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Indice

Working with 3D data in Zooarchaeology: potential and perspectives

Antonio Curci

The paper aims at highlighting the potential of 3D documentation in Zooarchaeology. These techniques are just beginning to be employed in this field but the potential benefits in a standard application are remarkable. The applicability of 3D-technologies to Zooarchaeology ranges from the micro to the macro-scale using different equipments, as well as, especially, performing different kinds of investigation. These new methodologies may speed up traditional zooarchaeological studies and bring up new questions posing new challenges to scientific research.

Introduction

Over the past years, innovative technologies have been widely used to support cultural heritage studies, especially working with the third dimension to improve the quality of the documentation. Largely applied also in archaeology, these technologies are stimulating the field, as shown by the growing scientific interest and the consequent increasing number of experimentations, conferences and publications.

However, due to several issues as costs, need for particular skills and time-consuming post processing operations, these applications are not well integrated yet into the daily workflows of archaeological research, which would require some more effort to bring them beyond the experimental stage. Since few years the Department of History and Cultures of the University of Bologna is working right on this way, organizing workshops to keep pace and being up to date on the most recent results and projects. The goal is to share informations and experiences, especially focusing on methodology, field work and data processing (Curci, Fiorini 2012; in press).

All these activities and applications, which are giving a good contribution in increasing the potential of archaeological research, encourage us to spend them more on specific disciplines such as zooarchaeology, which is playing an important role nowadays.

Therefore, our department in collaboration with the Italian Association of ArchaeoZoology (AIAZ) promoted a study-day to highlight advantages, approaches and perspectives that 3D documentation could provide for, gathering all the specialists involved.

3D applications in Zooarchaeology

Unlike the other experiences made so far on archaeological contexts and landscapes (Curci et al. 2011) the application of 3D techniques in zooarchaeology ranges from a micro to a macro scale. Depending on the aims and the purpose of studies the needed equipment must be chosen and setup in a specific manner. At the microscopic level, 3D-digital microscopy has provided significant contributions to taphonomic and traceological investigations. Modern digital microscopes can show, on high resolutions, traces of anthropic and non-anthropic modifications on bone remains. Using specific software allow creating quickly digital 3D models that can be easily used to perform morphometric measurement and a broad range of quantitative and qualitative quantitative and qualitative analyses (fig. 1). The possibility to

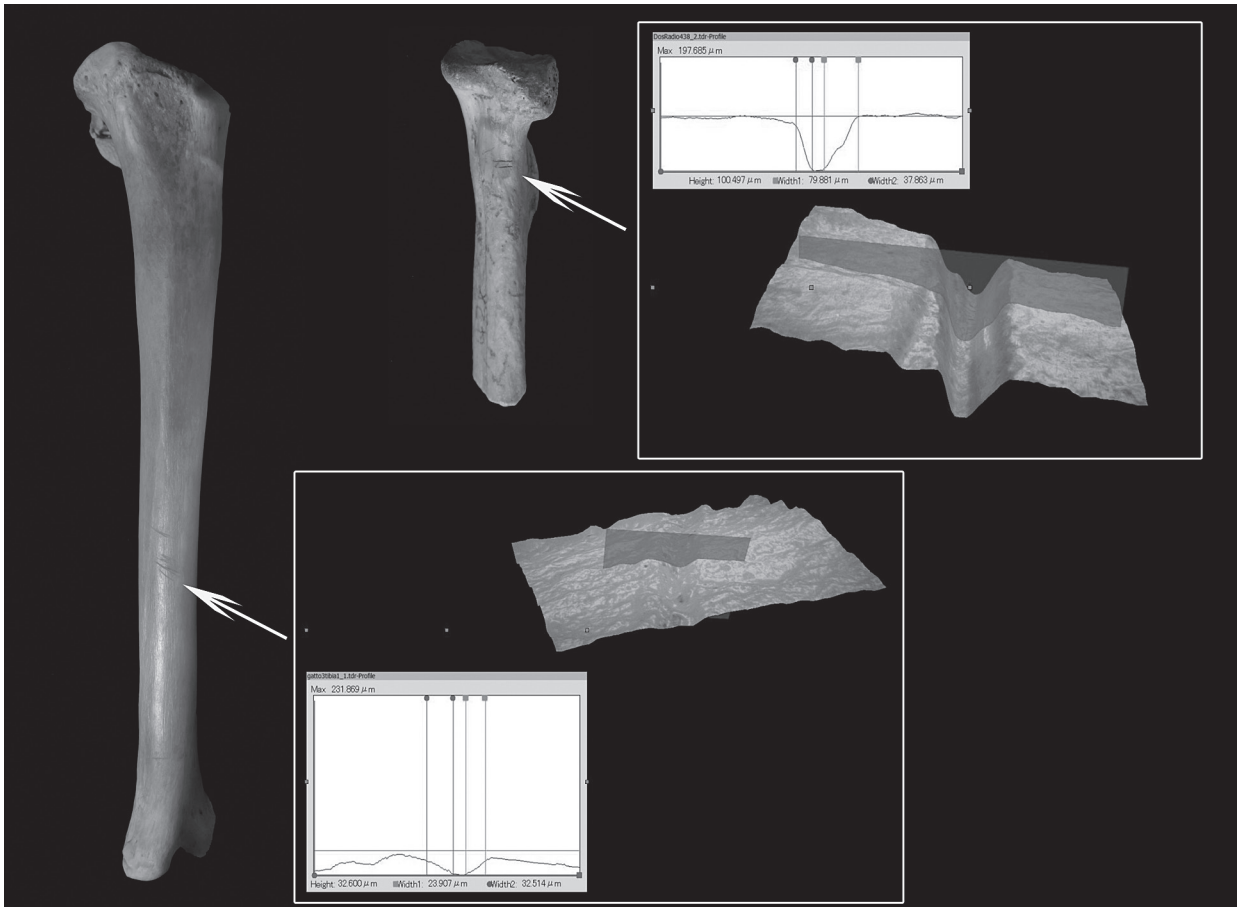

Fig. 1. 3D video-microscope images of cuts on a radius fragment of a wild cat (right) found at Dos de la Forca (province of Bolzano), of the Sauveterrian period, and on a tibia of a domestic cat (left), butchered in the lab (Crezzini *et al.*, in press)

store information in databases, where multitudes of traces can be recorded and studied in a digital format, can clearly help to analyze different morphologies and improve the quality of the resulting cultural interpretation.

At the macroscopic level, instead, 3D-technologies are mainly applied to document archaeological excavations. A wide selection of surveying tools can be used on this way, ranging from the versatile last-generation scanners (time of flight and structured light) to Metric and DSLR cameras that can be used for mono/stereophotogrammetry. No matter what kind of equipment is used, the goal is to obtain a representation, as metrically accurate as possible, of the zooarchaeological evidences in situ. Moreover, using realistic renderings to texturize 3D models, can highly reduce the subjectivity of a draughtsman for instance in favor of an exact and objective reproduction coming from a series of mathematical calculations.

Recently, the image-based technique called SfM (Structure from Motion) is giving very good results in terms of rapidity and accuracy. A generic workflow can be summarized as follow:

- First, the pictures are taken. It is important to shot them from as many angles as possible to capture every detail of the subject (fig. 2).

- The camera is calibrated and the angles of view oriented. Using "matching point" algorithms and allowing for the built-in error of the lens, the software reconstructs first the position of each shot, and then the whole scene as a point cloud.

- Next comes the meshing stage: every single point is used to generate a mesh of triangles (TIN) which defines the structure of the 3D surface. This surface is then photographically textured (fig. 3).

- The surface is edited.

- The 3D model is scaled through a series of control points measured its surface or on the ground (this step can be performed either with the Structure from Motion software, or with CAD applications).

- Layouts are then create from the models, mainly maps, plans, profiles and graphs which

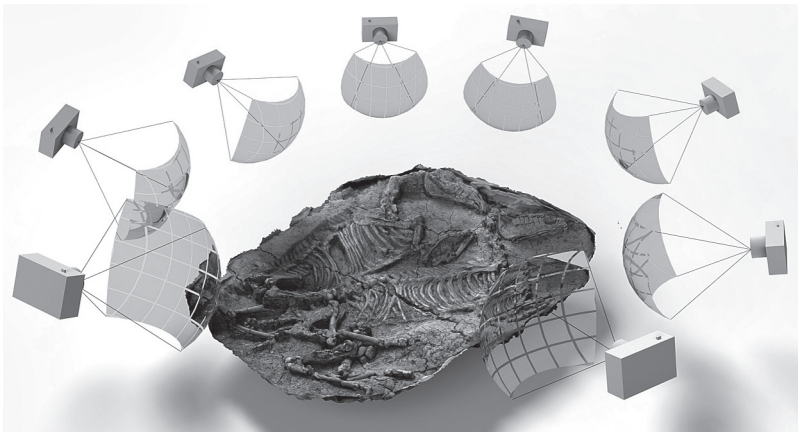

Fig. 2. Structure from motion technique: loop of sequential pictures from different angles for a 3D model of two buried horses in the Villanovan necropolis of Verucchio (by Giacomo Vianini)

The SfM has been tested out on several zooarchaeological contexts with excellent results. For example, it was used to acquire some of the horse burial from the Villanovan necropolis of Verucchio (RN). The virtual models were created to describe objectively shapes, geometry and color of the bone remains, using free and commercial software (respectively, Autodesk 123D Catch or Agisoft PhotoScan). Such digital representation is useful to communicate archaeological information both for scientific purposes and for an exhibition in a museum.

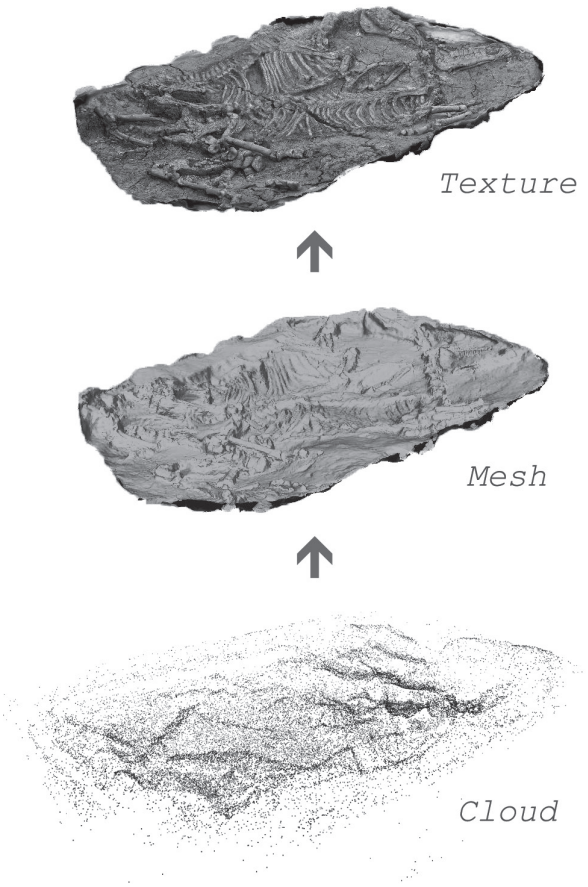

Fig. 3 – Structure from motion technique: using both free or commercial software it's possible to create a 3D model of the whole scene. The model can be used for specific measurements in the study phase as well as for museum displaying (by Giacomo Vianini)

represent a high level of informative documentation (fig. 4).

Fig. 4. Orthoimage from the 3D model of the horse burial in the Villanovan necropolis of Verucchio. The image can be used for plans, measurement, etc. (by Giacomo Vianini)

Although this method is still "young", many advantages are noteworthy:

- Low-cost hardware and software.
- Quick production of high-quality documentation, similarly to results obtainable with a laser scanner.
- Easily customizable within an archaeological environment.
- Easily usable for visitors enjoyment through videos, augmented reality, touch-screens and holographic technology.

Buy the way there are some disadvantages due to limitation of space around the objects, lighting problems and particular materials (glossy and/or reflective surfaces). Overall, however, the benefits are outweighing its shortcomings.

However, there is an area within zooarchaeology where 3D technologies have not found a regular employment yet. We can see that in the every-

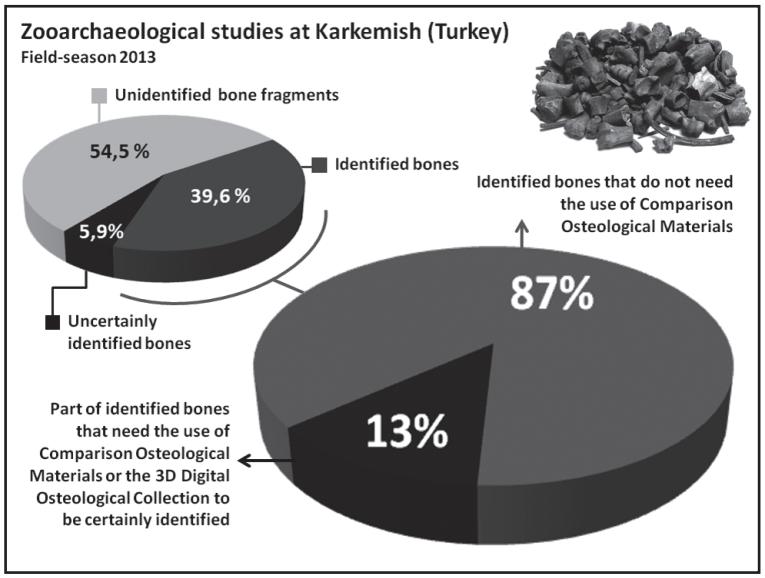

Fig. 5. Karkemish (Turkey): potential effect of the application of 3D documenting techniques in a field zooarcheological study (by Elena Maini)

Fig. 6. Different views of the 3D model made using a structured lighting scanner of a bone figurine (h. 34 mm) from the neolithic level of Grotta San Biagio (Ostuni-Italy) (by Alberto Urcia, Antonino Vazzana & Simone Zambruno)

day field and lab zooarchaeological analysis, where the study of the fauna mainly consists of identifications and quantifications of bone remains that can fit into a level of detail lying between micro and macro-scale.

During the 2013 excavation season at Karkemish (Turkey), Elena Maini has made an experiment (fig. 5) to test the potential of 3D documenting methods in a specific context. The results clearly suggested an application of these digital methods to create a 3D reference collection to help identifying the bones found on the site. This can be very useful considering how often a specialist usually consults published atlases or databases of images to do so. Thinking about the third dimension it is obvious how much a 3D model can be handy for this purpose, allowing 360 degrees rotations to make observations from each angle. Farther a detailed model could be printed out using a 3D printer to get a physical replica that can be important also for conservation purposes.

Creating a digital reference collection will certainly requires a considerable organizational effort that will probably require collaboration between several institutions to be carried out. However, thanks to modern technologies this goal could be not impossible to achieve. In the future, it is likely that scientists will also be able to experiment with software applications for the automatic identification of anatomical remains and the species they belong to, thus assisting the zooarchaeologist with the more complicated identifications. It is essentially a matter of interfacing existing image-analysis software with osteological and osteometrical databanks.

Another possible application of 3D technologies to zooarchaeology studies in the field concerns the documentation of specific osteological finds. Archaeological missions abroad are frequently not allowed to bring materials out of countries and to collect as much information as possible during the campaign is often crucial. There could be, for instance, hard-to-identify finds requiring further study, or special finds with traces of modifications or working (fig. 6) that need an accurate documentation. For this purpose, independently from the used equipment (and this is not the right place for further discussion on this aspect[1]), one will neces-

[1] In recent years, new equipment is coming out in the mar-

sarily opt for solutions granting sufficient metric reliability and, at the same time, that are easy to manage within the allotted time frame and sustainable for the financial resources of an archaeological expedition.

In conclusion, this short paper aims at focusing the attention of zooarchaeologists on the potential of 3D documentation techniques to support their studies. The techniques we have mentioned above are in some way still lagging behind as being part of a functional daily employment in archaeological research, and even less in faunal studies. In due time will likely bring up new questions and new challenges to scientific research.

Acknowledgements

I was prompted to write the present paper by the growing interest I developed for this subject in the context of my research projects and activities conducted as a professor of Methodology of Archaeological Research at the University of Bologna, but above all by a continuous exchange of information and experiences with so many friends and colleagues, whom I thank here: first of all, Alberto Urcia (Yale University) and Andrea Fiorini (University of Bologna), with whom I collaborate on research projects in Italy and abroad; Giacomo Vianini (University of Bologna), to whom I owe many innovative ideas and the creation of so many 3D surveys, often produced in difficult working conditions and in a very short time; Antonino Vazzana and Simone Zambruno (University of Bologna), for their great experience in the use of the structured-lighting laser scanner, and especially in the use of 3D applications in anthropology; Jacopo Crezzini and Francesco Boschin (University of Siena) for what they are doing in the field of 3D microscopy; to Elena Maini (University of Bologna) for her constant critical stimuli aiming at implementing an effective documentation system for the activities we conduct in ArcheoLaBio; and, finally, to my friend Nicolò Marchetti (University of Bologna) for always having supported bioarchaeology-- in his projects.

ket, as well as an increasing number of programs for 3D data management. Giacomo Vianini is currently preparing a comparative study of some of these programs and their applicability in Archaeology for his Master's thesis at the University of Bologna

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