

# ARCHAEOLOGICAL INVESTIGATION ON THE FOUNTAINS IN POMPEII AND CREATING VIRTUAL ENVIRONMENTS

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### ABSTRACT:

The archaeological site of Pompeii is surely one of the best known areas of Roman world, and many mosaic fountains were found in some elegant houses. Generally, it seemed that mosaic fountains which lay out in the gardens of the houses, shows one of the decorations, but the investigation for the mosaic fountains by archaeologists gave us many possibilities to know many aspects of daily Roman life. For example, the mosaic fountains had two functions: they were not only the decoration of gardens but also little *sacellum*, namely a shrine with a religious function. Therefore, splendid and brilliant mosaic fountains were produced using shining effect as a *sacellum* by the Roman craftsmen.

On the contrary, it is also important issue to know the geometrical features of mosaic fountains which give valuable information for studying culture in those days such as sculptural technique, art, aesthetic sense and so on. In order to understand religious meaning and structural features of the mosaic fountains, 3D modelling and visualization is an efficient method. However, the most difficult issue for the archaeologists in an archaeological project is surely the graphic campaign, acquisition of geometrical information such as size, length and shape for the archaeological objects.

In these circumstances, collaboration among the professional of different disciplines is absolutely necessary, and in order to realize these relationship, archaeological and photogrammetric investigations for the mosaic fountain in Pompeii were performed in cooperation with archaeologist and photogrammetrist.

## 1. INTRODUCTION

The archaeological site of Pompeii is surely one of the best known areas of Roman world, and many mosaic fountains were found in some elegant houses. Some years ago, we have begun a project about mosaic fountains in Pompeii (Iorio, in press) with following parts:

- 1) Ancient bibliography;
- 2) Research of ancient photos;
- 3) Research of ancient drawings;
- 4) Photo campaign;
- 5) Graphic campaign;
- 6) Final publication of the research.

Generally we use very traditional methods to draw, that is to say metre, pencil, eraser and naturally hands. Therefore, the most difficult part of this project is surely the graphic campaign, because drawing a mosaic fountain has many difficulties.

On the contrary, a convenient 3D measurement method using consumer grade digital camera is enormously expected with appearance of the low cost and high-resolution consumer grade digital cameras. Indeed, developing low-cost photogrammetric system have been ranked as one of the important issues during last decade in the ISPRS WG regarding Cultural Heritage; WG V/5 (World Cultural Heritage) for 1996-2000, WG V/4 (Image Analysis and Spatial Information Systems for Applications in Cultural Heritage) for 2000-2004, WG V/2 (Cultural Heritage Documentation) for 2004-2008. Furthermore, establishing

cooperative relations with related disciplines is also the important issue in the ISPRS WG regarding Cultural Heritage and cooperation is indispensable in archaeological investigations.

In these circumstances, archaeological and photogrammetric investigations were performed in cooperation with archaeologist and photogrammetrist in this paper.

## 2. MOSAIC FOUNTAIN IN POMPEII

Pompeii is the best site to study the mosaic fountains because there are about twenty mosaic fountains. The archaeological research in Pompeii gives us many opportunities for the knowledge of Roman world and the study of ancient mosaic fountains in this town also gives us many opportunities to know water technology and handicrafts of a typical Roman town in the first century A.D.

### 2.1 Mosaic Tesserae

The ancient Greeks and Romans used mosaics for floor but in some case we can see mosaics on the walls. The first mosaics in Italy are in South Italy and they belong to III or II century B.C. and they were made by little stone; ancient Greeks called them *lithostroda*. The tesserae of first mosaics were black and white but, generally from the I century B.C., they were coloured

(Pernice 1938). For mosaic tesserae, Greek and Roman craftsmen used stones but from the first century B.C., they began to use glass tesserae.

An other important aspect of Greek and Roman mosaics is the size of tesserae. Generally from the I century B.C. until the I century A.D. The mosaic tesserae are very little because in this period Greek and Roman craftsman were specialized to cut stones.

## 2.2 Portrayed Divinities on Mosaic Fountains

Usually the archaeologists call mosaic fountains, *nimphaei*, because *Nimphae* were divinities of rivers, lakes, springs, that is to say water. The importance of water in the mosaic fountain is testified by many factors.

The first factor is the colour. In fact tree colours are often present in the mosaic fountain, the azure, the blue and the green and they are colours which remind us to the rivers, the sea, etc.. The reference to water is testified also by the divinities, animals and plants portrayed on mosaic fountains. In fact many time on mosaic fountains some divinities are portrayed like *Neptunus*, the king of the rivers, lakes, sea etc. *Oceanus*, *Nereides*, *Venus* with *Cupidus*, her little son, etc. Among the animals, we must remember gees, ducks, swans, dolphins, fishes and among the plants, the reeds.

Another reference to the sea is the presence of many kinds of shells; generally they are put on the limits of mosaic fountains and they have the function of a frame; in other cases, the shells delimit a space for a decoration.

## 2.3 Gardens in the Roman Houses

Usually in the Roman houses the mosaic fountains were in the gardens, in the open air, in contact with the sky, so the azure tesserae remind to the sky.

So we have written, *Venus* was portrayed in mosaic fountains, but we must remember another aspect of this divinity; in fact *Venus* was also the divinity of the gardens and in Athens there was a sacred area, *Oi Kepoi*, that is to say “The Gardens”, where *Aphrodites*, the Greek *Venus*, was venerated like *Aphrodites en tois Kepois*, that is to say “*Aphrodites* in the Gardens”. So we can say, the mosaic fountains had two function: aesthetic function and religious function.



Figure 1. House of Big Fountain

## 2.4 House of Big Fountain

“House of Big Fountain” (Figure 1) lies near the *Forum*, the most important square in a Roman town, in the North-West area of ancient Pompeii. It is a good example of mosaic fountain in the Roman Age (La Rocca – de Vos – de Vos, 1994). The first phase of the “House of the Big Fountain” was built during Republican Roman Age; in fact the façade is built, in *opus quadratum*, by large stones. This house was subsequently transformed and in the last phase, a beautiful mosaic fountain was built in the west side of the garden (Figure 2). The place of the fountain wasn’t accidental, but it was well considered. In fact the fountain is in the garden, leant against the west closing wall of the garden; in that position, all the guests of the owner of the house could see it when they arrived.



Figure 2. Mosaic Fountain

## 2.5 Characteristics of the Mosaic Fountains

The archaeologist divide the mosaic fountains in many categories and this mosaic fountain belongs to *aedicula*, a Latin word meaning “little temple”, because its shape is like a little Greek temple. So we have written, this fountain is a good example of mosaic fountain of Roman Age; in fact it has many characteristic of the mosaic fountains.



Figure 3. The Triumph of the Colours



Figure 4. Elegant White Swans



Figure 5. Oceanus

**2.5.1 Colours:** The first characteristic is the glass coloured tesserae and in this fountain we can admire “the triumph of the colours” (Figure 3). Admiring this fountain, we can notice that the azure and the green are the predominant colours (Figure 3-4). The religious aspect of this fountain is testified by the presence of *Oceanus* (Figure 5). This divinity, not causally, is portrayed above a little rectangular covered lead space from where the water came out; so *Oceanus* gave kindly the water, symbol of life and joy. Let’s notice that the colour of the tesserae in the background is the blue. On the upper part of the fountain, we can admire two very elegant white swans (Figure 4); the birds are portrayed while they soar in the blue sky. Their position on the fountain is symmetric because the symmetry was a very important role in Greek and Roman architecture and decoration.



Figure 6. Gees & Blue Tesserates



Figure 7. Shells on the Upper Part of the Figure 5



Figure 8. Shell on the Low Part of the Fountain

**2.5.2 Decorations:** The presence of the swans in this decoration is very important because in the second-half of I century A. D., when probably the fountain was built, the swans are portrayed also in the painting and in the paintings of ancient Pompeii, we have many examples. Not only swans are portrayed in this fountain but also the gees (Figure 6). The gees are portrayed lower, almost in the central zone of the fountain. They don’t swim, may be we expect, but they are on their paws; but the blue colour of the tesserae, in the background, remind us to water.

So we have written, the shells are another very important factor for Roman mosaic fountain. This fountain has two kind of shells, the first is on the middle and on the upper part of the fountain (Figures 3-7) and the second in on the low part (Figure 8). The second kind of shell, the murex, was very important in the Roman Age, because, like the Phoenicians, the Romans used the murex to make the purple, a very expansive product that the Romans used to have the famous “purple red”. The shells of murex form a line and upper there is a beautiful decoration with glass blue tesserae.

**2.5.3 Statues:** When this fountain was excavated, the archaeologists found in the basin a little bronze statue representing *Cupidus*, with a dolphin; nowadays this statue is in the National Archaeological Museum of Naples. We aren’t amazed because *Cupidus* is *Venus*’s son and *Venus* is one of the most important divinities representing on the mosaic fountains. This fountain is surely very elegant because not only mosaic tesserae decorate it, but in the low part, there are some marble slabs, a marble the basin, a little marble staircase and two marble mask for tragedy (Figure 9). We can understand the presence of this mask if we remember the masterpieces of ancient Roman writers, like *Petronius*. This writer describes the dinners of the ancient Romans and so we know during the dinner they could watch a theatrical performances. Probably the owner of the “House of Big Fountain” had a dinner in the garden, in the open space, so the Romans loved and he watch a theatrical performances.



(a) Left Mask



(b) Right Mask

Figure 9. Two marble mask on the Fountain

**2.5.4 Pumice stone:** Finally, the last characteristic of this fountain is the presence of pumice stone in the low part (Figure 8). The pumice stone was used for decoration from the I century B.C. until the first years of II century A.D.. The Romans used pumice stone to make an impression of a cavern where often there was a spring.

### 3. 3DIVISION

A convenient 3D measurement method using consumer grade digital camera is enormously expected in various application fields with appearance of the low cost and high-resolution

consumer grade digital cameras, and there are many software for digital photogrammetry on the market in Japan.

In these circumstances, many performance evaluations for consumer grade digital cameras have been investigated from the view point of digital Photogrammetry (Fraser, 1997; Kunii et al., 2001, Noma, et al., 2002; Habib, et al., 2003), and it has been concluded that consumer grade digital cameras are expected to become useful tool for convenient digital photogrammetry (Kunii & Chikatsu 2001). Furthermore, "3DiVision" under the key words; 3Dimension, Digital image and Visualization has been designed to perform convenient 3D measurement using consumer grade digital cameras (Chikatsu & Kunii 2002). However, there are some issues for practical 3D measurements in many photogrammetric software including 3DiVision. One is surveying of Ground Control Points (GCPs) for camera calibration, and the other is interior orientation procedure which is implemented beforehand using test sheet or test target. These restrict conditions should be removed in ubiquitous digital photogrammetry using consumer grade digital cameras.

In order to remove these restrict conditions and to promote a convenient digital photogrammetry using consumer grade digital camera, 3DiVision was improved using triplet images. Figure 10 shows the concept of the improved 3DiVision (Ver.2), and it was concluded that 3DiVision Ver.2 is expected to contribute the various close range application fields since interior and exterior orientation parameters are calibrated simultaneously without any GCPs on object space(Chikatsu & Ohdake 2006).

Furthermore, the most difficult part on the project regarding the fountains in Pompeii was the graphic campaign, namely drawing the mosaic fountains, and it was realized that collaboration among the professional of different disciplines is absolutely necessary.

In these circumstances, archaeological and photogrammetric investigations for the mosaic fountain and sculptures in Pompeii were performed in cooperation with archaeologist and photogrammetrist using 3DiVision Ver.2.

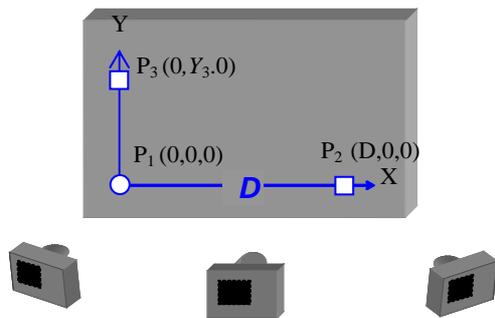


Figure 10. Concept of Improved 3DiVision

#### 4. ARCHAEOLOGICAL 3D MODELING

In order to investigate the mosaic fountains and statues using 3DiVision Ver.2, triplet images for the mosaic fountain and complex high relief sculptures were taken respectively.

##### 4.1 Mosaic Fountain

The mosaic fountain (Figure 2) lay out in the garden of the House of the Big Fountain. This house lies near the Forum, the most important square in a Roman town, in the North-West area of ancient Pompeii. Figure 11 shows ortho image and Figure 12 shows contour map with 5cm interval.

On the contrary, Figure 13 shows range images, and Figure 14,15 shows horizontal and vertical cross sections for the place where are shown in each figure.

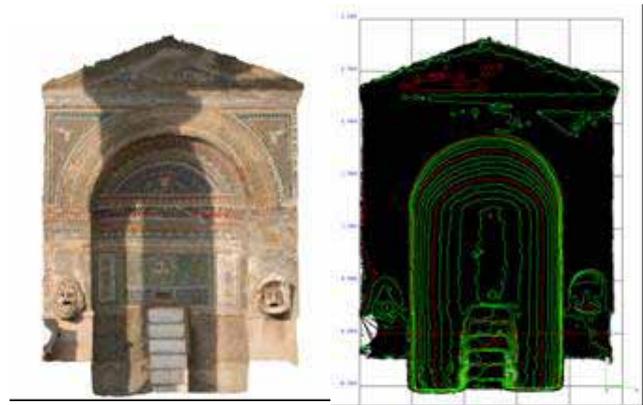


Figure 11. Ortho Image

Figure 12. Contour Map

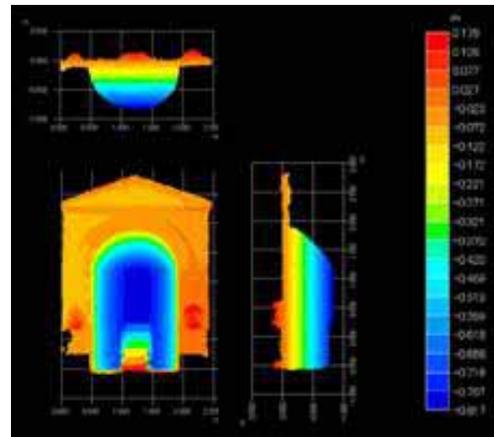


Figure 13. Range Images

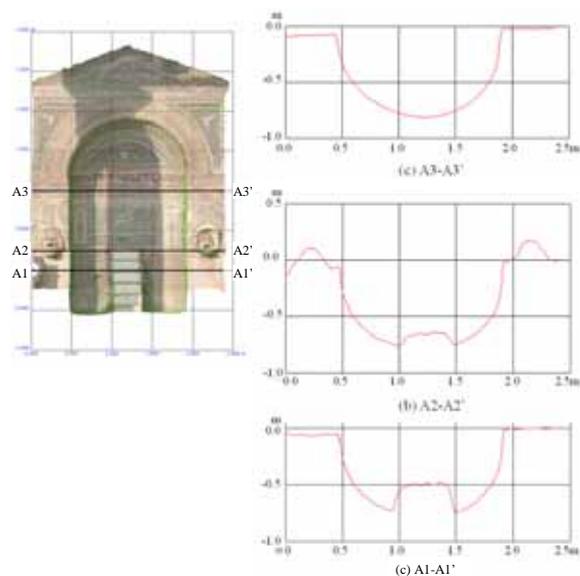


Figure 14. Horizontal Cross Section

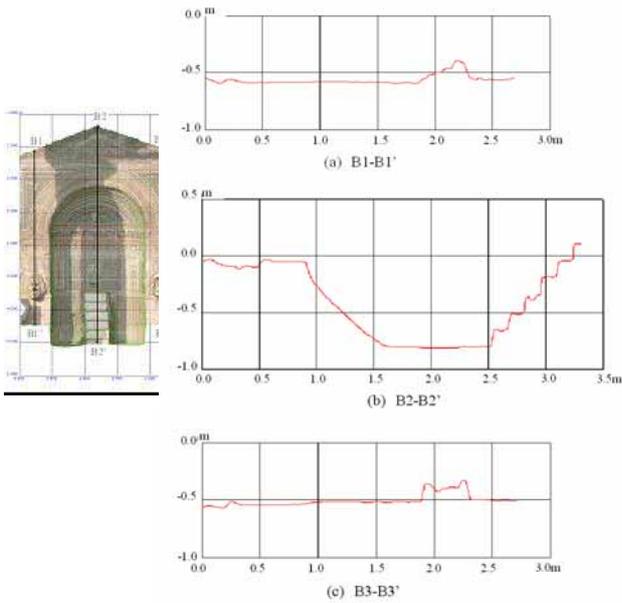


Figure 15. Vertical Cross Section

#### 4.2 Geometrical Features

Figure 16 shows horizontal cross section for A3-A3', and range images with a perfect circle 1.5m in diameter restrictively. It can be seen from the horizontal cross section for Figure 16 (a), (b) that the fountain was produced cylindrically with perfect circle. Therefore, it can be said from this point that the Roman craftsmen were expert on sculptural technique. On the contrary, nevertheless it seems that the roof parts shows roundly (for example Figure 3.), the roof part of the fountain shows linearity, doesn't show circle (Figure 16 (c)). From these results, it may be said that 3 dimensional illusionism was already fashionable among the Roman craftsmen.

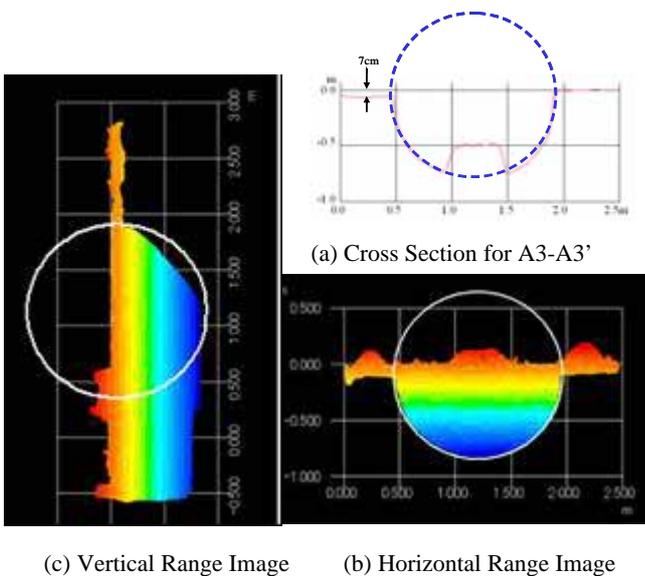


Figure 16. Geometrical Features

#### 4.3 3D Modelling

Recently, 3 dimensional visualization has been receiving more attention as a useful method to understand engineering phenomenon intuitively, or to find out important elements that

we can't detect in usual simulation. Furthermore, visualization under virtual environment is efficient method from a view point that people can appreciate or experience the archaeological objects or historical space through the computer.

With this motive, 3D animation for the mosaic fountain and sculptures were performed.

Figure 17 shows triplet images and TIN models for the high relief sculptures which decollate the fountain. TIN model were generated after camera calibration, and 3D texture modelling were performed using texture which were taken by consumer grade digital cameras.



(a) Left Mask



(b) Right Mask

Figure 17. 3D modelling of Sculptures

## 5. CONCLUSION

3 dimensional visualization is efficient method to understand the culture in those days intuitively. However, the most difficult issue for the archaeologists in an archaeological project is surely the graphic campaign, acquisition of geometrical information such as size, length and shape for the archaeological objects. On the contrary, a convenient 3D measurement method using consumer grade digital camera is enormously expected with appearance of the low cost and high-resolution amateur digital cameras.

In these circumstances, archaeological and photogrammetric investigations for the mosaic fountain in Pompeii were performed in cooperation with archaeologist and photogrammetrist.

As the results, it can be concluded that the mosaic fountains in Roman period were not only decoration of the gardens but also little sacellum from the view point of archaeological investigation. Similarly, it can be said that Roman craftsmen had high level skill in producing fountain, and 3 dimensional illusionism was already fashionable among the Roman craftsmen from the view point of geometric investigation using photogrammetric software 3DiVision.

Furthermore, it is verified that all the details of mosaic fountain and the colours of tesserae which were obtained by digital photogrammetry using 3DiVision aren't altered.

Consequently, it is concluded that collaboration among the professional of different disciplines is absolutely necessary, and the 3DiVision Ver.2 is expected to become useful software in the various photogrammetric application fields using consumer grade digital cameras. There is issue, however, for further work. This problem is development more simple and easy photogrammetric software, or more improvement of 3DiVision Ver.2 so that everyone can use in any situation without special technique.

### References:

Chikatsu H., Kunii Y., 2002, Performance Evaluation of Recent High Resolution Amateur digital cameras and Application to Modeling of Historical Structure, International Archives of Photogrammetry and Remote Sensing, Vol. XXXIV, Part5, pp.337-341.

Chikatsu H., Tatsuya O., 2006, Ubiquitous Digital Photogrammetry by Consumer Grade Digital Camera, International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVI, PART 5 (CD-Rom), ISSN 1682-1750.

Fraser C.S, 1997, Digital camera self-calibration, ISPRS Journal of Photogrammetry and Remote Sensing, Vol. 52, No. 4 pp. 149-159.

Habib, A., and Morgan M, 2003, Automatic Calibration of Low-Cost Digital Cameras, Journal of Optical Engineering, Vol. 42, No. 4, pp.948-955.

Iorio, in press, I ninfei ed i larari a mosaico nell'Area Vesuviana, in Actes du X Colloquium International de la Association Internationale pour l'Etude de la Mosaïque Antique, in press.

Kunii Y., Chikatsu H., 2001, On the Application of 3 Million Consumer Pixel Camera to Digital Photogrammetry, Videometrics and Optical Methods for 3D Shape Measurement, Proceeding of SPIE, Vol. 4309, pp.278-287.

La Rocca – de Vos – de Vos, 1994, Pompei, Milano.

Noma, T., Otani, H., Ito, T., Yamada, M. and Kochi, N.,2002, New System of Digital Camera Calibration, DC-1000, Proceedings of the ISPRS Commission V Symposium, pp.54-59.

Pernice, E., 1938, *Pavimente und figürliche Mosaiken*, Berlin.