From drone to web visualisation: accessing the 3D model of the Roman thermal complex of Massaciuccoli (LU)

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Introduction

During the last ten years, the use of photogrammetric surveys has become more intensive in Italy.It has been widely used both during archaeological excavation campaigns as well as to obtain accurate 3D representations of architectural monuments. The project presented concerns the realisation of a photogrammetric survey of a Roman thermal complex identified at Massaciuccoli (LU), carried out by using a RPAS, implemented with a series of data acquired by terrestrial laser scanners, performed by Castagnetti (2017) in the inter-university centre e-GEA within the project "Visual Versilia 3D". The web visualization of the whole model was achieved by using the open-source software 3DHOP, developed by Potenziani (2015) within the National Research Council.

The case study (Fig. 1) is located near the northwest coast of Tuscany, a few km from Viareggio and Lucca, overlooking the homonymous marshy lake. The structures lean on the hill overlooking the small village of Massaciuccoli (LU). The investigated thermal complex was probably built at the beginning of the I century B.C.E. and developed on two terraces. According to the sources, during the 18th-century structures were discovered on the upper terrace that were interpreted as the remains of a *villa d'otium.* These evidences are now unfortunately buried below the church of San Michele. The lower terrace is occupied by the structures of the baths. The complex is built around a large frigidarium with a corridor and a series of rooms to the west and a hypothetical vestibule to the east. To the south, there are two rooms with curvilinear walls and a large room heated by an oven under the floor (*sudatio*). Ciampoltrini (1994) supposed the complex probably belonged to the mercantile and senatorial Pisan family of *Venuleii*.

Fig.1 In this picture the panoramic view of Massaciuccoli (LU) Roman thermal complex is displayed.

Remotely Piloted Aircraft System survey

The first work phase consisted in the creation of a network of Ground Control Points (GCPs), measured with a dual frequency differential satellite receiver (GNSS Trimble R10). The survey procedure adopted on the site is defined 'real time kinematic' (RTK), according to which the device, in rover mode, calculates the positioning on the point with stations of variable duration 3 to 180 seconds. The antenna receives the differential correction – that is the refinement of the measurement – in real time from of a dedicated satellite put into orbit by the manufacturer of the device (RTX Trimble xFillTechnology): this configuration resulted in a declared precision of about 1 cm horizontally and 4 cm in elevation, with coordinates expressed according to the Gauss-Boaga projection system (zone 1) and Roma40 datum.

The measured landmarks, placed in a way to be visible from each other's location, set the basis for the topographic survey with an optical-electronic device (Trimble C5 total station).

The photogrammetric survey was made by integrating photos by RPAS and terrestrial photos. In the first case, both automatic and manual flights were performed to document the site with vertical images, and with oblique images, to detail the elevated structures.

An automatic flight plan was created with a double photo capture grid at an elevation of 10 and 15 m. In a subsequent phase of the work, terrestrial photos with a SLR camera were acquired to document the sides of the structures not visible from the drone survey.

A terrestrial laser scanner survey (TLS) was also supplied for the Massaciuccoli baths by e-GEA - inter-university centre.

The source data - drone and terrestrial images and TLS data - were processed in a single chunk with Metashape Professional 1.7.2: the workflow led to the creation of a 3D dense point cloud with an error of 0.0055 m. The 3D dense point cloud generated has been cleaned and optimized through specific Metashape tools by filtering and removing the least accurate points.

DEM (digital elevation models, GSD 8.33 mm/pix) and orthophoto (GSD 2.08 mm/pix) were processed from the 3D dense point cloud. On the one hand, these data constitute the basis on which it was possible to set up and draw up the traditional vector graphic documentation within the CAD environment; on the other hand, the starting point to obtain metric information automatically, quickly and extremely accurately, such as sections, walls elevations, contour lines, calculation of coordinates, distances and volumes (fig. 2).

Fig.2 In this picture the DEM with contour lines and cross-section of the thermal complex elaborated from photogrammetric survey (Agisoft Metashape ®) is displayed.

3DHOP

Thanks to the constant progress of new digital technologies applied to cultural heritage, in 2015 the CNR (National Research Council) developed an open-source software for the online visualization of three-dimensional models, even large ones, called 3DHOP[1] (3D Heritage Online Presenter). This program allows anyone to examine and interact with the 3D projects produced by any researcher, directly online and without installing any software. This project aimed at using 3DHOP to present the 3D models of the Roman baths of Massaciuccoli (LU) to a larger public.

A .ply format mesh of the photogrammetric model of the thermal complex, was created, together with the .jpg of the textures. Subsequently, the following 3DHOP software files were downloaded:

- The "Nexus 4.3" software, for the compression of the .ply file and its conversion into a format readable by the program.

- The "3DHOP 4.3" software, including files and templates for web visualization.

The mesh was compressed and converted it into .nxz format. By slightly modifying the templates, developed through the use of programming codes in HTML, javascript, and spiderGL, it was possible to insert any three-dimensional model, making it completely interactive for any user. In order to realise this project, it was necessary to intervene on the first lines of the code by inserting the path to the previously compressed file and its name. Within the template used, the scripts useful for interacting with the model were already present, such as the measurement and coordinate capture tool.

The HTML file was uploaded to the server of the MAPPALAB (Digital Methodology Applied to Archaeology) website of the University of Pisa. In order to visualize quickly the complete model and reducing the loading time, the triangles of the mesh were lowered from 35.403.277 to 497,492 (fig. 3).

Results

The realization of this project allowed the testing of a specific procedure for the online visualization of large-scale three-dimensional models. In addition to the simple web visualization, the 3D model is interactive for any user, by rotating the thermal complex in any direction, changing the angle of

[1] https://www.3dhop.net/

the simulated solar light. A deeper level of interaction with the model can be reached by measuring features, acquiring point coordinates, and creating cross sections. Moreover, the model could be annotated by inserting selected hotspots, linked to short textual descriptions. The project thus made it possible to extend the usability of this model to a broader and diversified public. The realisation of the 3D model could also be used to carry out a series of studies related to the reading of the stratigraphic units of the wall elevation. This work would allow the creation of hypotheses on how the thermal complex must have looked in ancient times, helping a virtual reconstruction of the building following the extended matrix approach created by Demetrescu (2015).

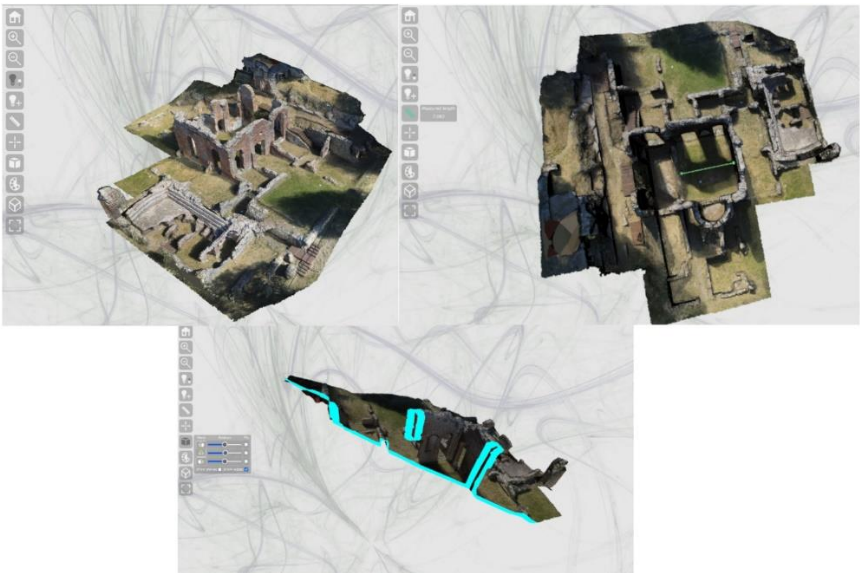

Fig.3 At top left the 3D model is displayed in 3DHOP; the top right picture exposes the measure features, and, on the bottom, the cross section is displayed.

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