

# 5 THE 3D SURVEY OF THE KLINE OF HOCHDORF

## An Example of Integration between Archaeology and New Technologies

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The new studies on the so-called Kline of Hochdorf have launched a project of interdisciplinary research, conducted both with an historical-archaeological and technological approach, aimed at giving birth to an analysis that could embrace multiple scientific fields. In support of the project was provided the realization of a 3D real-based model of the Kline,<sup>1</sup> that would allow both the acquisition of data in a non-invasive way, because the object cannot be touched, and the production of an overall view, since it is not entirely reassembled. In this context, our work was related to the management and processing of all the computers and the photographic data already produced, in order to create orthophotos, plans and thematic maps for some essays in this volume; in addition, to enrich the amount of available data, more detailed surveys of some parts of the Kline,<sup>2</sup> by using photogrammetry,<sup>3</sup> were also planned.

### THE PHOTOGRAMMETRIC SURVEY OF KLINE'S DETAILS: HANDLES, CHAINS AND FIGURINES

The Kline is an extremely complex object, both from a structural point of view and in relation to the material of which is made. It is a bench of about 2,80 m in length produced by the union of thin bronze sheets and characterized by the presence of handles with chains and pendants, thick decoration all along the backrest and eight bronze figurines of about 30 cm height that constitute the supports.

Since this is a specific intervention, we decided to use photogrammetry, exploiting two

digital cameras with tripod: a reflex camera Olympus E-520 and a compact camera Nikon Coolpix S640. We focused on the six handles that decorate the back outside, with their chains and pendants, and the arms of some of the supporting figurines that, since the discovery of the Kline, had been sticking to the lower profile of the seat in their original position. The peculiarity of these elements required therefore a different approach and imposed for each of them a change to the camera acquisition mode; despite of this, in relation with a requested representation scale of 1 : 1 or 1 : 2, we tried to keep a constant shooting distance, in order to not significantly change the scale of each frame (GSD).

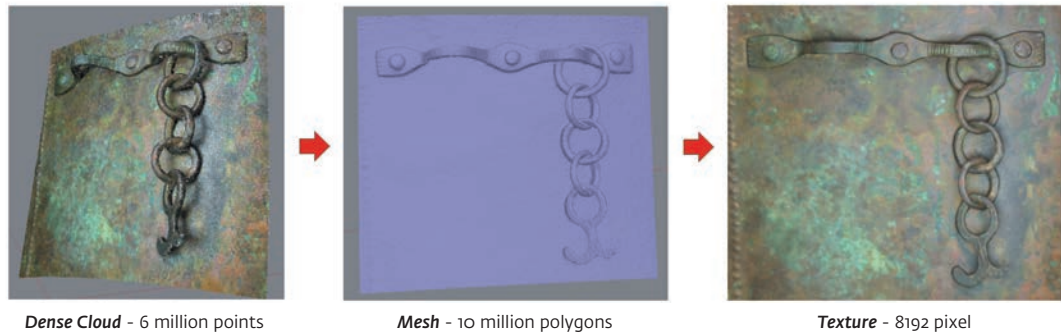
Regarding the handles, the survey was made in order to provide four datasets that guaranteed a complete coverage of every part: the first ones are all detailed datasets and are related respectively with the structure of the handle, with the individual chains, and then with the background, which is the Kline's wall below the chains. The last dataset instead consists of a sequence of general photos, useful to create the base on which to anchor detail models. In the case of the DG1 handle, which has a width of 11,9 cm and a 10 cm long chain, four camera datasets were for instance carried out (116 photos), using the reflex camera Olympus E-520 equipped with a tripod. In order to obtain plates and images with a representation scale of 1 : 1, the photos were all taken with fixed focal length (14 mm) at a distance of not more than 50 cm, so that the GSD or the individual pixel size in each frame was 0,2 mm. The realization of the survey, however, was not easy: some

1 The 3D model was made by ArcTron 3D GmbH. Afterwards part of the survey was remade by Landesamt für Denkmalpflege Baden-Württemberg.

2 We thank J. Biel (†), E. Keefer, W. Löhlein and the Landesmuseum Württemberg in Stuttgart for having us involved in this project.

3 For information about photogrammetry see for example Mikhail et al. 2001; Luhmann et al. 2006; Fryer et al. 2007.

1 3D model of the DG1 handle. Data processing from dense point cloud to texture mapping.



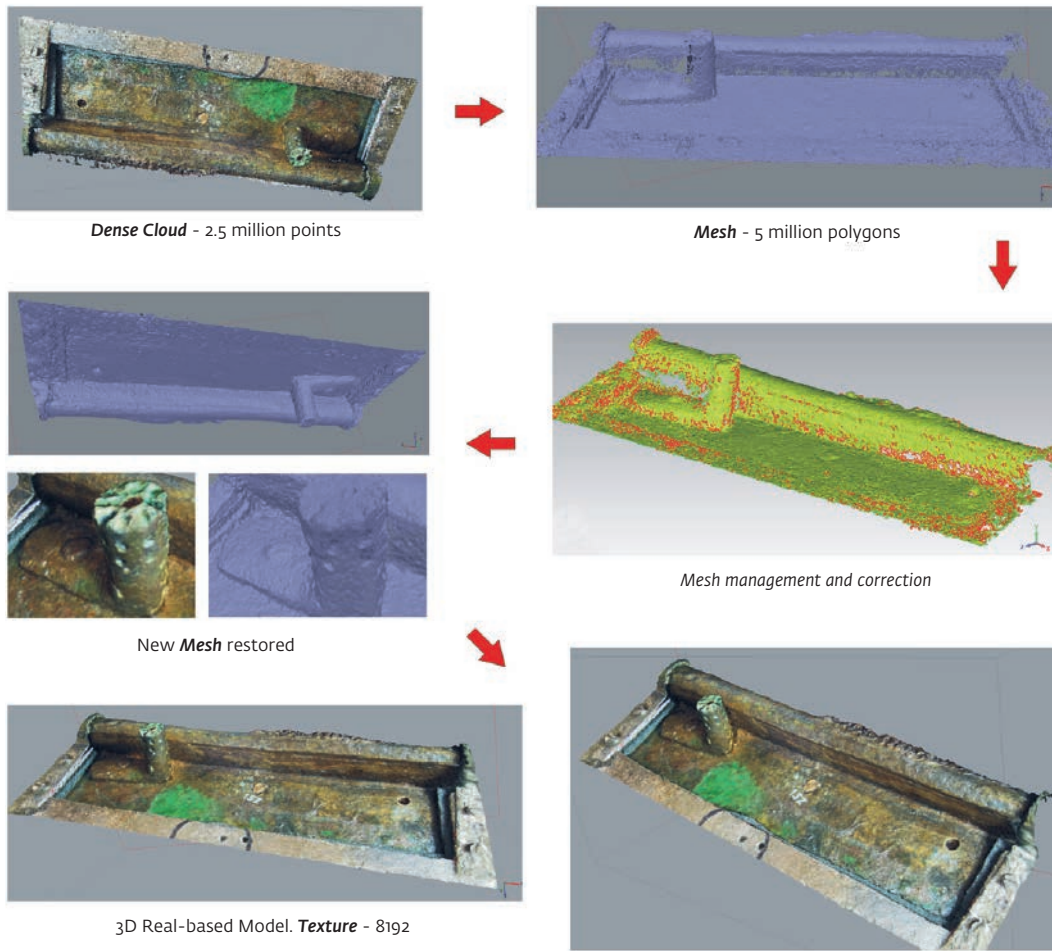
problems immediately emerged, especially related to lighting. The poor light conditions of the room, impose the use of a direct source of light that framed the entire Kline, but the bench did not lend itself to this type of expedient: being a metal object, it was highly reflective and, in the case of the handles, there was the additional problem of the projection of the shadows. Then we decided to proceed with the survey using oblique illumination produced by two opposing sources of light; this has caused a partial alteration of the colors but has helped to eliminate shadows and reflections and has ensured a greater sharpness of the pictures. For the occasion, it was finally necessary the use of a low ISO value (100) in order to avoid overexposure. Later, the photographic sequences were processed by using a photogrammetric software: through a first automatic orientation process we obtained a dense point cloud (6 million), from which it was then possible to generate a 3D geometric solid, the Mesh, composed by 10 million triangles (fig. 1). The DG1 handle's model was then modified by using a 3D modeling software, with which it was possible to correct the gaps at the intersection points between the chain links and remove surface imperfections. At the end, the mesh was texturized (8192 pixels) obtaining an high-resolution real-based 3D model useful to produce detailed images and ready to be examined to get information (fig. 1). If in the first case the product has allowed to realize orthophotos with high precision, however, in the second, it was still necessary to "decimate" each model, or reduce the number of triangles of the mesh, in order to lighten them and make them more manageable.

The other elements of the Kline involved in this additional survey were the arms of some supporting figurines found under the bench, still attached to the seat. They are the limbs belonging to the figures no. 132, 138 and 146. The data acquisition was planned to collect two sequential datasets for each arm: a generic one, relative to the lower profile of the Kline, and a detailed one. In regards to the „Hand 132“, for example, composed by a little hand of 4,7 cm and a 3 cm long arm portion, we took 95 pic-

tures by using the compact camera Nikon Coolpix S640. The survey had to have such an accuracy as to allow a representation scale of 1 : 1 and 1 : 2, then using a focal length of 5 mm, the photos were taken at a distance of less than 30 cm. As far the handles concern, also in this case, in addition to the small size, the light conditions have still created many problems, not only in relation to the position of the object, but especially for the presence of a steel slab that covered the whole bottom of the Kline. This element in fact amply reflected the projected light, preventing a proper data acquisition and causing distortions in the final survey. So we decided to shield the slab by creating an opaque background and by using the camera with a high ISO value. These settings, on one hand, have ensured photo shootings with a reduced chromatic alteration, but on the other hand, in some cases, they have influenced the sharpness, determining a percentage of noise visible during the modeling phase. For this reason, at the end of the entire process of creation of the points cloud (2,5 million points) and of the subsequent Mesh (5 million), the model required a massive geometric correction, leading to a partial manual remodeling of the surfaces in order to eliminate the gaps. The entire development process ended with the final texture mapping, that allowed to obtain an accurate 3D real-based model, useful to integrate the model of the figurine 132 in its missing part (fig. 2).

## THE DATA PROCESSING AND MANAGEMENT: ORTHOPHOTOS, PLANS, THEMATIC MAPS

With the enormous amount of information produced by the general survey of the Kline, it was immediately evident the need to undertake a careful data management activity, so that they could provide useful support to this ambitious scientific project. In this case, our intervention consisted of two distinct phases of work: the first one was dedicated to the 3D model management in all its parts, the second one to the production of drawings, plans and thematic maps.



The activity of data processing and management was performed by the use of a 3D modeling software, aspect 3D,<sup>4</sup> with which we analyzed the model of the Kline in every part to extrapolate not only photos of the whole object, but also sections, orthophotos, and high definition images of detail. The Kline, the figurines, the decoration, the handles, the chains and the umbos were therefore proposed according to different representation scales, from 1 : 1 to 1 : 20, producing images and plates that allowed to document in the best way this interesting object<sup>5</sup> (fig. 3).

Thanks to this documentation, even through some 2D graphic software, we made total perspectives of the bench in order to appreciate the profile and the dimensions. Thematic maps were also made relating to the decoration and to the traces of fabric.<sup>6</sup>

This activity has firstly provided with a visual aid the scientific analysis described, confirming information already known and making them easier to understand, but it has mostly favored the collection of new data about the Kline, al-

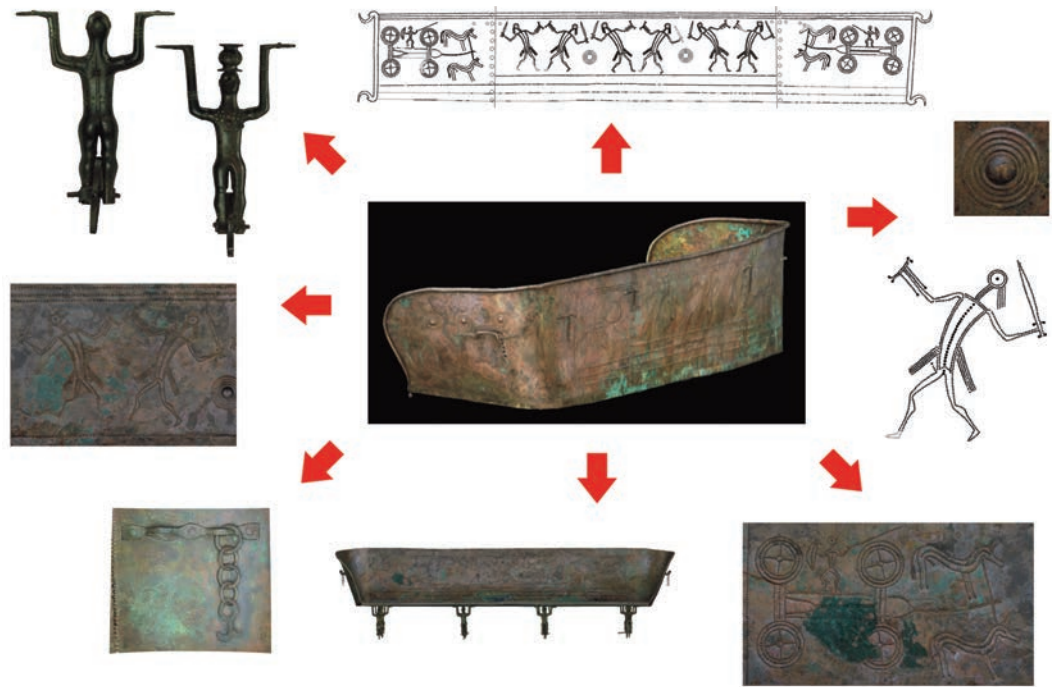
lowing integration of a cognitive framework already very large and complex. During the survey of the decoration on the backrest, for example, interesting news about the arrangements for its achievement have emerged: if on one hand, a detailed analysis has encouraged the collection of information on preparatory lines, identifying new ones; on the other hand the survey on the 3D model surface has allowed us to verify the actual size of punches. About punching, the new information could contribute, for example, to trace a typological map of their use in relation to the subject represented or, analyzing their different depths, could help to provide interesting data about the type of instruments used (fig. 4).

At the end, the production of a 2D survey of the engravings on the Kline's back has been useful to supplement the missing parts and to provide a complete reconstruction of the decorative pattern, allowing to make important evaluations about the existence or not of representation schemes that are common between warriors, horses, chariots and weapons.

4 The use of aspect 3D software was kindly granted by ArcTron 3D GmbH.

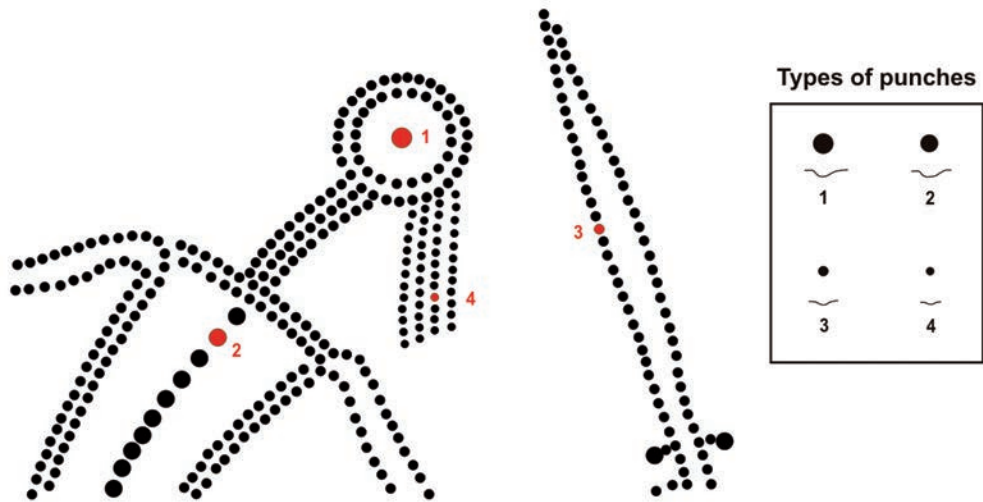
5 See W. Löhlein's essay in this volume (chap. 11).

6 See J. Banck-Burgess's essay in this volume (chap. 9).



3 Data management. Orthophotos, drawings and high definition images from the 3D model of the "Kline".

4 Thematic map of punching. In detail, the size and section of the four types of hole.



### CONCLUSIONS

The involvement of different scientific disciplines in the study of the so-called Kline of Hochdorf, clearly shows the importance of this great project, testified by the apparent openness to a more modern researching approach, confirmed also by the realization of the 3D survey of this object. Our work should be seen in some ways linked to these two areas and regarded as

the interpreter of an important interaction process that here sees archeology and new technologies talking together. Making new surveys, managing and processing previous data have allowed to put the 3D model at the complete service of research, using it to support the historical and artistic analysis and also as a rich source of information and observations.

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## FIGURE CREDITS

Abb. 1–4: E. Belgiovine/D. Capuzzo.

## ABSTRACT

In the new studies concerning the „kline“ of Hochdorf, part of the research project was on the on the information from a 3D model, built to gather important information on the structure of the bronze couch. This model served as the basis for orthophotos, plans and thematic maps, managing and processing all of the available photographic data. In order to acquire additional data for the study of the bench, this was followed by new photogrammetric assessments of parts of the „kline“, such as handles, chains and figurines.

**Keywords:** kline, photogrammetry, orthophoto, handles, chains, figurines

## ZUSAMMENFASSUNG

Im Rahmen der neuen Studien über die „Kline“ von Hochdorf basiert ein Teil des Forschungsprojekts auf den Informationen, die aus einem 3D-Modell stammten, das erstellt wurde, um wichtige Daten über die Struktur der Bronzeliege zu sammeln. Dieses Modell war die Grundlage für die Erstellung von Orthophotos, Plänen und thematischen Karten, ausgehend von der Verwaltung und Verarbeitung aller verfügbaren fotografischen Daten. Um weitere, für die Untersuchung der Bank nützliche Daten zu erhalten, wurden anschließend neue Vermessungen von Teilen der „Kline“, wie Griffe, Ketten und Figuren, mit Hilfe der Photogrammetrie durchgeführt.

**Schlagworte:** Kline, Photogrammetrie, Orthofoto, Griffe, Ketten, Figurinen