Photogrammetric techniques applied in bad lighting and reflection conditions: the case of a museum workart

Laura Inzerillo[1]

[1] University of Palermo, Palermo 90100, ITALY

laura.inzerillo@unipa.it

Abstract. In recent years, Photogrammetric techniques have been widely used especially in the field of Cultural Heritage. However, some applications remain undefined in cases where the boundary conditions are not suitable for the technique. Examples of this are instances where there are poor light conditions and the presence of glass and reflecting light sources. This paper shows the case study of the SfM application, using a DSLR camera (Nikon D5200), of the Head of Hades inside a glass theca and under a large number of light sources at different distances and of different intensities and sizes. The geometric evaluation has been made comparing the DSLR camera model against the 3D data acquired with structured light systems.

Keywords: photogrammetry, museum, 3D model.

1 Introduction

Photogrammetric techniques have had widespread use and application especially in 3D acquisition of the Cultural Heritage and in particular of Architectural and Archeological works. [1-6]. Thanks to these numerous weapon applications and experiments, it has been possible to draw up a sort of manual of application that indicates the ideal and optimal conditions which work to get a trusted model under the metric profile. [7-8]
In this study, on the contrary, a very particular application is shown: it is a specimen of inestimable historical value: the *Head of Hades*, exhibited in a museum inside a theca. The presence of 5 light points, with a diameter of 6 cm, at the top, and all dark around has made the use of the flash necessary, which however has created problems of reflectance due to the glass. The data set produced according to the photogrammetric indications [9-12] produced a final model that seems not to have taken into account the real problems of using the flash, the change of lens and focal length. On the contrary, the model obtained has exposed colors and geometries of the work that are not always perceptible from an observation with the naked eye.
Despite these operative conditions we cannot speak of geometrical and, let alone, radiometric accuracy. The geometric evaluation has been performed comparing the DSLR

camera (Nikon D5200) model against the 3D data acquired with structured light systems.

1.1 Aim and structure of the paper

This paper aims to evaluate the potential of a DSLR camera, verifying its imaging capability to provide accurate 3D geometries of the 3D models in bad lighting and reflection conditions. For this reason, a methodology is applied to the Head of Hades sample and the achieved result is compared to ground truth data collected with a high-resolution structured light scanner.

The methodology adopted, requires skills in the fields of image acquisition and processing. [13-14]. However, it would be desirable to identify a repeatable methodological approach in these extreme conditions.

2 Head of Hades sample

The Head of Hades (or Barbablù) is a polychrome terracotta head of Hellenistic age, most likely depicting the Greek god of the Inferi Ade and coming from the ar-chaeological park of San Francesco Bisconti to Morgantina (Enna, Sicily, Italy).

The use of color in the Head of Hades has a clear symbolic value: the blue of the beard, in fact, devoid of realistic references, recalls the concept of eternity for assimilation with the color of the sky, but has also funerary references, relating, therefore, to the image of the god of the underworld.

The Head of Hades was stolen at the end of the Seventies by the archaeological site of Morgantina, in the territory of Aidone. Between the end of the seventies and the eighties, the archaeological park was the subject of numerous underground excavations, resulting in confiscation of finds, illicitly exported and returned to Italy in recent years.

In the following, figures are shown of the Head of Hades within the glass theca and with the light sources on the head.

In figure 1, you can see the environment and the visibility of the object in the same way of the naked eye: without the flash mode the camera reproduces the same colors that you see with your eyes. The colors are a little faded and difficult to see in some parts of the head. In figure 2, you can see the black environment and the contrasted colors due to the flash camera mode.

The final model is affected by these shades and intensities of colors from both data sets with and without flash. So we will observe the shadows due to the light sources (without flash) and the contrasted colors of the hair and beard (with flash). To obtain a color fidelity of the 3D model, we needed to use a color checker close to the object and having different light sources, but this was impossible in the Head of Hades sample.

Fig. 1. The Head of Hades exhibited at Salinas Museum inside a glass theca, under light sources. These pictures have been done without flash.

Fig. 2. The Head of Hades flash pictures: in these pictures it is possible to admire the hair and beard colors.

3 3D reconstruction model

The data set has been performed considering the resolution of the Structured Light Laser model. [15] In fact, it has been necessary to have the camera shots at a 1 m distance from the object to obtain a GSD of 0.07272 mm according to the Nikon and laser specs (Tab1,2).

The data set was made in two different altitudes according to two different horizontal layers and following a circle around the object with 1 m radius approximately.

The model carried out has been scaled using the side glass theca measurement. It was interdicted to use any other markers.

Table 1. Nikon D 5200 features.

	Nikon D 5200
Sensor name/type	APS-C CMOS
Sensor size	23.5 x 15.6 mm
Image resolution	6000x4000 px
Pixel size	4 micron
Focal lenght	55
Distance from the object (m)	1
GSD (mm)	0.07272

Table 2. Structured Light Scanner features.

	Structured Light Scanner
3D resolution (mm)	0.1
3D point accuracy (mm)	0.05
3D accuracy over distance	0.03% over 100 cm
Texture resolution (mp)	1.3
Colors (bpp)	24
Structured light source	Blu LED
Data acquisition speed	1 mln points / sec.
Video frame rate (fps)	7.5

The calibration and the scale phase of the model, made before to produce the dense reconstruction, allowed the comparison in the Cloud Compare environment [16]

The data set has been made with 284 shots at 24 Mpx, of which have all been aligned. The parametric calculation requested 22h 27min 51s and the final 3D model has 7.4332,829 faces and 3.781,806 vertices. (Fig. 3)

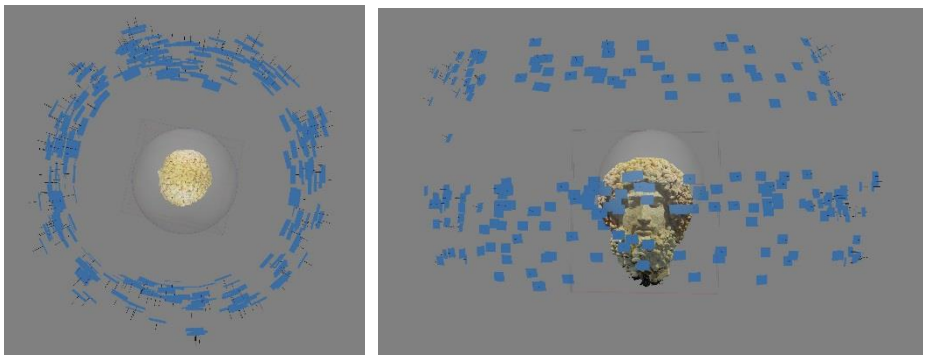

Fig. 3. Top and front view of the 284 shots.

Fig. 4. Right, front, back and left side of Head of Hades 3D textured model.

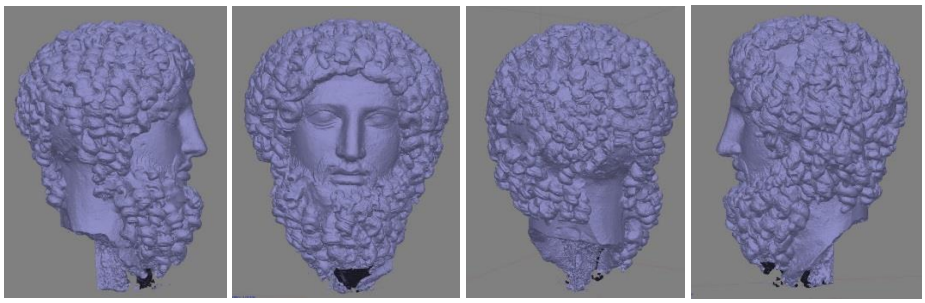

Fig. 5. Right, front, back and left side of Head of Hades 3D meshed model.

Fig. 6. Point and dense cloud and detail of Head of Hades.

In figures 4, 5, and 6, you can see the different visualizations of the photogrammetric model: the textured, meshed one and also the point and dense clouds and the textured detail.

4 Geometric results

The geometric evaluation has been performed in the Cloud Compare environment through the alignment between the dense cloud model carried out from the photogrammetric reconstruction and the Structured Light scanner. The alignment has been made using the two clouds by picking at least 4 equivalent point pairs.

The result overcame every expectation with a RMS value of 0.00689649

As you can see in figure 8, the worst parts in the model are those that are in correspondence of the hair and beard. This result was presumable since those are the most complex geometric parts of the Head.

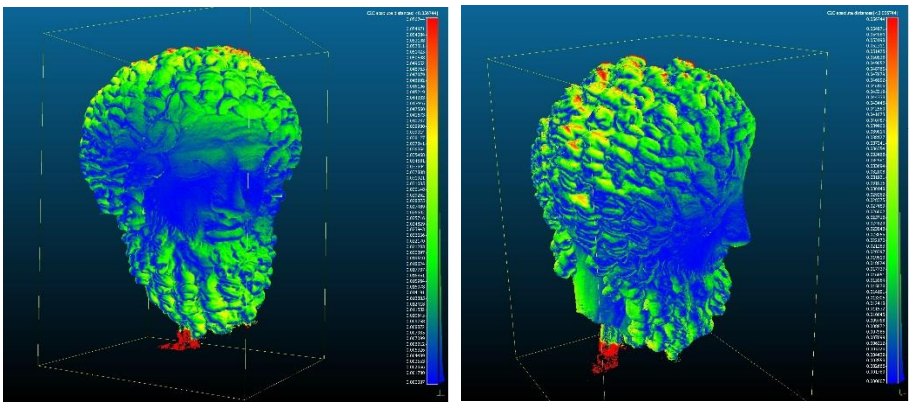

Fig. 8. Two different views of the alignment phase on Cloud Compare.

5 Conclusions

This paper presented an evaluation of (something missing here) to verify DSLR camera and its capability to provide accurate 3D geometries of the final models produced under bad lighting and reflection conditions.

The comparison of the models shows that the image outputs from Nikon D 5200 camera is suitable to cover the geometric requirements in replicating small objects in a bad external environment. This outcome fits the needs of Small and Medium Heritage Museums in producing accurate 3D catalogues of their small artifacts and objects even if they are inside a glass theca.

The results from the experiments show potential for the future of 3D Modeling within the fields of Archaeological and Architectural artefacts in any lighting and reflection condition. Considering the RMS value it was interesting to make a 3D printing at real scale. (fig.9)

Fig. 9. 3D printing.

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