, is highly efficient and fast, has been applied for the metric documentation of Villa Poiana (Poiana Maggiore, Vicenza, Italy). Villa Poiana was designed by Andrea Palladio (1508-1580) between 1540 and 1560. The Villa, in which the author reaches an absolutely synthetic and essential language, almost metaphysical, is presented as one of the more interesting works of the architect. Owned today by the CISAP (International Centre for Studies "Andrea Palladio" of Vicenza) the Villa is now open to the public. The great noble floor known for its great architectural forms can be visited. The visitor is hit by the richness and elegance of its internal equipment decorated by the painters Bernardino India and Anselmo Canera and by the sculptor Bartolomeo Ridolfi. The survey and the modelling of the Villa is part of a broader study in collaboration with the CISAP about historical surveys of Palladian works for the preparation of a critical catalogue. This study shows the lack of documents regarding the Villa, providing today (except eighteenth-century historical drawings by Bertotti and Muttoni) only graphics dating to 1970 of a single survey made by the architect Soltan. This condition, in addition to the mentioned characteristics (rigour and essential form, decorative wealth) transformed the Palladian Villa into an ideal laboratory to complete the testing of the innovative survey system defined as "spherical photogrammetry" (Fangi, 2007, 2008, 2009) that has the main characteristics: rapidity, economy and precision referring to the primary task of documentation and communication of quantity and the specific quality of palladian architecture; coincidence of photogrammetric survey with photographic documentation; ease of restitution and management of the digital model through direct metric acquisition on spherical panoramas; firstly here is the possibility of integrating architectural and decorative apparatus (including frescoes) through using control points directly acquired in the photographic documentation. The advantages to use such a technique turn out to be many: first of all the great simplification of the photogrammetric problem: every single panorama replaces many photogrammetric takings representing a complete documentation of the object, then the high speed of execution and the easiness to plot by non-expert technicians. Then the photographic back-projection of the same panoramas used for plotting directly over the 3dimensional solid model, used as texture, gives the possibility of obtaining a perfect uniformity between the geometric and photographic model. Back-projection enables the editing of the model until the best fitting with the projection of the different panos, solving partially the problem of the lack of stereoscopy. There is also the opportunity to take measurements on decorative apparatus, at the same precision of photogrammetric restitution, between 1/1000 and 1/5000 of the distance camera- object. The back-projection is possible due to the knowledge of the orientation parameters of the panoramas. The software for the restitution has been developed by Fangi. The model so obtained is exported in VRML format to be explored in interactive form through popular commercial client-software (e.g. Cortona). At the end of the communicative process a holographic model of the Villa was obtained.

1 INTRODUCTION

The work of Andrea Palladium constitutes the most noticeable Italian architectonic production of the XVI century and, in absolute, one of most important of the whole history of the architecture, also in relation with its extraordinary influence of the palladian language in the spread in the renaissance world of classic-renaissance styles. 66 are the very many projects reported in the atlas of the architectures

of Andrea Palladium published in the 2001 by Marsilio publisher (12, Guidolotti, Beltramini, 2001) and brought in the section "Palladium" of the portal of the International Center of palladian studies (www.cisapalladio.org). To this huge corpus of the palladian production we add a fundamental consideration, say that it regards the characteristics that Howard Burns defines "a systematic and communicable architecture", which is a judgment synthetically and effectively synthesizing the importance of the palladian work and emphasizing "its rational base", "its clear grammar", "the validity of its text as mass media communication instrument" (11, Burns, Beltramini, 2008).

Quantity and quality of the Andrea Palladio's architecture, therefore, imply that the survey of his work is one of the most meaningful aspects regarding the analysis, protection, diffusion and communication. Recently, during the Symposium of the 500 years (Vicenza 5-10 May 2008) an accurate study about the survey of the palladian work in collaboration with the CISAP, put in evidence the following characteristics of the patrimony of the palladian surveys (14, Clini 2008):

- Presence of a huge amount of the built palladian heritage requiring technical and economical funds for its protection and its documentation to be optimized, also considering the possible transformations (recoveries, restorations);
- Missing surveys of ten palladian projects;
- There exist some surveys, old from the historical and methodological point of view, not always of high quality but mainly lacking regarding their employ in view of the diffusion and communication of the palladian work, taking into consideration the possibilities given by the new technologies.
- Few accurate surveys, of private owners,
- Need of quick and good updating of the surveys according to their restoration.

By that time, it has been proposed a possible solution for the palladian heritage archive and protection taking advantage of the possibilities given by the spherical photogrammetry. An already long series of experiences assess the reliability of the new technique of survey and documentation, characterized by the following features:

- High speed, low cost, and accuracy suitable for the documentation
- The photographic documentation is performed in the same time of the survey

2 THE SPHERICAL PHOTOGRAMMETRY

For the details of the technique see (Fangi, 2007, 2008, 2009). The photographic documentation done with spherical photography is a technique already very well known and applied. In addition it does have metric capabilities. From a unique point of view a series of photographs, partially overlapping, are taken covering 360°. Then the panorama is mapped on a plane with the so-called equirectangular projection (figures 7, 11).

From the image point P' and the corresponding object point P , (figure 1) the collinearity equations hold:

$$\begin{aligned} x &= R \cdot \left(-\theta_0 + atg \frac{(X - X_0) - d\alpha_y(Y - Y_0)}{(Y - Y_0) + d\alpha_x \cdot (Z - Z_0)} \right) \\ y &= R \cdot \frac{d\alpha_y(X - X_0) - d\alpha_x(Y - Y_0) + (X - X_0)}{\sqrt{(X - X_0)^2 + (Y - Y_0)^2 + (Z - Z_0)^2}} \end{aligned} \quad [1]$$

where x and y are the panorama plane coordinates, X, Y, Z are the terrain 3d coordinates, R the radius of the sphere, $d\alpha_x$ and $d\alpha_y$ the correction angles (roll and pitch), θ_0 the heading, X_0, Y_0, Z_0 the terrain coordinates of the sphere centre. The solution of the panorama orientation is performed in a bundle adjustment procedure, while the restitution is given by the [1] by means of the estimated parameters. The initial approximated values of the parameters can be obtained directly using control points in a minimum number of three

or in a different procedure using the relative orientation (performed by coplanarity) followed by the s transformation using at least one distance for the size to get a model at scale 1/1 and some information for the levelling of the model, like verticality of the buildings corners.

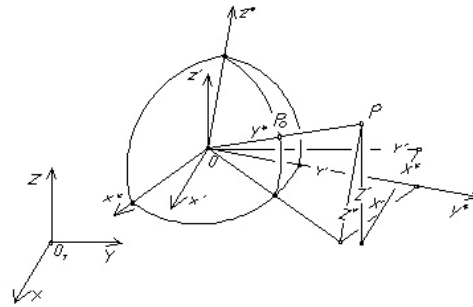


Figure 1 – Relationship between the pano-sphere and the object point P and the image point P'

3 VILLA POIANA

The experience here described refers to one of the most interesting villa of the whole palladian production and it is particularly useful to illustrate the characteristics of the employed method. Villa Poiana (Poiana Maggiore, Vicenza, Italia) was designed by A. Palladio (1508-1580) at the end of the years 40 and finished in the years 60 of the XVI century.



Figure 2 – Villa Poiana, Poiana Maggiore, Noventa, Italy

The villa, where the author uses a very substantial and metaphysical style, is one of the most interesting works of the architect. It is now owned by CISAP (International centre for study about Andrea Palladio), it is open to the public allowed to visit the great first floor, particularly worthy besides the architectonic forms of its volumes, also for the wealth and elegance of its decorative interior apparatus executed by the painters Bernardino India and Anselmo Canera and by the sculptor Bartolomeo Ridolfi.

The survey and modeling of the villa is part of a wider study carried out in cooperation with Cisap Palladio about the historical surveys of the Palladian work of which a critical catalogue is getting ready. Just from this study one can note the scarcity of the documents regarding the villa since we have today (besides the '700 drawings by Bertotti and Muttoni) only some sketches made in the years '70 by the architect Soltan. These conditions, a part the characteristics of rigorousness and decorative richness, made the work an

ideal laboratory to experiment of the survey system of spherical photogrammetry.

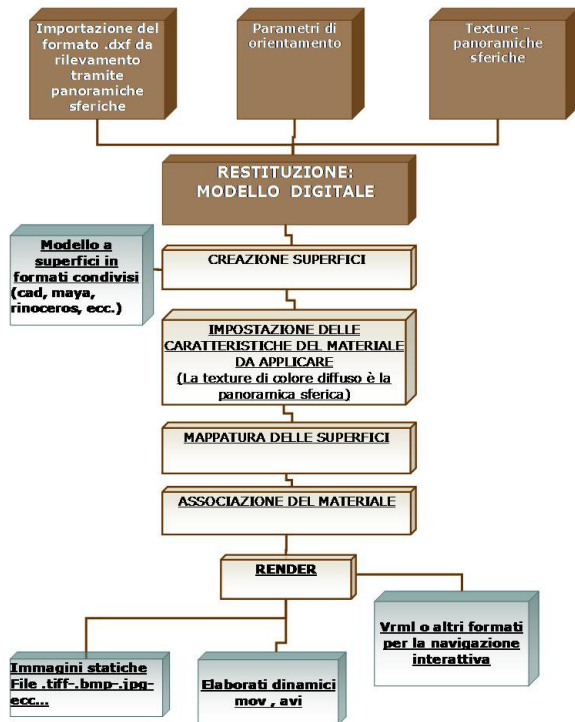


Figure 3 – The general procedure

Such a survey can be done generally for the whole building, due to low cost and short times, also not specifically for the restoration but for its documentation mainly. For restoration projects it is always possible, just selecting the specific parts, or single constructive elements, interested to the intervention, to make high accuracy survey for the purpose, such as laser scanning or high accuracy stereoscopic photogrammetry.

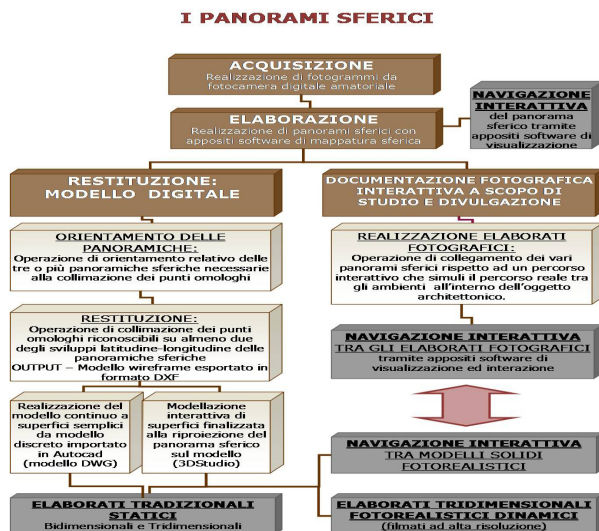


Figure 4 – The flow-chart of the archiving procedure

In figures 3 and 4 the general procedure is illustrated. The gathering phase consists in the simple photographic coverage, the number of the images variable according to the focal length, to the final resolution, needed for the spherical

panoramas. Only some distance measures are needed to get the proper size of the survey¹.

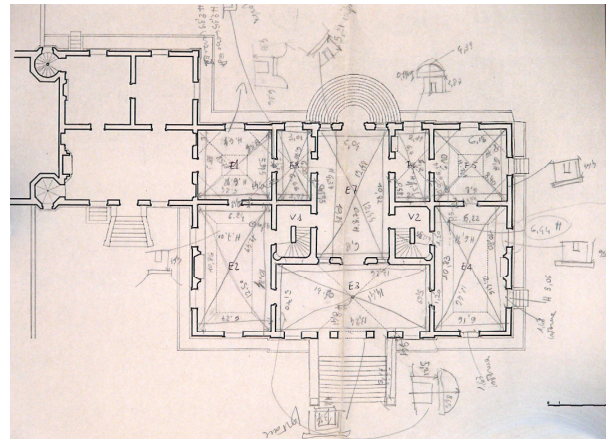


Figure 5 – The plan of the villa and the distance measurements taken on-site

The panoramas are realized with common digital cameras, then mosaicated with common and cheap commercial software (in our case PTGuy, Easy Pano). It is possible to produce dynamic models such as quick time movies (figure 6) for the high resolution interactive exploration of single environment or through a selected path.

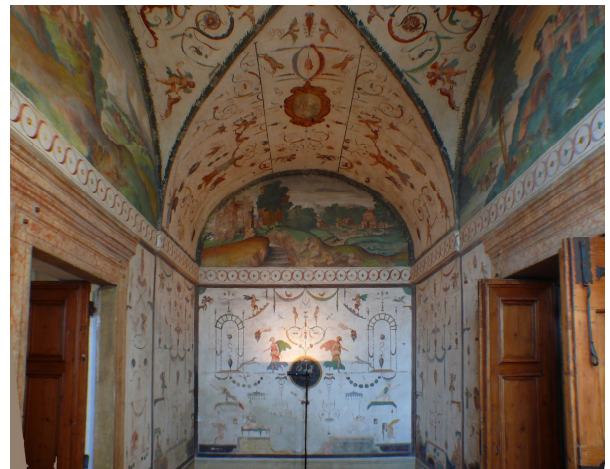


Figure 6 – Quick time of the grotesque paintings hall

They are the first and meaningful document of the survey with the possible view and synoptic exploration of the object space. The spherical panoramas have indeed precious metric contents. It is possible to build-up wire-frame model scale 1/1.

¹ One of the most significant novelty, from the point of view of photogrammetry, consists in that the metric application of 360° panoramic images, were been obtained only with high resolution rotating cameras, very expensive and sophisticated. See (Luhmann, Tecklenburg, 2004)

4 THE SURVEY

The survey of the villa has been carried out with two series of panoramas:

- 1) Panoramas regarding the outside of the villa
- 2) Panoramas regarding the interior rooms
 - 1) For the outside ten panoramas and a control topographic network have been done
 - 2) Five interior rooms: entrance loggia, entrance room, library, the grotesque paintings room, and the main hall, have been surveyed. For any room a variable number of panos ranging from three to five, have been taken. The orientation has been performed in the following sequence: model formation, followed by scaling - by using some distance measurements (figure 5) - and by the leveling, taking advantage of the vertical corners of the rooms.



Figure 7 - The entrance room of the villa, panorama

The accuracy is the typical one of the monoscopic low-cost photogrammetry say ranging between 1/1000 and 1/5000 of the camera-object distance. The wire-frame can be rendered with the model computer techniques, deriving traditional front and lateral views, cross-sections, and plans useful for the description of the work. High realistic metric models, useful for spatial description of the work, are then derived.

5 THE BACK-PROJECTION MODELLING

We applied for the first time the back projection of the panorama. For the details see (Fangi, 2009). The essential steps are:

1. Wire-frame plotting with the spherical panorama
2. From wire-frame to solid model, closing the polygons, and let the surfaces to form the volume
3. Back-projection of the oriented panorama over the solid model to enable its editing improvement, and finally to constitute the texture of the model.

The main limit of this technology is the lack of stereoscopy that makes the rough, uneven, curved surfaces and lines not suitable for plotting. One possible solution of this problem can be the interactive modelling enabled by the back-projection of panoramas, over the solid model of the architectural object. Lines and surfaces can be modified and corrected by the operator until they fit with their projection of the different panoramas taken from different points of view.

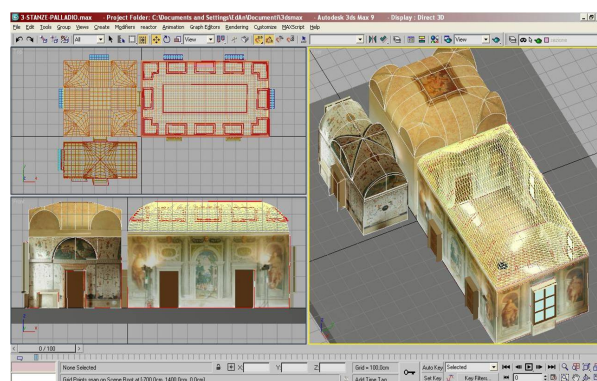


Figure 8 – The solid modelling and the back projection of the panorama

In figure 8 images of the model got by back-projections of the same panos over the model in 3d Studio Max environment (10). The model has been exported in VRML format ready to be explored in the interactive form by means of software like Cortona or Cosmo player (figures 6, 9).

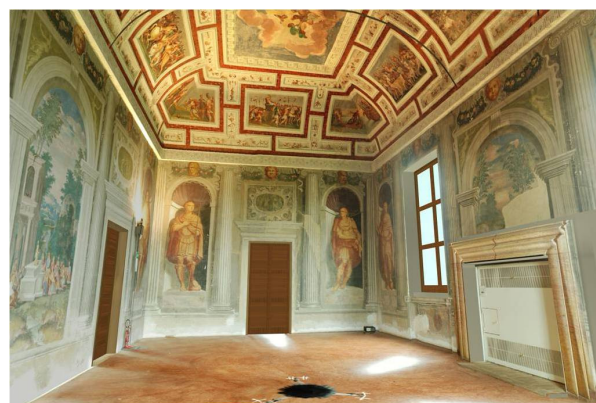


Figure 9 - The rendered model of main hall, on the centre of the floor the black hole produced by the bottom of the tripod can be seen.

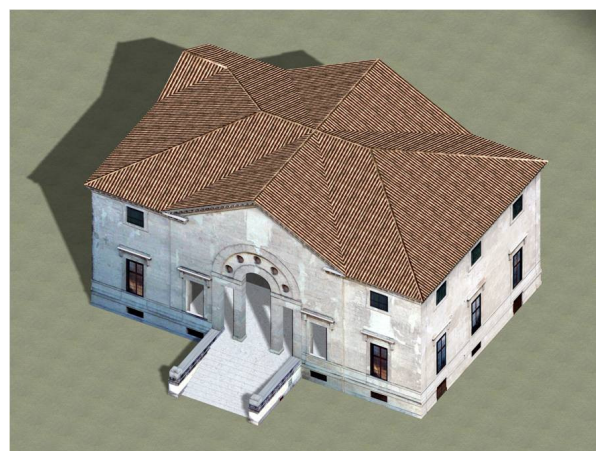


Figure 10 – The rendered model of the villa Poiana

6 CONCLUSIONS

This was the very first occasion to test deeply the efficiency of the spherical photogrammetry as metric documentation system. From this first attempt the efficiency and all the qualities seem to be confirmed. Nowadays it is already ten years that the laser scanning made its appearance in the field of cultural heritage recording. Architectural photogrammetry seemed to have achieved its final evolution and to be at its

last stage. Never the less because of the possibilities given by digital photography, spherical photogrammetry seems to be able to open an evolution in the CH metric archiving technology and methods. Low costs, easiness, rapidity are the essential values, the main limit being the lack of stereoscopy.



Figure 11 – The panorama of the main hall

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