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PHOTOGRAMMETRIC SURVEY IN THE LATRINES OF CHAMBORD

LEVANTAMIENTO FOTOGRAMÉTRICO DE LAS LETRINAS DE CHAMBORD

Pinte Antoine[a,*], Simon Bryant[b]

[a]École Nationale des Sciences Géographiques, 6-8 av. Blaise Pascal – Cité Descartes, Champs-sur-Marne 77455 Marne-la-Vallée cedex 2, France. antoine.pinte@ensg.eu

[b]INRAP, UMR 7041 ArScan, Centre archéologique d'Orléans, 525 av. de la Pomme de Pin, 45590 Saint-Cyr-en-Val, France. simon.bryant@inrap.fr

Abstract:

The two rooms of a latrine of the *château de Chambord* were surveyed by photogrammetry. The paper reports on the specific constraints of the acquisition (small and dark rooms, isolated from the outside world and separated by a narrow corridor) as well as on the processing operations elaborated (compensated scaling and relative registration from manual points). The resulting 3D clouds and orthoimages provide metrical models for archaeological analysis.

Key words: digital archaeology, cultural heritage, documentation, 3D reconstruction, photogrammetry

Resumen:

Este artículo trata de un estudio fotogramétrico de las letrinas de *Chambord*. Las restricciones de la adquisición (pequeños y oscuros cuartos, aislados y separados por un estrecho corredor) y las operaciones de tratamiento elaboradas para la ubicación métrica se exponen. Los productos fotogramétricos ayudan al análisis arqueológico.

Palabras clave: arqueología digital, patrimonio cultural, documentación, reconstrucción 3D, fotogrametría

1. Introduction

1.1. Context of the survey

The *château de Chambord*, an emblem of French Renaissance architecture, is one of the most famous castles in the world. Built at the beginning of the 16th century, it was inscribed on the UNESCO World Heritage list in 1981. The monitoring of the monument requires scientific descriptions, notably in the forms of orthoimages and 3D models. A photogrammetric survey was recently performed by students from the specialized master in Positionning, Photogrammetry and Deformation Measurement (PPMD) of the French national school for geographic sciences (ENSG).

The many acquisitions carried out by the students have provided, among other results, orthoimages of all the outer walls and towers of the castle (Pinte *et al.* 2015). The present paper reports on the surveying of the latrines in highly-constrained conditions, and on the data processing strategies applied to ensure precise results.

The latrines at Chambord are integrated into the foundations of the towers, cylindrical masonry structures some 5 m deep, dug into the marshy ground of the valley of the Cosson. The vaulted cess-pits materialise the earliest stages of the building project which underwent several modifications between the initial laying out and foundation work in the early 1520's and the final state of the mid 1540's. As such, they form an important element in the ongoing debates as to the original plan of the castle "keep" and the influence of Leonardo Da Vinci in its design (Guillaume 1974; Lesueur 1954; Ranjard 1973; Ponsot 2007). Recent research tends to favour the hypothesis of a "gyrating" plan (Caillou and Hofbauer 2003 and 2007).

Until then, the latrines were documented only through manual drawings and sketches. Simon Bryant, archaeologist at Inrap Orléans, needed more reliable data, especially of the North-West tower latrine. He needed orthoimages, in order to analyse how the stones are disposed in the wall and to create an accurate series of plans and elevations for further archaeological analysis. We decided to perform a photogrammetric acquisition in this latrine, which is composed of two rooms connected by a very narrow corridor.

1.2. Constraints of the survey

The acquisition conditions were severely constrained:

* Corresponding Author: Pinte Antoine, antoine.pinte@ensg.eu

- Given the extent of the castle, only one day could be dedicated to the surveying of the latrine rooms. In addition, the whole acquisition had to be made during the opening hours of the castle.
- The latrine rooms are neither artificially nor naturally lit. We had to operate the lighting.
- The two rooms are connected by a sole corridor, which is about 2 m long and less than 50 cm wide at its narrowest (Fig. 1).
- The smallest room is exiguous for photographing (5x3m²). Moreover, it was encumbered with a heap of rubble bags in a corner.
- The larger room was flooded by water (10 to 30 cm deep) (Fig. 2).

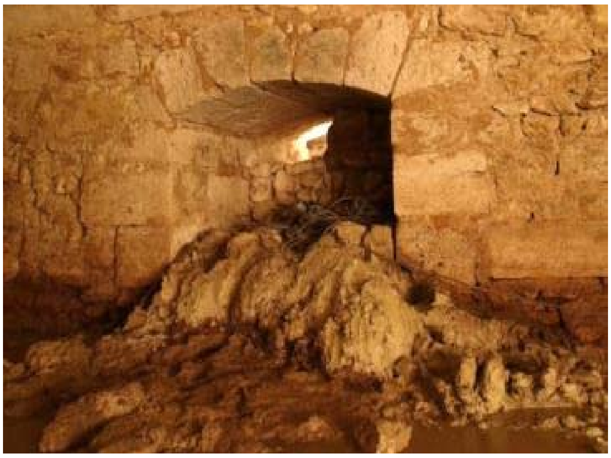

Figure 1: Corridor between the two rooms.

Figure 2: Image of the second room of the latrine, captured with a fisheye lens and with opposite lightning.

The next sections report on the methods used for photographing the rooms and on the solution chosen to scale the two models and to reconcile them in a same referential.

2. Acquisition protocol

2.1. Lighting

Neither room being lit, we resorted to a powerful spot set on a tripod. After many tests, it appears that the most adequate configuration is radical indirect lighting where spot and camera aim at opposite directions. This solution provides a uniform light on the walls and prevents hot spots as well as under-exposed parts in the images, even when taken with a fisheye lens (Fig. 2).

2.2. Image acquisition

Acquisition was made with Canon EOS 5D Mark II and III cameras. Given the exiguity of the rooms, we resorted to short focal lenses (24 mm). Some images were taken with fisheye lenses (focal length: 15 mm), in order to improve recovery and to help to orientate all the images. A total of 285 images were taken in the two rooms.

3. Image processing

Data, at all stages, were processed with MicMac, a set of free open source photogrammetric software solutions to build 3D models from images (Pierrot-Deseilligny *et al*. 2006).

3.1. Image orientation

First were computed the position and orientation of the cameras for either room separately. Tie points between all images of one room were extracted with MicMac, using a specific module based on the SIFT algorithm (Lowe 2004), followed by a multiple matching phase. In total, almost 7 million tie points were calculated, and bundle adjustment (including self-calibration for the two cameras) led to an average image residual of 0.6 pixel. The two rooms were processed separately, because we had no time for a specific acquisition in the corridor, and also because, at the beginning, common registration was not planned.

3.2. Scaling

Two methods were used to compute the scaling of the rooms. The first solution, quite simple, consisted in measuring the size of the stones first in the room, and then in stereoscopy on the images. However, no adjustment algorithm on measures meant for scaling is available in MicMac: a locally imprecise measure on a given stone will lead to imprecise parameters which will greatly distort the scaling on other parts of the room.

To prevent such problems, we tested another solution. It was based on the choice of 4 points, well distributed in the room, all at the same level. The 6 possible distances between any two of these four points were measured. Least square adjustment provided the 3D coordinates of the 4 points in a fictive system. The four points were also measured in the images, and an adjustment was computed, scaling the orientation. Moreover, with this method, since the four points are chosen on a same high level, the new orientation is verticalized.

3.3. Common orientation of the two rooms

No specific images were taken for the narrow corridor (Fig. 1) which connects the two rooms. As a consequence, all automatic solutions to assemble the rooms are doomed to fail.

Nevertheless, we manually identified a few tie points between the two rooms. Due to the very different perspectives, it was difficult to find common details. Four points however could be found on the sides of the corridor, and two extra points, one in each room, could be found on the opposite walls of the corridor. These 6 points were measured on 2 images at least in each room. The images for each room being oriented, the 3D coordinates of all 6 points could be computed in both room systems. Between these two datasets of 3D points, a Helmert transformation was then computed, in order to tilt the orientation of the second room into the first room system, which is at scale and verticalized. Eventually, all orientations are defined in the same coordinates system (Fig. 3).

4. Photogrammetric products

4.1. 3D reconstruction

3D reconstruction for each room was computed independently, with a new module for MicMac, based on image geometry reconstruction (Fig. 3). From points cloud, sections can be computed (Fig. 4).

Figure 3: 3D reconstruction of the two rooms in the same system coordinates.

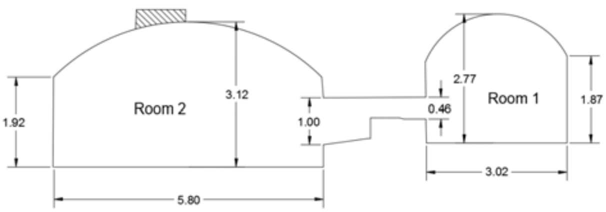

Figure 4: Vertical section computed from 3D reconstruction.

4.2. Orthoimage

Orthoimages of the walls of the latrine could be computed easily, on any adequate plan chosen for the orthorectification. Orthoimages of the vaults could also be computed, using a cylinder, estimated from the 3D point cloud, as projection surface. The point cloud is first converted into a depth map on this cylindrical surface: an unwrapped orthoimage can be computed using this depth map (Fig. 5).

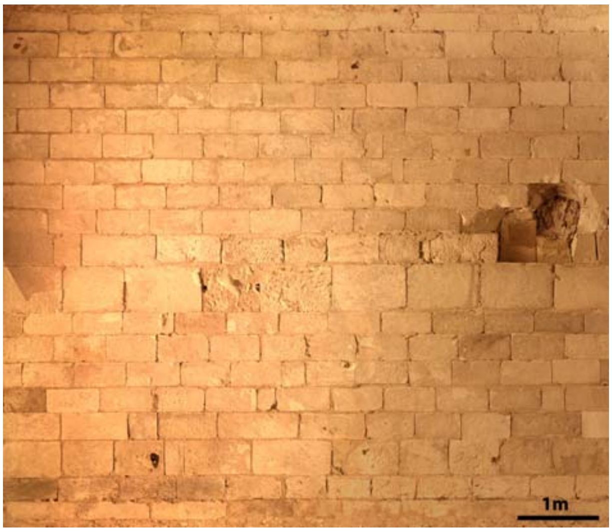

Figure 5: Unwrapped orthoimage of the second room vault.

5. Perspectives

Chambord castle remains a fertile ground for scientific research along many lines. The needs of monitoring and architectural conservation have impelled the development of accurate and detailed scientific descriptions in the form of orthoimages, 3D scans and photogrammetric models. These provide an evolving archive of the state of the edifice at any given moment and constitute valuable tools for the recording of different types of archaeological data at different scales and on a variety of supports. They also offer new opportunities for ongoing archaeological research and allow manual survey and drawing methods to fulfil a more interpretative and reflexive role in the recording of archaeological remains whilst improving the accuracy and interchangeability of acquired data. This is of particular interest for a site where many different researchers may intervene at different times and for different reasons since the documentation may be re-used, updated and enriched through time. Older archaeological data may be integrated into these documents and offer the possibility to re-evaluate findings and guide future research programs.

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