The 11th International Symposium on Virtual Reality, Archaeology and Cultural Heritage VAST (2010)
A. Artusi, M. Joly-Parvex, G. Lucet, A. Ribes, and D. Pitzalis (Editors)
Short and Project Papers

3D-digitization of the "wild goat" vases

D. Kolin[1] and M. Joly[1]

[1] Centre de Recherche et de Restauration des Musées de France, Paris, France

Abstract
The wild-goat vases are a style of Greek vases that have been crafted between the 7th and 6th century BC. The 3D-digitization of these vases has been ongoing at the C2RMF for a few years now. Different scanning techniques have been used, and the latest and most effective, is through the use of a NextEngine camera. The aim of this project is to help curators to digitally analyse the vases, compare their shape and colours, and monitor their state through time.

Keywords: 3D scanning, laser triangulation, photogrammetry, wild goat vases

1. Introduction

The Wild Goat style refer to East Greek vases, crafted between 670/660 and 580 BC, in South and North Ionia, Chios, Aeolis and in the southern part of East Greece (Rhodes and its neighbourhood). The "wild goat" style owes its name to the predominant motif found on such vases: friezes of goats.

The digitization of the "wild-goat" vases has been a project ongoing at the C2RMF for a few years, in collaboration with the Greek, Etruscan and Roman Antiquities (GERA) department from the Louvre museum. The history, the state of the vase and the artistic point of view where taken into account by Anne Coulié, curator at the GERA department, in order for her to chose the most relevant art pieces to be digitized.

Different techniques have been experimented, in order to obtain realistic 3D models. The first method implied the use of photogrammetry, which consists in taking multiple picture around the object, and then compute them into a 3D model. The result is photo-realistic, but has a poor level of details concerning the surface. The second method, currently in use at the laboratory, is based on a triangulation technique, using a laser-grid that is projected on the object, slowly browsing the surface. A digital camera is included in the whole system in order to have a coloured model.

2. Hardware used

2.1 Photogrammetry

The photogrammetry only implies the use of a digital camera, in order to obtain a 3D model. The number of pictures required varies, but the more the better, because most angles will be covered that way.

The C2RMF used photogrammetry by silhouette, in order to digitize some of the vases. In that case, 36 pictures where taken with a digital camera, the object being rotated 10° between each shot.

2.2 Laser triangulation technique

The 3D laser scanner used at the C2RMF to acquire the Greek vases is the NextEngine camera, manufactured by the NextEngine company. It's precision is ¼ of millimetre in the macro mode (used for scanning small object - range from 12cm to 22cm), and ½ millimetre in the wide mode (used for scanning medium sized objects - range from 35cm to 55cm).

A NextEngine scan is obtained in 2 minutes, using the maximum quality (40K vertices / inch² in macro mode, 4400 vertices / inch² in wide mode). However, to scan the full object, the operator needs to cover every blind spot, and rotate around the object (or having the object rotate itself). Therefore, the number of scans required in order to obtain a full 3D-model is between 30 to 70, depending on the object's size.

3. Software used

3.1 Photogrammetry

The software used by the C2RMF for reconstructing 3D models out of the pictures taken was developed internally. Alternatively, for some of the 3D reconstruction done at the C2RMF, Arc3D has been used, but in that case, the pictures have to be taken differently (i.e. having the camera turning around the object, not the object turning on himself).

DOI: 10.2312/PE/VAST/VAST10S/063-066

3.2 Laser triangulation technique

The Scanstudio HD software, is the acquisition software that is delivered with the camera. It integrates a control system for a turntable, which allows the object rotates automatically between each scan, and an automatic alignment algorithm, to reconstruct the 3D model. However, if this feature works with very small objects, models like the Greek vases have to be reconstructed manually, with Meshlab.

The Meshlab software is developed by ISTI - CNR in Italy, and integrates a lot of functionalities, filters and algorithms used for processing 3D meshes. The alignment tool, based on the ICP (Iterative Closest Point) algorithm, is used for reconstructing the 3D scans produced by the NextEngine camera, into a final 3D model. However, although the 3D reconstruction works well, a problem persists with the colour balancing of the NextEngine camera.

4. Issues encountered

4.1 Photogrammetry

The main issue resides in the fact that the silhouette needs to be perfect in order to obtain a good model. Depending on the colour and complexity of the object, having a good silhouette can be time consuming. Besides that, no major issue is encountered, but the 3D model resulting has a poor level of detail concerning the surface.

4.2 Laser triangulation technique

The main issue with the NextEngine camera is the white balance of the pictures used to create the texture of the 3D model. Between each scan, a new white balance is made, instead of keeping the same through the whole process. This results in distinctive colour differences between the different meshes composing the 3D model. Furthermore, the Greek vases being round, a shadow appear on the edges of the scans, due to the white neons used by the NextEngine to provide the camera the lighting it needs.

Different solutions have been tried in order to correct the white balance and the shadow problem.

– Blocking the neons light: using only external light sources, we tried to solve the problem of the shadow by making them disappear. However this solution accentuates the white balance problem: the neons light is considered by the camera as the main and closest source of lighting. Therefore, by suppressing them, the white balance become totally unstable, and wrong colours appear on the model.

– Adding strong external light sources: by doing so, the camera has an equalized light everywhere. However, the result is really insignificant and no major changes is noticed in the white balance of the camera.

– Using a colour chart on each scan: the white balance being wrong from the start, and changing between each scans, this solution is not relevant.

– Suppressing the darker parts manually: this solutions works well, although it is a fully manual process, which can take a lot of time, depending on the complexity of the object.

5 Issue solving

5.1 Shadow suppression

Due to the shape of the "Wild goat" vases, we always have, on a single scan, a bright zone located directly in front of the camera, and a dark zone, corresponding to the side of the vase. However, when the vase rotate for the next scan, the dark part goes over the previous' scan bright part. Therefore a clear colour gap appear. Currently, the easiest solution consists in suppressing the shadow part on both scans, so that the overlap zone only have the bright zone, with about the same luminance.

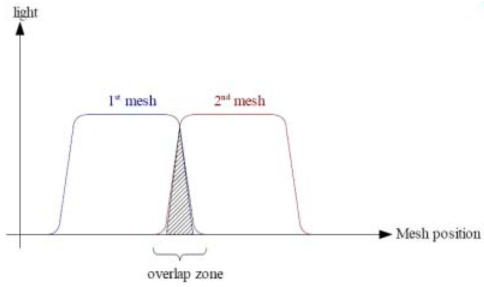

Figure 1: *luminance graph before shadow suppression*

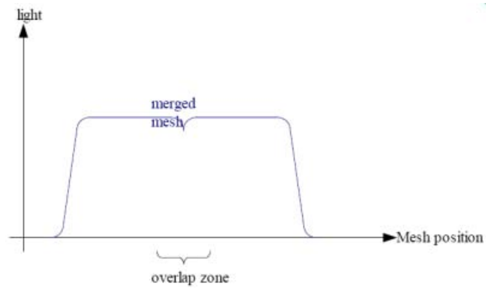

Figure 2: *luminance graph before shadow suppression*

6. Result obtained

6.1 Photogrammetry

The photogrammetry shows good results with the Greek vases. However, the surface contains absolutely no details. The average number of vertices for an object of this size is 10 000.

***Figure 3:** « Wild goat » Greek vase, texture applied*

***Figure 4:** « Wild goat » Greek vase, no texture*

***Figure 5:** « Wild goat » Greek vase detail, texture applied*

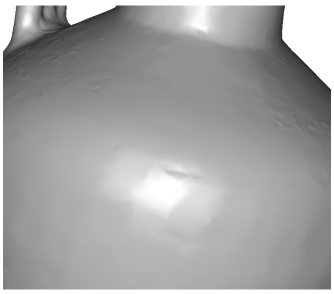

***Figure 6:** « Wild goat » Greek vase detail, no texture*

6.2 Laser triangulation technique

After cleaning the shadow, the 3D model we obtain has a smooth colour, and no distinction between the different meshes can be made. The result allow a clear view of the surface of the vase, revealing many details. The average number of vertices for an object of this size is 30 millions.

***Figure 7:** « Wild goat » Greek vase, colour per vertex*

***Figure 8**: « Wild goat » Greek vase, no colours*

***Figure 9**: « Wild goat » Greek vase detail, colour per vertex*

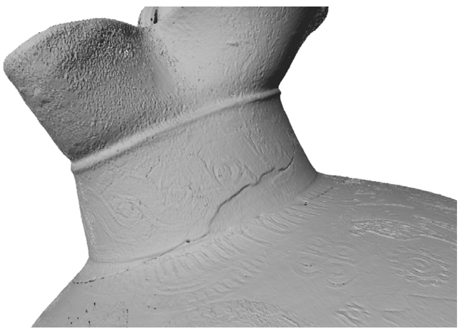

***Figure 10**: « Wild goat » Greek vase detail, no colour*

7. Conclusion

From a scientific point of view, the laser triangulation technique allows a better understanding of the surface of the Greek vases, using the 3D model obtained. It shows small cracks, small bubbles of air that have exploded during the cooking of the vase, restorations made, glued parts... However, the very high number of vertices composing the model make the model complicated to show on a web based 3D-viewer, and the problem with the white balance, which originates from the device used (i.e. The NextEngine camera) make any attempt of colour analysis complicated.

From a demonstration point of view, photogrammetry allow to show on web based viewer the 3D models obtained. However the absence of realistic surface information can be a problem for some analysis.

As a axis of development, the C2RMF tries to merge the 2 types of models to have both good surface information and colour information. However, major difficulties occur, and this is still a work in progress.

In the near future, a database will be created with historical, scientific and curatorial data linked to the 3D model, in order to help the transmission of the information between all cultural heritage experts. A web-based annotation system is also under study.

8. References

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