

PHOTOGRAPHER-FRIENDLY WORK-FLOWS FOR IMAGE-BASED MODELLING OF HERITAGE ARTEFACTS

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ABSTRACT:

Because of its low-cost and ease in use, 3D reconstruction from sets of images has a great potential for enhancing cultural heritage documentation, conservation and valuation. However, these technologies, from image acquisition to final 3D model obtaining, are often difficult to master for non-expert people. Our work consists in developing a series of acquisition protocols for the museum's photographs. The end-goal being to enable those professionals to generate efficiently and easily 3D models of heritage artefact.

1. INTRODUCTION

Since the recent convergence of the researches in the fields of photogrammetry and computer vision, photogrammetric results relevant for the documentation and the study of heritage artefacts (archaeological fragments, paintings, sculptures, furnitures, architectural elements, buildings, sites) can be computed with high quality photographs without others data, through the APERO and MICMAC pipeline for example (Pierrot-Deseilligny, 2011).

How to precisely define this quality? There is both a photographic quality (definition of the picture, sharpness, dynamic range, etc.) and the correct setting of parameters linked with the image-based modelling constraints, especially the spatial configuration of the points of view.

Nonetheless the settling of these parameters cannot be the same for all cases since the artefacts have very different characteristics. Thus the whole corpus must be divided within a technical typology including morphology, scale, brightness, etc.. Each group of these classifications lead the photographers to a suitable protocol. It explains how to choose the different points of view, how to enlighten the artefact, etc..

The photographs taken are then processed with the web interface on cloud. The whole pipeline, including photogrammetric acquisition, data processing, data indexing and data exploitation is the aim of the Culture 3D Clouds: synthesize technical solutions for 3D surveying.

New businesses and technical models can emerge in the institutions that houses and cares for collections of artefacts. The photographer working in these institutions could learn and develop a practice of photogrammetry.

CONSTRAINTS

The combined computer vision/photogrammetry approach of APERO for estimation of initial solution allows a certain flexibility in the data acquisition, for example a leeway in choosing the points of view. The photographers can even shoot without a tripod if the shutting time allows it.

The automatic process consists in tie-points extraction (with SIFT algorithm), internal and external orientation by bundle adjustment (Apero), and dense image matching (Micmac). The final output is a set dense and accurate pointclouds.

However in order to make the relative orientation converge and to produce precise results, some constraints have to be respected:

- for each desired points cloud take a “master” image and several closed associated images (with low ratio base to distance and important overlapping) (Pierrot-Deseilligny, 2011),
- between each master image take a sufficient number of intermediary images to assure the connection during the orientation step (Pierrot-Deseilligny, 2011),
- avoid to move a punctual light source during the photographs acquisition,
- use a context with enough details spread in all the space photographed as background,
- fix as many parameters of the cameras as possible.

The cultural heritage aspect introduces others constraints:

- put a metric reference in the scene as scale,
- compute relevant surface description for the whole (at least the maximal) surface of the artefact with a sufficient resolution for its study.
- reproduce all the photometric values of the artefact,
- control the lighting and the digital capture for a colorimetric (or radiometric) study of the artefact,
- long-term archive the photographs and the results.

These different constraints can sometimes be contradictory. For example the optimal way of enlightenment for colour reproduction can be different than the one for the dense image-matching. This is why several solutions coexist, even for the same artefact.

2.TYOPOLOGY LEADING TO PROTOCOLS

However, we can classify the corpus of artefacts in groups sharing similar constraints. This organisation of the corpus in typologies leads to different protocols developed as guidelines.

2.1 General explanations

Managing the acquisition requires to understand the basic concepts of the data processing.

Understanding the basic concepts of data processing is a necessary first step towards the understanding of the protocols.

Therefore, a first document explains the different steps of the Culture 3D Clouds pipeline (tie points computation, internal orientation, external orientation, dense image-matching, points clouds generation and meshing) and the constraints previously delineated.

For these explanations, we need a vocabulary both rigorous and easy to understand for the non-experts. This is why technical photogrammetric vocabulary will be used as little as possible or will be simplified. However, some vocabulary are necessary such as 'orthoimage' which will require clear definitions.

Although the visual standard of representing a camera by a pyramid is used in our protocols (see Figure 2).

Moreover, our Protocols uses the standard of representing a camera as a pyramid (see Figure 2).

This way, it is still possible to show different focal lengths and the photographers are then able to read photogrammetric explanations from other sources.

Aware of these specificities, the photographer is able to understand where the difficulties lie. We can list three essential rules which must be controlled as much as possible:

- The photographs must be automatically orientable.
- Each master photograph and the related associated photographs must be suitable for the dense image-matching: sharp, in sufficient number for multi-stereo, with a good height-base ratio and representing the whole surface with a precise texture.
- The colours must be well reproduced and permit radiometric equalization.

These rules impose conditions on different parameters. Some are listed in the tables 1 and 2.

	Automatical orientation	Quality dense image-matching	Good reproduction of the colors
focal length(s)	short necessary	Maximal magnification	
focus	small change	fixed	
aperture	fixed	depth of field maximal	used for the characterization
sharpness	enough for tie points	maximal	maximal
lighting	all over the artefact	no flare visible texture no shadow no reflect	no flare, shadow or reflect characterized (colorimetry)
texture projection	no	for smooth surface	no
overlapping	See Table 2	almost 100 %	
rotation angle			

Table 1: Some parameters relative to the constraints

	Overlapping of textured background necessary	Rotation of camera (ratio of lap)	Proportion of the artefact necessary in the frame
Mainly artefact used for orientation	1/5	1/36	4/5
Both artefact and background used for orientation	½	1/16	½
Mainly background used for orientation	4/5	1/8	0

Table 2. recommended parameters for automatic orientation

These parametrizations are not absolute but constitute an entry point.

For instance, to take intermediary pictures automatically orientable, the photographer has to understand the different parameters and the links between them. The rotation angle of the cameras (giving the required number of pictures) is linked with the overlapping of the background and its texture. For example, only height intermediary pictures can be sufficient if they are taken from a high-angle shot framing on a textured support.

Nonetheless, the settling of the acquisition depends on the artefact. We need to provide the correct protocol for the photographer.

2.2 Typological approach for protocols

To do this, how do we split up the complete architectural and museum corpus?

The user of the pipeline needs to focus on the sensitive technical constraints. The physical characteristics of the artefact are the base of the typological approach :

- morphology (convex, concave or flatten),
- scale,
- texture (sharp all over the surface or smooth),
- brightness.

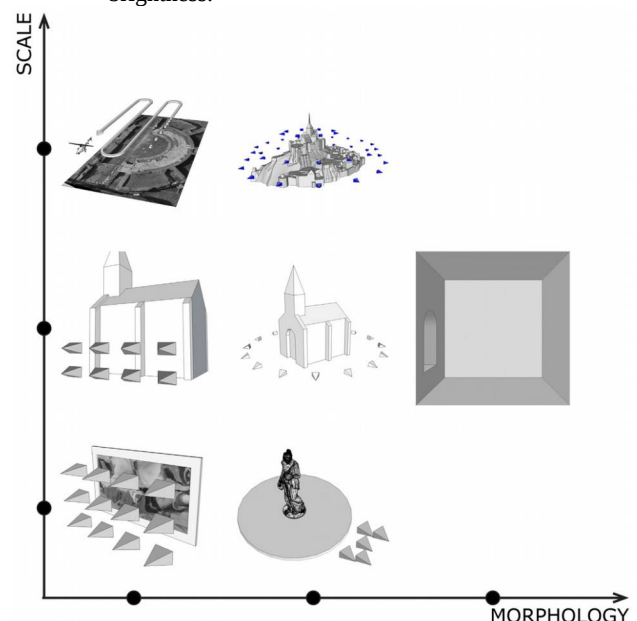


Figure 1. One of the typologies

With the typology presented in figure 1, the user can rapidly understand the different general cases to which corresponds protocols with a spatial configuration of acquisition.

2.3 Protocols

For each group defined by the typology, a protocol is proposed. It explains the work-flow, the critical parameters and at the end, it synthesizes it in a short procedure.

For example, the protocol “all around a simple artefact” explains how to photograph an artefact with a simple morphology situated in an easy context (space around, textured background) in order to compute exhaustive point-clouds.

The figure 2 shows the spatial configuration of the master images (in blue), of the associated images (in white) and of the intermediary images helping to connect all the image in the orientation (in green).

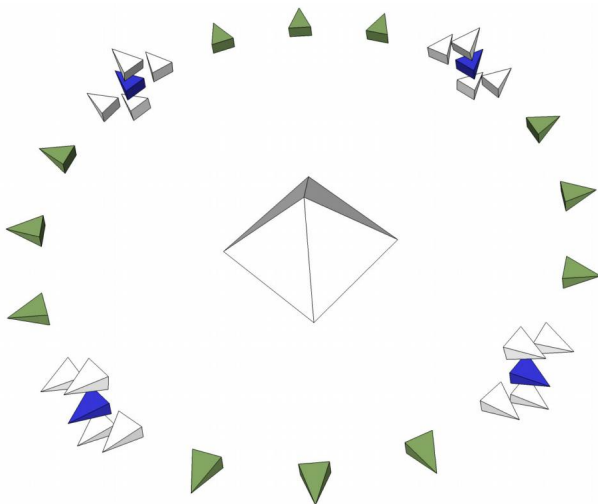


Figure 2. Spatial configuration of the acquisition of an artefact with a simple morphology

A morphology is said to be simple when it can be exhaustively observed from few points of view. In this case, a number of four master images are enough to digitize the whole superior part (the bottom can not be visible without moving the artefact). Each master image is associated with four images which offer vertical and horizontal multi-stereo. The ratio base to distance is circa one to ten and the overlapping as largest as possible. The photographs are taken with a small angle toward the support of the artefact. With such a spatial configuration, the artefact can easily (if it is matt enough) be lighted with a diffuse zenith light: outdoor an overcast sky and indoor a studio flash with a big light box for example.

The organization of the introduction explanations and of the different protocols is from general concepts to precise parameters. If the user of the pipeline really understands the concepts of image-based modelling, he can develop a practice and not just be dependent of a technology.

After the first tries with a protocol, a photographer will probably adapt it to the artefacts he photographs and to the way he works. The round-trips between protocol applications and on-field experimentations make it evolve.

Even for one group of artefact, there are several possibilities of digitizing it. This is why the pipelines have to be open: each photographer can develop his own practice.

3. WEB-INTERFACE: TEMPLATES AND RECIPES

These protocols and the possibility of creating new ones are translated into the interface. It exists in two versions: one with different parameters for the users who want to develop their own processing, another simplified for the users who want to use a process template.

Each template is developed for one protocol. It takes into account:

- the data organisation (naming, function of each picture),
- the mode of tie points computation and the resolution of the picture for this step,
- if an auto-calibration is done or not, and on which photographs,
- some parameters of the orientation (calibration, distortion model, pre-orientation, bascule),
- some parameters of the dense image-matching (using of masks, regulation factor, etc.),
- some parameters for the colorimetric equalization, the points cloud export and the meshing (image used for the texturing, regulation, etc.)

Enough parameters are provided while keeping a user-friendly form. Therefore the interface stays simple enough to be rapidly understood. In addition its structure presents the different photogrammetric steps. It helps the user keep in mind the mechanism of the processing and take into consideration the photogrammetric constraints during the acquisition.

4. PRACTICE ISSUES

Which professionals are able to produce the quality photographs necessary for the 3D digitization?

The photographers working in the cultural heritage field already should have the knowledge, the equipment and the communication skill to extend their practice to 3D digitization.

As noted in part 2.1, a lot of parameters and constraints are linked one with each other. Managing the photographic parameters for classical shooting is a prerequisite to begin the practice of image-based modelling.

Moreover a photographer already working with architects, curators or other professionals already has a sensibility with the objects he photographs and an ease to communicate about it.

This communication is essential for the acquisitions specifications to be clear and the results, properly documented. Such professionals are the best-equipped and best-prepared to achieve optimal results.

The Culture 3D Clouds project could represent a good opportunity for institutions that houses and cares collections of artefacts. This method provides the ability to create 3d models of artefacts without major investments, as no equipment nor recruitment of 3d expert are necessary.

The main technical difficulty in the photogrammetric method is the data processing and that phase might require a specific technical expertise, which is very rare in cultural heritage institutions. To resolve this problem, the process used in Culture 3D Clouds will be based on an online-tool for non-experts. Web service to create 3d model with photographs allows the utilization of photogrammetric method with a limited technical expertise and removes the need to install a specific software, train on it and maintain it.

By separating acquisition and calculation phase, this process might give to the institution an easy way to create 3D models of digital artefacts with photographs that they still have the capacity to produce.

A second benefit in the use of web-service is to facilitate downstream needs for cultural institutions with 3d models produced. Digitizing heritage artefacts for institutions is not only a question of method of acquisition but also about storage, metadata and dissemination. Therefore the solution provided by Culture 3D Clouds will facilitate the storage of 3D models, give the possibility to add standardized metadata and offer services to consult and to have the possibility of reuse those resources. The photogrammetric method appears to be an adapted solution for digitize artefacts if it is associated with services not only for technical treatment but in relation to other issues about Digital Heritage. The ambition of the Culture 3D Clouds project is to give a global solution for 3D models of artefacts from acquisition, based on photogrammetric, to access and reuse.

5.CONCLUSION

Taking correctly the photographs to compute relevant 3D results is crucial because the artefacts are generally accessible just one time. Through the typologies and protocols, the photographer can learn how to take it. With a background in cultural heritage photography, they can extend their practice to 3D digitization of the artefacts.

This is a good opportunity for institutions that houses and cares collections, in which photographers are working.

The cooperation in the Culture 3D Clouds project already leads two photographers from the RMN¹ to take the photographs for well 3D reproduction of artefacts.

This cooperation in the project may lead to a futur cooperation between the different agents working the cultural heritage field. A community of photographers using photogrammetric tools and exchanging about their technical and cultural matters could see the light of day.

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¹Réunion des Musées Nationaux