

DOCUMENTATION OF THE ROMAN BRONZE HAND FOUND IN THE SITE OF “EL TOSSAL” IN LUCENTUM

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ABSTRACT:

In this article we present the results of the investigation of an extraordinary piece appeared in the excavations of the Roman forum of Lucentum (Alicante, Spain) in 2005. It is a fragment of a bronze sculpture which is catalogued as a *Unicum*, that is, a work that presents some singular elements with no comparison with other examples of the Roman Art. This sample represents the only part that is conserved so far of that sculpture. Over this piece, a complete and exhaustive study where carried out. One of the most important parts of this study was the 3D digitizing of the rest, that permitted an anthropomorphic study of the hand and arm and giving as a result the position of the whole statue. From this reconstruction, and from the symbolism extracted from the rest, it was possible to obtain the identification of the person represented.

1. INTRODUCTION

1.1 Location of the discovery

In the year 2005, a very important archaeological rest was found in the site of “El Tossal”, in the ancient city of *Lucentum* –the roman name of the city of Alicante, at the south of Valencia– inside the roman province of *Tarraconensis*. This piece, a *Unicum* (that is, an extraordinary and unique rest due to its characteristics), was a left hand sectioned from a bronze statue.



Figure 1. Bronze hand found in “El Tossal”

After its appearance, the MARQ (Archaeological Museum of Alicante, management entity of the site and the rests appeared on it) contacted some spanish centres and institutions in order to begin a whole analysis of the piece and the performing of all the involved tests needed on the rest. One of the contacted centres was AIDO (Technological Institute for Optics, Colour and

Imaging), that became in charge for the 3D digitalization of the piece and its reconstruction.

The final purpose of this project was the execution of a complete and exhaustive study of the rest, and the site where it was found, in order to extract all the information it was possible from them for the reconstruction of the original statue the hand belonged to and to make the identification of the person the statue represented.

For that, all kind of tests were done, from chemical to radiological and geometric studies, apart from architectural and chemical ones from the site, for the space-time location of the rest.

Once performed all the tests and analysis, a series of hypothesis were emitted on the figure represented by the statue and its location inside the forum of the city the rest was found, proposing some possible identities for the person represented, the motivations of the creation of the statue and, also, presenting some possible total reconstructions of the statue and the forum where it was located.

1.2 What kind of rest was found

The found rest was the left hand of a bronze hand. This part was sectioned from its original statue some centuries ago and, in the present, it is the only part that actually exists. Apart from that, this is a very special and important rest because it presents some special features not very common in the statues created in the same period, so, at the moment it was found it became evident that a complete study on the hand was needed.

1.3 Tests carried out by AIDO

Inside this complete set of tests, one of the most important was the 3D digitalization of the rest. This part was carried out by AIDO, a technological institute located in Paterna (near

Valencia), that works on I+D+i projects related with optics and its applications. This institute, created 20 years ago, is a national and international leading centre in sectors like machine vision and colorimetry.

For that purpose, AIDO has a wide variety of systems, based on different techniques like laser scanning, white light scanning, contact scanning and photogrammetry. In that case, AIDO decided to use the white light scanning system in order to get the best possible results it can give.

2. TESTS OVER THE PIECE

2.1 Introduction

For the reconstruction of the original statue and its spatial an time location, a lot of analysis and studies were performed on the rest and over the site. For the site, this included chemical and architectural ones. For the analysis of the rest, this included chemical, metallographic, X-rays, tomography and 3D digitizing. On the next paragraphs of this article we develop and explain some of these analyses.

2.2 Structured light 3D digitizing

AIDO has a 3D digitizing system based on structured light. This kind of systems uses the fringes projection technique and extracts the geometric information from their deformation. These patterns are coded in order to create a correspondence between each pixel on the image with each code in the fringes network.

The pattern projection techniques can be classified, attending to the strategy used, in three main blocks:

- Multiplexing technique
- Spatial neighbourhood technique
- Direct codification technique

Inside the multiplexing technique, the most extending ones in the commercial field, there are three different subgroups:

- Binary technique
- N-ary codes technique
- Grey codification and displacement phase technique

The most important one in the commercial field, and the one most used for 3D digitizing systems is the first of them, the binary technique.

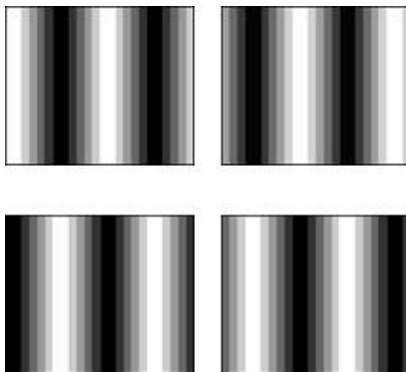


Figure 2. Fringes patterns

The measurement principle is as follows:

The system projects a vertical variable fringes pattern that displaces horizontally. The deformation of these lines is captured from the camera and the system compares them with the original form (straight) the lines had.

From the data obtained in this process, the system extracts the z-distance information of every point in the CCD, via a Fourier transform, obtaining a point cloud used in generating the shell.

These structured light systems are stable on the measurement. As the process is based on the analysis of the deformation of the fringes, without using reflected light from the object, there are avoided problems derived form that configurations. As an example, the Speckle effect (consisting in a ring noise) is avoided. Also, these systems can scan polychromatic surfaces without the step effect appeared on surfaces with different colours, consisting in a “step” in the transition between one colour and another.

Another important feature of the white structured light systems is the precision. With this technique it can be reached a high level of accuracy, pointing at values of accuracy at the level of microns (usually in the range of 10 microns). Also, it can be reached a level of resolution in the level of 50 or 75 microns. All of these features permit to get the digitalization of an object with a high level of detail and to get a high density corresponding polygonal model.

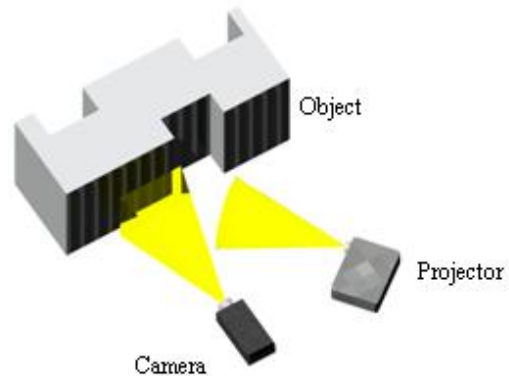


Figure 3. Schematic image of a white light scanner

2.3 Other tests

Apart from the digitizing process, other tests were carried out on the rest for the reconstruction of the whole statue and to identify it. Among these tests, it is important to highlight the following ones:

Architectonical reconstruction

As one of the purposes of this complex study was the spatial localization of the original statue, a architectonical reconstruction of the forum was carried out. This consisted in digging up all the forum area for finding al the elements the forum consisted in. After that, it was necessary to reconstruct the structure of the forum for finding t possible positions for the statue and its pedestal. With this, it was possible to locate the statue and to give it a symbolic meaning inside the forum.

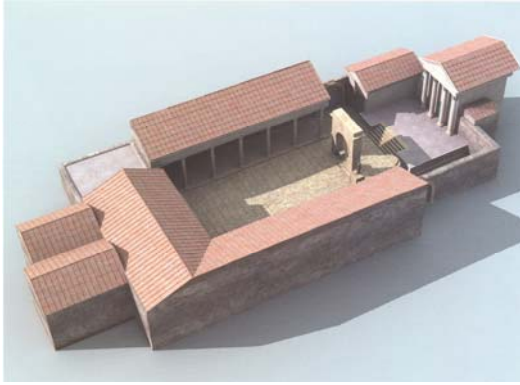


Figure 4. Reconstruction of the forum

X-rays imaging

One important test was the performing of an X-ray study. This was important because with this test, it was possible to get the inner part of the piece, obtaining information on the distribution of material inside the part and differentiating between the hollow parts and the solid parts.



Figure 5. X-ray image of the rest

Computer tomography test

One important question was the analysis of the inner part of the rest. For that reason, a tomographic study was performed. By this way, it was possible to get the thickness of the rest.

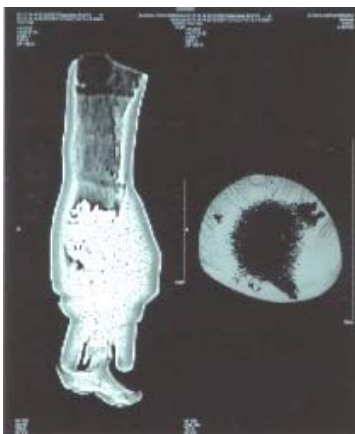


Figure 6. Result of the tomography

Metallographic study

A metallographic study was performed on the rest, in order to analyse and obtain the chemical composition of the rest, to identify the alloy and to detect the origin of the inner materials. This was important to determine how the statue was constructed and where and how the inner part was filled in after its sectioning.

Symbolism study

A crucial point for the identification of the person represented in the statue was the study of all the symbolism associated to the hand found. An important part was the identification and reconstruction of the sword carried by the statue and the ring attached to one of the fingers that has the image of a crook used by religious authorities.

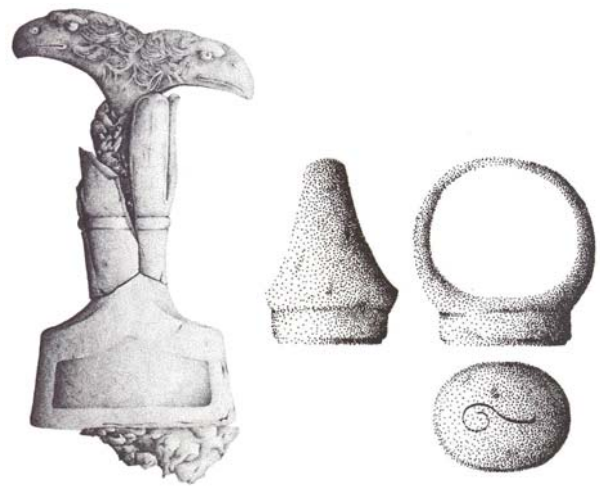


Imagen 7. Symbolic elements in the rest

3. OBTAINED RESULTS

3.1 Calibration

The first step before scanning is always to configure and calibrate the system, for getting the maximum performance from it. To fix the configuration, the most important point are the requirements of the customer, which in that case were a value of resolution of approximately 100 microns for the extraction of the maximum detail. The configuration process consists in the selection of the relative position between the fringes pattern emitter and the camera, which in that case was the most accurate one.

Once the configuration is selected, the next step is the calibration of the system. This is very important because the scanner needs this process to adjust the subsequent scans to the units given in the process and to fix the measurement error associated to each scan in this configuration. With this process we made the scanner work in the conditions specified by the manufacturer and needed by the customer. After the calibration process, the calibration parameters obtained were:

- Scanning area: 130 x 100 x 80 mm
- Precision: 10 – 20 μm
- Resolution: 100 μm

3.2 3D digitizing

For the digitizing process, a MML position system was used. This device consists in two fringes projector that projects a pattern similar to the scanner one, using the same light source. This system generates a set of optical marks over the surface of the object, allowing aligning each capture automatically every time it is scanned by obtaining the relative position of the different scans. This is similar to scanning with the support of a photogrammetry system, but with the difference that is not necessary to attach markers to the object, a very important feature in scanning archaeological pieces and heritage and art in general.



Figure 8. AIDO 3D digitizing system

For an optimal digitizing process it is very important to adjust the different elements of the scanner and to execute a test of the environment and working conditions. Among these options, it is needed to adjust the position of the diaphragm and the polarisers and the selection of the value of multi-exposure scanning. For the option of the diaphragm, the goal is to capture the optimal amount of incident light, trying not to saturate the camera and to adjust the image input threshold to a value that allows getting enough image. Another parameter is the exposure of the camera. The darker the object is, the more opened the camera must be. The problem here is when the object is a polychromatic one, because every colour has a different darkness and normally the same value of exposure is not valid for every colour of the surface. In this case, the solution is the use of another option of the scanner, the multi-exposure. With this option, the scanner can execute 2 or 3 different scans with a different exposure value, allowing getting information of dark and light colours. The last parameter to adjust is the position of the polarisers attached to both the emitter and the camera. With this element is possible to progressively decrease one of the components of the electromagnetic field, giving as a result that the brightness over the piece progressively decreases. This option is very useful when scanning bright objects because we don't need to use spray to do the surface of the object become flat.

The final purpose of these adjustments is to get the best scanning proceeding. To complement this part, is important to fix a good scanning strategy, consisting in finding critical the zones in the piece for the scanning process. Normally, these zones are related to shadow zones where the scanner cannot access. In this case, these zones were two: the palm of the hand, hidden by the fingers and the hilt of the sword, and the interior

part of the piece or inner cavity, because it the scanner couldn't access there.

Once fixed the scanning process and strategy, it is the moment to begin scanning. The scanning strategy consisted in dividing the hand in three different parts that were processed in different computers:

- Upper zone
- Medium zone
- Lower zone

There were two reasons for dividing the piece in 3 parts. One of them was to avoid the overload of a single computer, because every part processed had much less points and a lighter weight of the files generated. The other reason was to save time, by post-processing the three parts at the same time as each of them was scanned. By this way, a total of 250 scans were taken, producing a total of 18 million points.



Figure 9. Image of the scanned hand

3.3 Post-processing: final results

Once the hand was scanned, it began the post-processing of the obtained files. As it has been told, the hand was divided in three different parts, which generated a total of 18 million points that, after the application of the filtering tools were reduced to 12 million points. After the post-processing of the different parts of the hand it was needed to join them, for recovering the original model. For that reason, before proceeding to generate the final model, a deviation report of the deviation between every part was carried out, ensuring that the model deviations due to processing in parts was under the customer tolerances.

After the application of the merge tool, a polygonal model including only external information captured from the scanner was generated. To complement this information, it was necessary to obtain the inner part of the hand. This was performed executing the volumetric textures method, supported by the information extracted from some bi-dimensional images. After that, some optimization tools were applied in order to enhance the quality of the final model.



Figure 10. Final model and some details

Once the model was finished, and once the optimization tools were applied, a model of 7 million points was created, with a processing time of 20 hours. As this model was too much heavy for the customer, some decimation operations were performed, in order to reduce the weight of the file and allow the customer to manage it. This reduction was executed with reduction values of 1/2, 3/4, 1/4 and 1/10.



Figure 11. Pictures of the final model

4. CONCLUSIONS

4.1 3D digitizing and the reconstruction and identification process

Thanks to the 3D digitalization of the rest, it was possible to obtain the 3D shape of the rest in digital form. This point was crucial to perform the anthropomorphic study, because the virtual information allows recreating different positions and to

add and delete parts continuously without acting on the original one, avoiding any kind of damage on it due to the manipulation of the rest. Thanks to the digital model and the virtual work, some total reconstructions were executed, presenting different possibilities for the statue, simulating different positions of the hand with respect to the body, and analyzing the intersection between the sword and the body, allowing to select the position unique and most possible position of the arm. This point was one of the goals in the reconstruction of the statue and gave as a result the recreation of the possible statue the citizens of Lucentum could see in their forum.



Figure 12. Reconstruction of the original statue

4.2 Information obtained from the symbols of the rest

From the symbols of the rest, it is possible to extract important information for the identification of the person behind the statue. For example, the hand holds the tilt of a *Parazonium*, a special ceremonial sword reserved only for high rank military men, for high society members and for the emperor. From the data of that, is deduced that the statue represents a person dressed in the military way, that is, a *Thoracata*. Also, in one finger there appears a ring with the symbol of a *Litus*, a crook that represents the maximum religious command and reserved for very important people of the empire.

4.3 3D digitizing and the reconstruction and identification process

Finally, with the reconstruction of the statue, with the reconstruction of the forum and with the information extracted from the architectural study that gave the location of the possible position of the statue inside the forum, it was possible to obtain a reconstruction of the original forum with all the elements inside it, including the most important one: the statue, that possibly represented the emperor.

An image of this forum could be like this:



Figure 13. Reconstruction of the forum.

As a final conclusion, we can say that this example shows the power that the new technologies (optical and digital), that can help us in the art in general in obtaining better results in less time and giving visual information that otherwise it could be impossible. Also, this has shown that with the new technologies, it is possible to work on a rest without using the physical rest, apart from obtaining the digital model, allowing to perform a lot of geometric, optical and geometric tests while it is preserved from damage, as it is not used anymore, and can be restored and kept from damage and deterioration, and shown in the museum.

5. REFERENCES

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