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CLOSE-RANGE SENSING FOR GENERATING 3D OBJECTS IN PREHISTORIC ARCHAEOLOGY

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Abstract

Prehistoric archaeology is an object-oriented discipline. Archaeological objects like stone tools, bone tools or pieces of mobile art embed human behaviour. A central task of prehistoric research is to decode this information in order to reconstruct ancient human behaviour. This premise affords a defined set of tools for analysis and documentation to describe and evaluate particularly the shape of the object and its surface modifications manufactured by humans. Basis for all types of analysis is therefore a precise visual description of the object. This documentation forms part of the scientific process and should follow a generally accepted convention. Only when these rules are respected, a standardised and reproducible recognition of the object becomes possible.

Keywords: surface scanning, stone tools, mobile art, documentation, palaeolithic

1 Introduction

For more than hundred years, prehistoric archaeology has used object drawings to accomplish a visual description and documentation. Over decades a basic set of defined conventions have been developed that perform the technical status of an object (Fig. 1). These conventions facilitate sensing of objects, allow quick visual comparisons of various items, and enable the information to be put into a larger scientific context. The sensing of drawings of stone tools or bone tools works much faster than exploring the originals themselves. Teaching of drawing techniques is integrated into the educational schedule for prehistoric archaeologists at university. Though, items of mobile art are different. They present more complex visual information than stone tools and display a special aesthetic value and are therefore still the field of expert illustrators (Fig. 2). The transformation into a drawing is very time-consuming and needs experience. This is also true for photography, which has until now not replaced the drawing. Taking a photo of a prehistoric object is even more difficult. It is not possible to visualize all relevant features important for the analysis of an object in just one shot (Fig. 3). The cost-performance ratio for drawings is therefore better than for photography. Photos of prehistoric objects are published mainly under the premise to present their aesthetic value to the broad public. Within the scientific community, drawings are the most frequent medium of information transfer. But these technical drawings are problematic for several reasons:

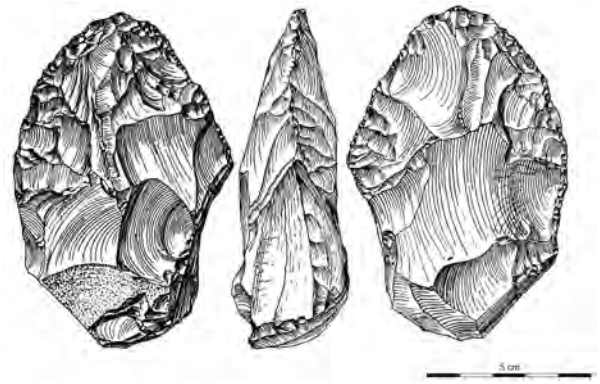

Fig. 1: Salzgitter-Lebenstedt: Traditional drawing of a stone tool; handaxe (Tode 1982, Plate 12, 2)

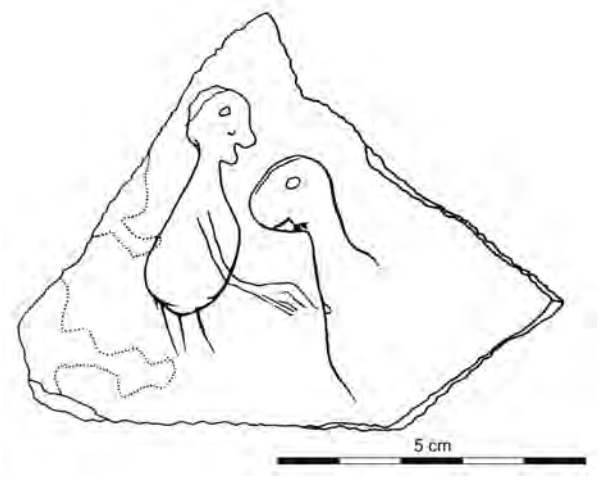

Fig. 2: Enlène: Traditional drawing of a mobile art object; see also Fig. 7 (Bégouën & Clottes 2007, Fig. 12a)

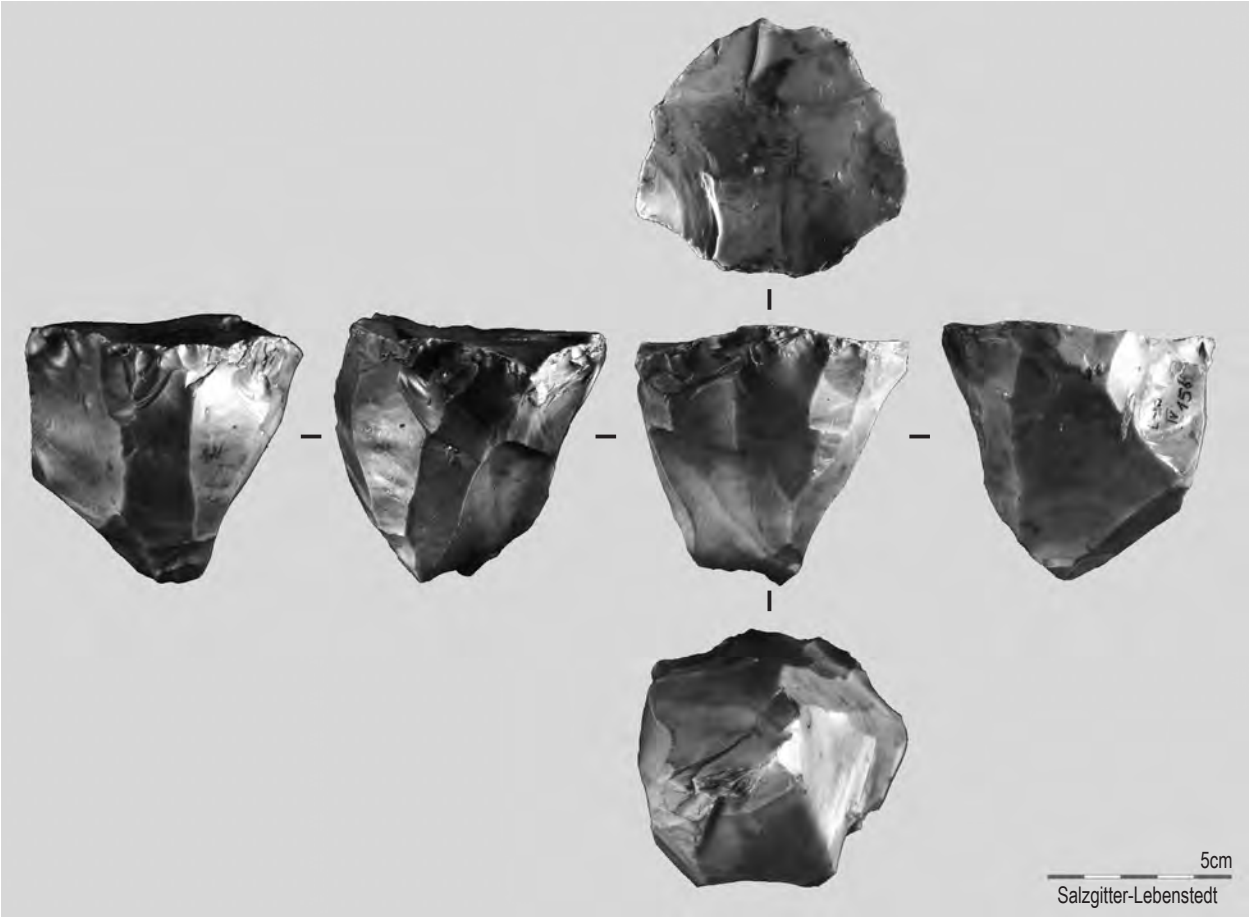

Fig. 3: Salzgitter-Lebenstedt: Photos of a stone tool; blade core (Pastoors 2009, Fig. 8)

- Although some general conventions for graphical documentation exist, they reduce the object to a small set of selected features. These drawings turn out to be a hybrid between graphic art and science. The reduction is due to the individual interpretation and the scientific drawing therefore looses objectivity. By skilfully dispensing or adding of minor features the unambiguousness of an item can be manipulated. This happens, for instance, when a decision between geofact and artefact has to be made or the classification of a tool depends on non-specific features.

- Drawings do not allow a precise recording of all metric data of the object. Usually, drawings are published in small formats in scientific papers or books, which are still the most important medium of diffusion. These downscaled drawings do not allow further distortion-free metric analysis such as calculation of areas, angles or distances. Unfortunately, this makes it impossible for other researchers to use published data and to continue the analytical process by integrating the published data into their own sample. As a result, samples have to be restudied again and again by several generations of researchers. In terms of efficiency of labour and sustainability of research this does not make sense.

- The reduction from complex 3D objects to 2D drawings means a loss of important information. Especially mobile art objects display a great variety of forms, from simple engravings via bas-relief to sculpture. Width and depth of lines is important for the understanding of engraved depictions. Drawings do not allow direct access to these details.

By integrating computers in prehistoric research, alternatives for traditional graphic documentation were tested. But still in the 1990s a computer-based approach was thought to be ineffective (Hahn 1992, Inizan et al. 1999). Today, beside the traditional way of documentation, a potpourri of individual applications of graphic software tools overstocks the publications. Archaeological objects are, for instance, documented by a non-standardised combination of photo, vector graphic and symbols named “info-graphic” (e.g. Le Brun-Ricalens 2005). This reflects the intensive search for new methods and is a striking argument for the establishment of new standards. Beside these efforts, various 3D scan applications with different perspectives have been tested in his-

toric archaeology during the last years (Borderie et al. 2004, Sumner & Riddle 2008, Grosman et al. 2008, Breuckmann et al. 2009). Especially 3D surface scanners record a wide range of different prehistoric objects with variable resolutions. Compared to high resolution digital microscopy (Mélard 2007) the produced data set is still manageable by standard hardware.

2 Methods

3D sensing of prehistoric objects obtains reproducibility and minimises individual impact on or even manipulation of the process of graphic documentation. Documentation and interpretation get separated, which is not the case in traditional ways of graphical transformation. The pure mechanical-technical treatment of the objective needs special technical skills but not necessarily specific archaeological know-how and can therefore be separated from scientific analysis. This could simplify data acquisition by including technical staff, and accelerate the process of documentation.

Actually we use a topometrical high definition 3D surface scanner, based on fringe projection techniques, to scan a variety of prehistoric objects made from various materials. Concerning for instance stone tools, we found out that raw material characteristics covering basically three classes of homogeneity from smooth via coarse-grained to quartz can be separated easily. The same is true for descriptions of surfaces that display all secondary shock attributes which are important to classify the debitage process. All knapping features are well documented (Fig. 4). Therefore, this documentation technique meets the requirements of scientific documentation. Recently Grosman (Grosman et al. 2008) demonstrated that, on the base of 90 3D scanned bifacial tools, an automatic analysis of morphometric features is possible. The development of this type of standard recognition is a major advance in documentation technique. In the future even the refitting of scanned stone tools might be feasible.

Concerning mobile art objects, some examples are difficult to interpret. In these cases we need more experience and tests to produce convincing results. While small sculptures are quite easy to document (Fig. 5 and Fig. 6), fine engravings are sometimes difficult to record and their identifica-

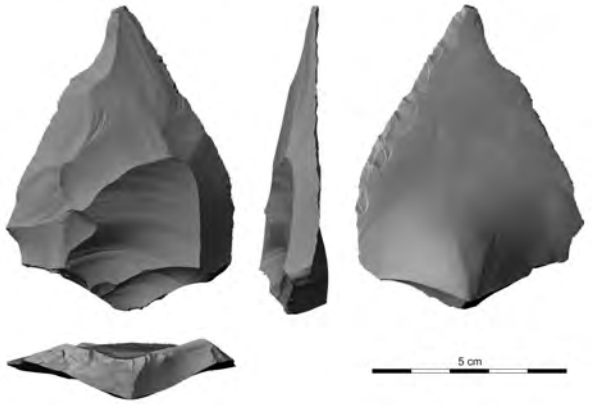

Fig. 4: Umm el Tlel: Surface scans of a stone tool; retouched Levallois point (© Neanderthal Museum)

Fig. 5: La Garma. Surface scan of a mobile art object; bear (© Museo de Prehistoria y Arqueología de Cantabria)

Fig. 6: La Garma: Surface scan of a mobile art object; ibex (© Museo de Prehistoria y Arqueología de Cantabria)

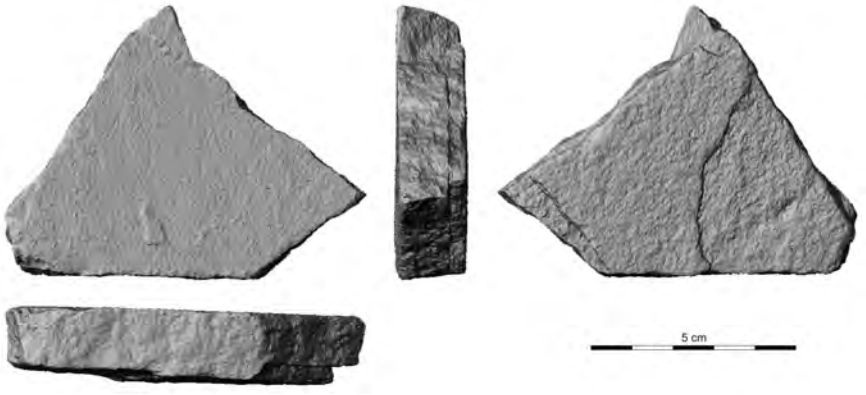

Fig. 7: Enlène: Surface scan of a mobile art object; humans, see also Fig. 2 (© Association Louis Bégouën)

tion might be problematic (Fig. 7). Therefore we need a more detailed test protocol for the sensing of line width, shape and depth. It might be important to use software extensions as, for example, developed just recently for cuneiform clay tablets (Mara et al. 2010). This example from protohistory shows that the sensing of engravings technically comes into reach.

3 Outlook

Another important factor of 3D scanning is the easy way of data diffusion. Web-based digital archives are an excellent tool for worldwide access to data. Examples like NESPOS (www.nespos.org) for Pleistocene humans and objects, the Digital Library of Cuneiform (www.cdli.ucla.edu) or the Arachne project for classical archaeology (www.arachne.uni-koeln.de) prove the importance of web-based distribution. Documentation techniques in prehistoric archaeology will undergo a substantial change within the next decade. This will result in new venues of scientific information exchange and cooperation within the scientific community.

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