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USE OF PROCESSING OF RAW IMAGE TO ANALYZE MECHANICAL WORK OF THE STONE IN VAULTING WEBS

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Abstract

Studies of the static behavior of vaulted systems that is found in most of the architectural heritage, requires precise knowledge of the shape these elements. The progress experienced in digital photography has placed photogrammetric methods at the forefront of data collected systems, thanks to the great amount of information the images offer to us. Data collection stored in raw files allows selective processing which, for the constructions we have analyzed, means a precise rising enriched by the large amount of data that the current digital photography is able to pick up.

Key words: *stone structure, vaulting web, data collection*

1. INTRODUCTION

The stone as support is present in the construction of the most of cultural goods that form our architectural heritage, for whose preservation is essential to carry out interventions whose application depends on how the building is and the knowledge about it we may have.

In this sense it is very important to get a good prior documentation to the analysis and subsequent intervention, both historical as planimetric. In fact, it is not possible to carry out the studies required without it, such as the constructive analyses, typological and formal or even structural studies, and from which to obtain a right proposal for intervention on the constructed element, whether for repair, replacement or reconstruction it.

So we can say that the final result depends largely on the accuracy of the documentation that describes building geometry, construction and pathology before the architectural intervention. Then, any work of this type must be preceded by comprehensive information from which it is possible to develop the right techniques in each case.

In this type of interventions, the most suitable methods for collecting data in situ, which are necessary to generate the previous documentation, are indirect measurement systems, due, in large part, to the difficulty of direct access to a lot of the intervening elements that usually offer this kind of construction.

In addition, to being non-intrusive methods work is performed without altering the object of study, feature that in buildings of great historical interest, such as that in this work are presented, is not only a value-added but necessary requirement.

Currently, using photogrammetry, it is possible to make an architectural survey with great precision and efficiency. Thanks to the million points obtained, it is possible to generate a three-dimensional virtual model of the object we are studying.

This article shows how a treatment of pictures taken for a rising architectural by photogrammetry, prior to the processing thereof for the 3D models, improved accuracy and visual quality of the results. This work has been developed by the research group of the architectural heritage of the Department of industrial systems engineering and design of the University Jaume I of Castellón as an alternative to the uprising with traditional surveying systems for the realization of the corresponding graphical documentation that serve for the further analysis and proposals for intervention in different religious buildings made with stone, belonging to the Mediterranean Gothic.

2. METHODOLOGY

Research is carried out in three different phases which are consecutive and which have been defined from the stages of work that currently involves the realization of an architectural survey.

Thus, the first phase of the work corresponds with the contact with the constructive element which is the reason of the study and whose main purpose is the data collection in the most comprehensive and accurate way. From

the obtained data it is developed, in the second and most elaborate part of work, three-dimensional models which serve as base for the subsequent and final phase when a geometrical and constructive study of the proposed construction is made.

DATA COLLECTING

Previous planning to the field work ensures the correct determination of the position and number of photographs to perform. For this system, the determination of the day and time are of special importance because light is a key factor for the camera.

Under a technical point of view, the use of targets or control points makes easier the subsequent work of processing the images, although texture of the used stone in this kind of construction is enough to identify homologous points.

It is also to take into account that the results depends on the link between the right images, so it is expected that each zone to represent can be photographed at least from three different positions and taking them with a considerable overlap between an image and its adjoining.

Although it is not essential to calibrate the cameras before field photos, it is true that you can speed up the subsequent work of processing of the images. This task is performed with the same software of Photogrammetry which processed data for the obtaining of the corresponding point clouds.

Data collecting are made using two cameras, in a way that results can be contrasted. One of them is a 10.2 Mega pixel digital camera Nikon D-80, with an objective from 18 to 135mm and focal aperture of f/3.5-5.6. The pictures serve both a support for a direct reading of different building elements and for their application in processes of Photogrammetry (Table 1).

Camera	Nikon D-80
Image Sensor	RGB CCD 23.6X15.8 mm/10.75 million total pixels
Sensitivity	100 to 1600 (ISO equivalent)
Exposure metering	3D Color Matrix Metering II/Center-Weighted/Spot Metering

Table 1: Used camera characteristics. www.nikon.com.

It should bear in mind that for this data collection system, the quality of the results is determined by the position and number of pictures, as well as the resolution of each of them. Then, a correct position of the camera and the appropriate number of photographs allows us to ensure the necessary continuity between the different photographs that run through each studied element image.

To achieve this, between photo and photo camera position must be moving between 0.15 and 0.25 the distance that they keep with the object. For example, placing the camera to 3.5 m from the being photographed object, between a camera position and the next should be between 0.5 and 0.9 m, this is about a step. In this way, the shortest is the distance from the object, the greatest numbers of pictures are made and therefore the geometry of the element is recorded in greater detail.

In addition, the resolution of each photograph depends on the used values in each different photographic parameter, such as the opening of the diaphragm, degree of ISO sensitivity and shutter speed fundamentally (Table 2).

Camera	Aperture	Focal length	Sensitivity	Shutter speed
Nikon D-80	F/5	26 mm	ISO100	1 second

Table 2: Picture characteristics

His determination is based on the kind of used camera. For the digital camara Nikon D-80, it must be put the ISO-100 and the F/11 or F/16 aperture from manual mode. After the camera is positioned in front of the object, we focus using the automatic mode and again passed the camera to manual mode. In this way we get the focal length does not change. Finally, we chose the rate of fire so that photography is a bit overexposed, with the aim that the sensor takes the best possible information. To achieve optimal results it is recommended using the tripod because, although it depends on the light, the shooting speed will be slow and freehand camera movement subtract sharpness to the image. In this sense, a trigger is used by cable and of course the shot is delayed to avoid movement of the camera that is very harmful in photogrammetry. It is also recommended lowered mirror previously, because reflex cameras always mirror is lowered automatically when the photograph is made, but there is usually an option in which you can program to be lower in advance and not a few moments before the shot. All of this aims to avoid the trepidation of the camera and to obtain sharper pictures that we can.

It has rejected the use of other types of lower-end cameras because we would not have the possibility of adapting all the above parameters, so we should use the camera on auto, which makes dependent on the result that we are able to photograph at the same distance and the same conditions of light, so that the camera adopts the same provision. But of course, it would be suitable to use tripod and naturally delaying the shot to avoid camera movement that is very harmful in photogrammetry.

PROCESAMIENTO IMAGENES. REVELADO DIGITAL Y GENERACIÓN DE LOS MODELOS 3D.

As mentioned previously, in photogrammetry, it is not possible to have immediate cloud of points that make up a three-dimensional model of the object of study, but once downloaded the pictures it is necessary to work with them with a specific software for the generation of the textured surfaces based on three-dimensional models.

This procedure of work will allow us to define the precision of the results, getting better the more elaborate definition is the processing of the data. This is because that in photogrammetry, the amount of points that define the virtual models generated, are determined to process data, not to capture them. In this way, we will be able to generate three-dimensional models of the object to be analyzed with different resolution, without any new records.

The first step is the processing of the images in RAW format, format in which the image has not suffered any post-processing and therefore stores all information captured at the time of the taking. To be able to make adjustments has been used RawTherapee program version 4.0.12.60, specific free software to process RAW files and convert them to JPEG or TIFF. Some aspects that we can handle will be the balance of whites, exposure, contrast, saturation, and calibration of the different color channels, all without loss of information.

Then, for the later geometric and structural analysis of construction, data are processed to create the corresponding textured surfaces (Fig. 3) that Yes, with a higher density of points for the study of geometric, looking as above to minimize the possible deviations in the representation of paths and generating sections of the various elements that make up the building.

Currently, thanks to the breakthrough that Photogrammetry has suffered in recent years, can be found online software for processing images that, as usual, offer basic services for free. This is a great time saver and whose precision is another of the parameters in this study. For this study, the program facilitated by Autodesk has used 123DCatch, with which the three-dimensional models of the constructive element analyzed, are obtained as well as orthophotos that help and enrich the layout of the traditional planimetry: floors, elevations and sections.

The results are exported in format DXF and OBJ are compatible with specific programs for the treatment of three-dimensional mesh, as well as to proceed with its representation and graphical analysis. For the latter process has been used program Meshlab, an open source, portable, and extensible system for the processing and editing of unstructured 3D triangular meshes which has been developed with the support of the 3D-CoForm project.

3. RESULTS

To demonstrate how the parameters of the photographs affects final three-dimensional models based on the processing of photos taken, three types of adjustments are conducted on the images.

To demonstrate the variations that occur in final three-dimensional models on the basis of the information contained in the images used, before proccessing pictures to generate 3D models, have been different settings of its parameters from the RAW files.

JPG1- Obtained directly to make photographs. In this case the settings are those that camera Nikon D-80 automatically to take the picture

JPG2- Obtained in a first processing of RAW files, adjusting the parameters corresponding to the exhibition, so removed the areas burned or over-exposure and the areas in shadow or under-exposure.

JPG3- Obtained in a new processing of the original RAW files that fit the parameters corresponding to the sharpness of the image

To adjust the parameters of RAW files aims to facilitate the search of homologous points between the different photographs, so it has tried to differentiate as much as possible the environment of each pixel to the next. This is due to the program of return to assess the correspondence between points evaluates pixels around each of them, how much more difference exists between those pixels, will be easier to check the correctness of the approval.

As a result, we obtain three different 3D models, one for each group of processed images, each of which is generated from a cloud of points on which you create a faceted inheriting the texture of the corresponding images group.

3D model	Vertices	Faces	Texture
A	139626	91981	JPG1
B	141435	93348	JPG2
C	104666	103592	JPG3

Fig 1. 3D model characteristics.

Model B, retrieved by adjusting the parameters corresponding to the exhibition of RAW files, which has highest number of vertices, this is localized homologous points. However it is in model C, retrieved by adjusting the parameters corresponding to the sharpness of the RAW files, where the largest number of faces, despite being the model with less number of vertices.

Furthermore, the model A, obtained from the JPG files directly extracted to the tealizar photos, maintains values similar to those of the model B, below both in number of vertices and faces.

GEOMETRIC STUDIES

The geometric definition of the constructive element we can get is very similar in the three 3D models. However, there are certain deviations from the model B with respect to the models A and C that a virtually identical geometry is obtained.

These differences, little appreciable to the paths on the ground, are evident in a way clear in the layout of the arches of the edges that define the vaulting web studied. Thus, can be seen as resulting in the model RADIUS B is smaller than the one obtained in the other two models and their journey does not conform neither with the same precision but, rather, seems to be the path of two arches different to complete the entire length of the Ridge, one to cover the start of nerve and other necessary, equal radio that models A and C, which covers the rest.

SURFACE TEXTURE

One last factor to compare is the texture resulting in each of the surfaces. In this case it's studying the quality of detail offered by the 3D models with the continuity in the development of the surface.

Here, A and C models also offer a similar solution with a high quality of detail and a not very smooth surface continuity, although images on model C provide a proper appearance of texture far away from the excessively dark tones on the model A.

Although this difference in the appearance of both models texture does not seem to have been relevant when it comes to obtaining the homologous points, it should be noted that there is a difference of approximately 35,000 vertices between one and another model, which is one-third more of points that have been obtained in the model A to C.

In the model B takes place otherwise, while quality of detail is impaired by excessive shading, surface continuity achieved is higher than in the other two cases.

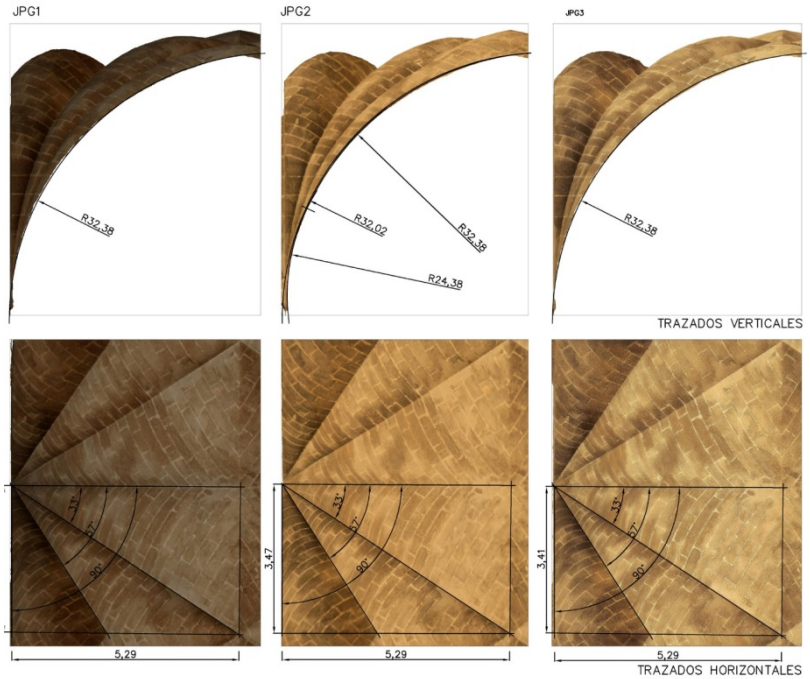


Fig 1. Geometric studies on orthophotos.



Fig 2. Surface Texture View.

4. CONCLUSIONS

For the case of the stone buildings and more specifically for systems of vaults that used this material and in view of the results, we can say that a treatment of photos taken prior to processing them to make an architectural survey by photogrammetry, improves accuracy and visual quality of the results.

It can thus be to compare the results obtained by the image files directly generated by the camera with those obtained as a result of adjusting various parameters of RAW files.

In this sense, the generation of different models from the setting each of them one of the parameters that determine the end result, has allowed us to associate each of these settings with a concrete improvement. In this way, greater surface continuity is achieved with the setting of the exposure parameters, as in the case of the B model, which is motivated by the greatest number of vertex, or homologous points that the defendant has managed to determine. However to achieve greater accuracy in detail, it is necessary to adjust the sharpness, as verified in the model C. In addition the improvement achieved in one of the features has meant one decline in the other.

In terms of the work of data collection, prior planning of the field work, here takes on vital importance as, not only ensures the correct and complete information, but that avoids unnecessary redundancies and significant time savings can be invested in the phase of processing.

Should also mention the improvements obtained in the final graphic documentation, since it gets textured surfaces whose appearance improves in the same degree that makes it the sharpness of the resulting images, being in view on floor where you can see more accurately is not necessary to carry out this work with the data from the laser scanner, and puts in evidence the low difference between the orthophotos obtained from the different 3D models.

On the other hand, textured surfaces generated by Photogrammetry are the best instrument for the study for pathologies because the data reported precisely thanks the lightness values of the photographed surface.

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