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Virtual Archaeology: Work in Progress

Abstract: The aim of this paper, which was presented as a poster at the Berlin conference, is to emphasize the importance of 3D technologies in creating reconstructions for the study, interpretation, preservation and dissemination of archaeological sites and artefacts. I aim to do this by complementing traditional alpha-numeric data and images with new digital methods of registration, virtual interaction and digital data. I shall present some of the virtual archaeological projects that we are developing at the IPA (Instituto Português de Arqueologia; CIPA, Centro de Investigação em Paleoecologia Humana e Arqueociências).

Evolution of Natural and Built Landscapes

In order to reconstruct the Roman *Villa* in Rabaçal (central Portugal) we used both modern and archival data. These included GIS (topographic maps, orthophotos), illustrations, drawings, photographs, texts and maps. We were then able to create real-time interactive 3D digital models and progressively build up structural knowledge of the site, as well as of the evolution of both the natural and the man-made landscapes "as they could have been", "as they are" and "as they might be".

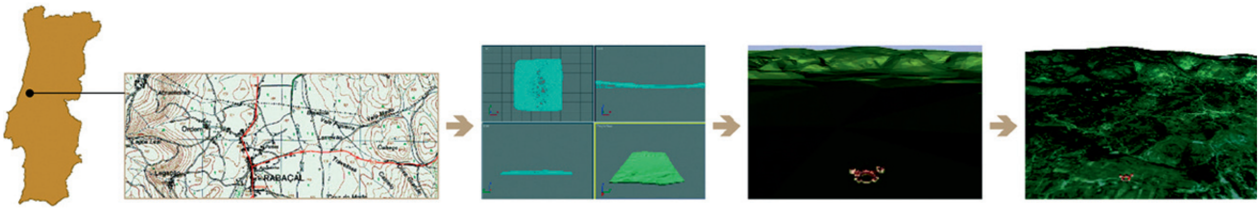

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Fig. 1. Terrain – a) Geographical location, Portugal, b) Topographic map, c) Polygonal mesh and surface, d) 3D terrain model, e) Terrain with texture map.

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Fig. 2. Architecture – a) *In situ*, b) Architectural drawing, c) "As it could have been" drawing, d) 3D virtual reconstruction in Autocad, e) Interactive VRML model.

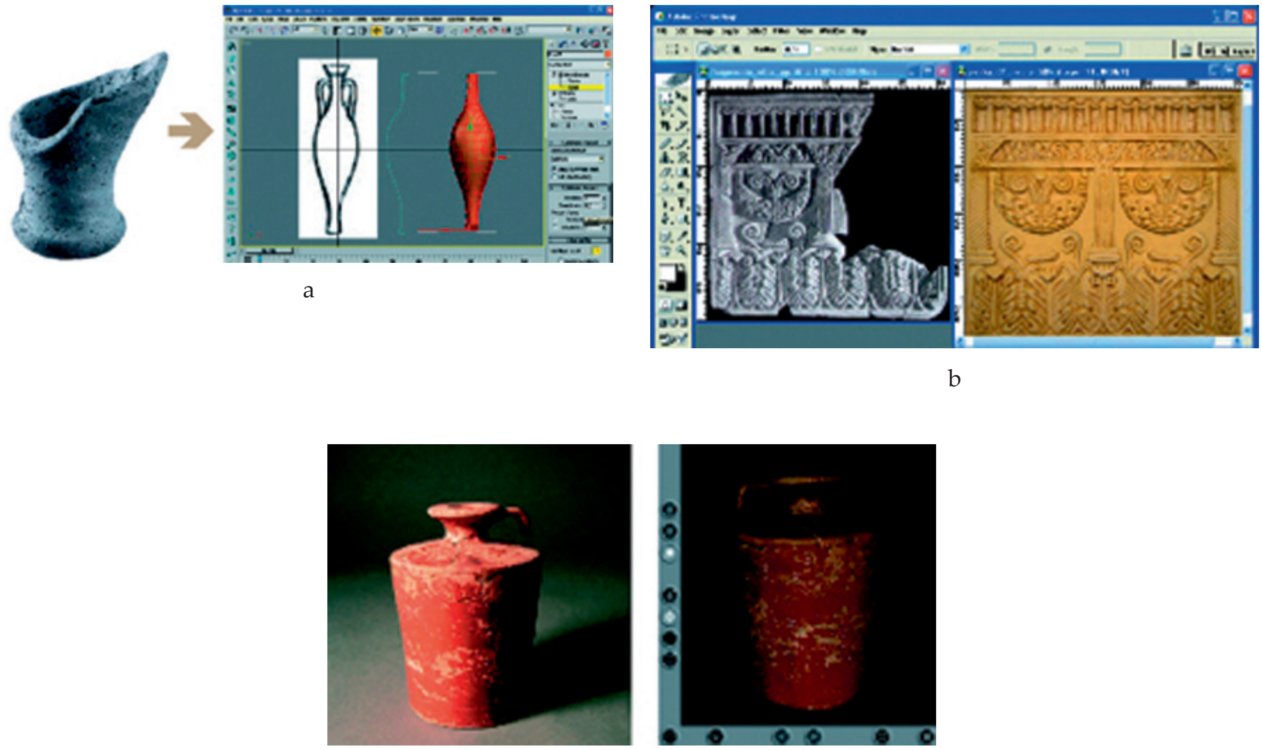


Fig. 3. Objects and Ornaments – a) Pottery fragment, b) 3D virtual reconstruction after object and type identification, c) Fragmented wainscot and 2D virtual reconstruction (Courtesy of Pedro Madeira).

3D Analysis of Quartzite Industries

Collections of quartzite industries are "macro-like". The volume and weight of each artefact means that such collections are difficult to transport. This often means that it is impossible to study them outside research centres and universities. Moreover, transporting them often causes them to deteriorate. To facilitate their study, we undertook a preliminary comparison between the use of close range photogrammetry and 3D laser scanning of a few Paleolithic pebble tools (cores and shaped tools) from Granho-Vale Coelheiro (central Portugal).

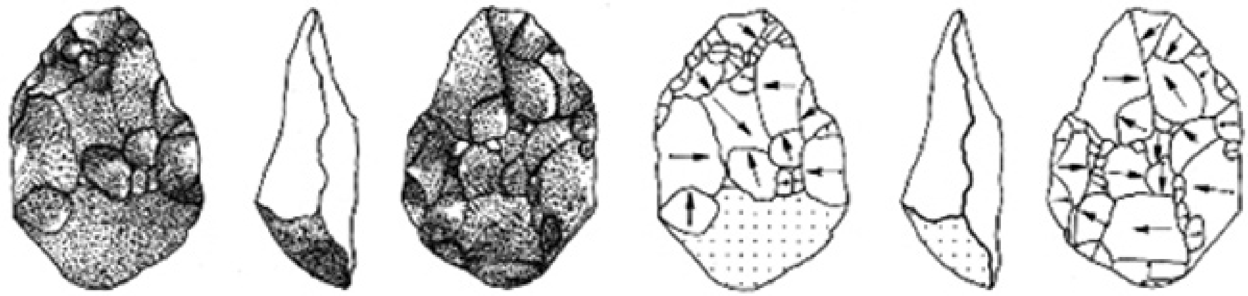
2D Representations

The major problem with 2D representations of lithics has been that assumptions, rather than measurements, have often had to suffice for a missing third dimension – for instance, assumptions that surfaces are plane or that they are truly vertical or horizontal. So, if one needs to study an artefact in depth, 2D representations are generally not sufficient.

3D Representation – Close Range Photogrammetry

Two different pieces of multiple image based software were used in this project: D Sculptor v2.0 (D Vision Works, UK) and PhotoModeler v5.2.3. (EOS Systems, Canada). By using these applications we were able to compare different kinds of results. These applications are well known in archaeology and architecture.

3D photogrammetric reconstructions can be very time consuming because the number of stone tools to be analyzed is often enormous. The total number of days required to study collections assumes that an experienced person takes about 2.5 hours to photograph and reconstruct a 3D model of a core. Complex geometries may require more time – e.g. for the 166 cores found in Granho-Vale Coelheiro it would take at least 457.5 hours, or approximately 2 months.



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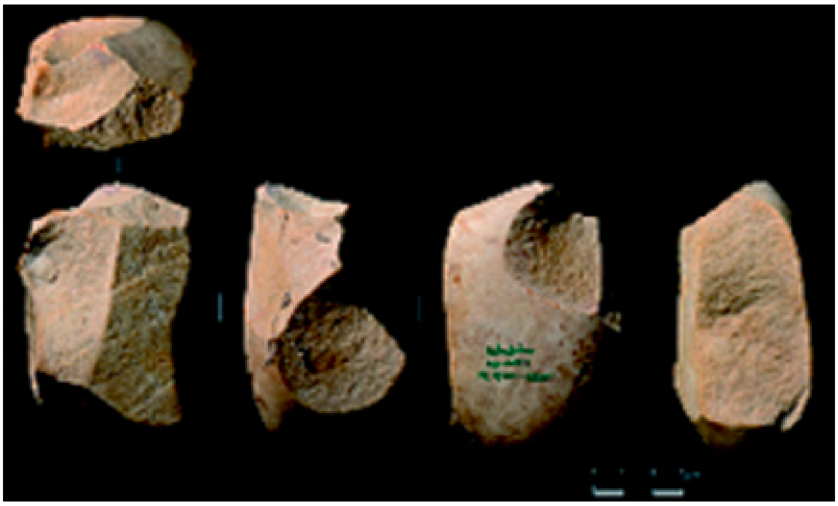

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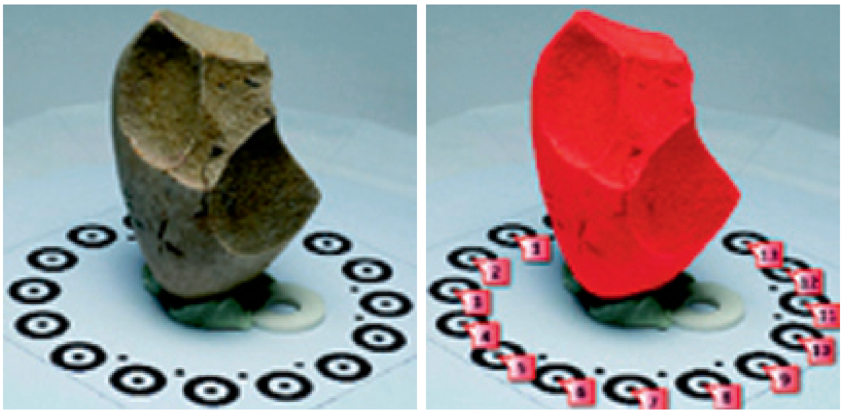
Fig. 4. a) Descriptive drawings (Courtesy of Telmo Pereira), b) Diacritical diagrams (Courtesy of Telmo Pereira), c) Photograph with top, front, left, reverse and right views (Courtesy of J. P. Ruas).

Our initial requirements included low-cost software, easy-to-use technology, reconstructed 3D virtual models with metric data available and small-sized and interactive output formats, all performed by a single person. In our approach, Photomodeler proved to be much more adequate to reconstruct 3D virtual models of lithics because of its photographic recording flexibility and its ability to output both objects and images in an uncompressed format. Unfortunately, in terms of accuracy, both software packages proved to have limitations which prevented us from obtaining certain kinds of important data. Thus, we had insufficient resources for the quartzite lithic industries study at both the scientific (archaeological) and the higher educational levels. However, if we take into account the time required, it does not seem feasible to reconstruct 3D virtual models of entire lithic collections. We suggest it is better to concentrate upon the most important stone tools.

Conclusions

- ✓ Software packages are easy to use and not expensive;
- ✓ Models with metric data are available;
- ✓ Output formats include interactive VRML files (for the Internet) of approximately 400 KB to 1 MB;
- ☒ Concavities and convexities perpendicular to the camera are difficult to process with great accuracy;
- ☒ A sufficient level of accuracy is provided for use in reconstructions for scientific (archaeological) and higher education;
- ☒ Reconstructions are good for the game industry, museums and other cultural and educational applications.



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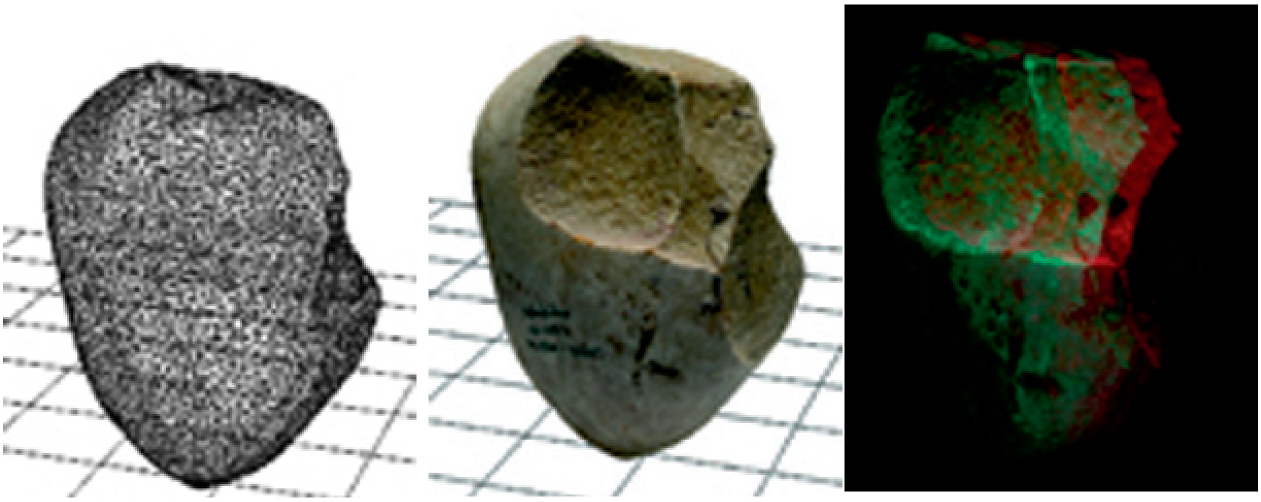

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Fig. 5. Multiple Image Based Software: geometric and color data processing are extracted from a set of convergent photos. D-Sculptor software: a) Referenced points, b) selected object, c) generated polygonal mesh, d) texture map. Real-time manipulation: e) Stereo red-blue interactive VRML model.

3D Representation – 3D Laser Scanning

We used a Konica-Minolta VI-9i laser scanner and RapidForm analysing software.

Conclusions

- ☒ Equipment and software needed for data analysis are expensive;
- ✓ Models with metric data are available;
- ✓ Output formats include STL (for rapid prototyping) and interactive VRML files;
- ✓ Concavities and convexities perpendicular to the camera are easy to process accurately;
- ✓ Reconstructions for scientific (archaeological) and higher educational use are accurate;
- ✓ Provides excellent reconstructions suitable for the game industry, museums and other cultural and educational uses.

3D Reference Collections

The purpose of this project is to create 3D digital models with the available metric data of entire pieces, existing fragments or any other kind of visual data, for later study.

Conclusions

- ☒ Traditional methods of inspection are insufficient:
  - Visual – may be subjective/non mathematical;

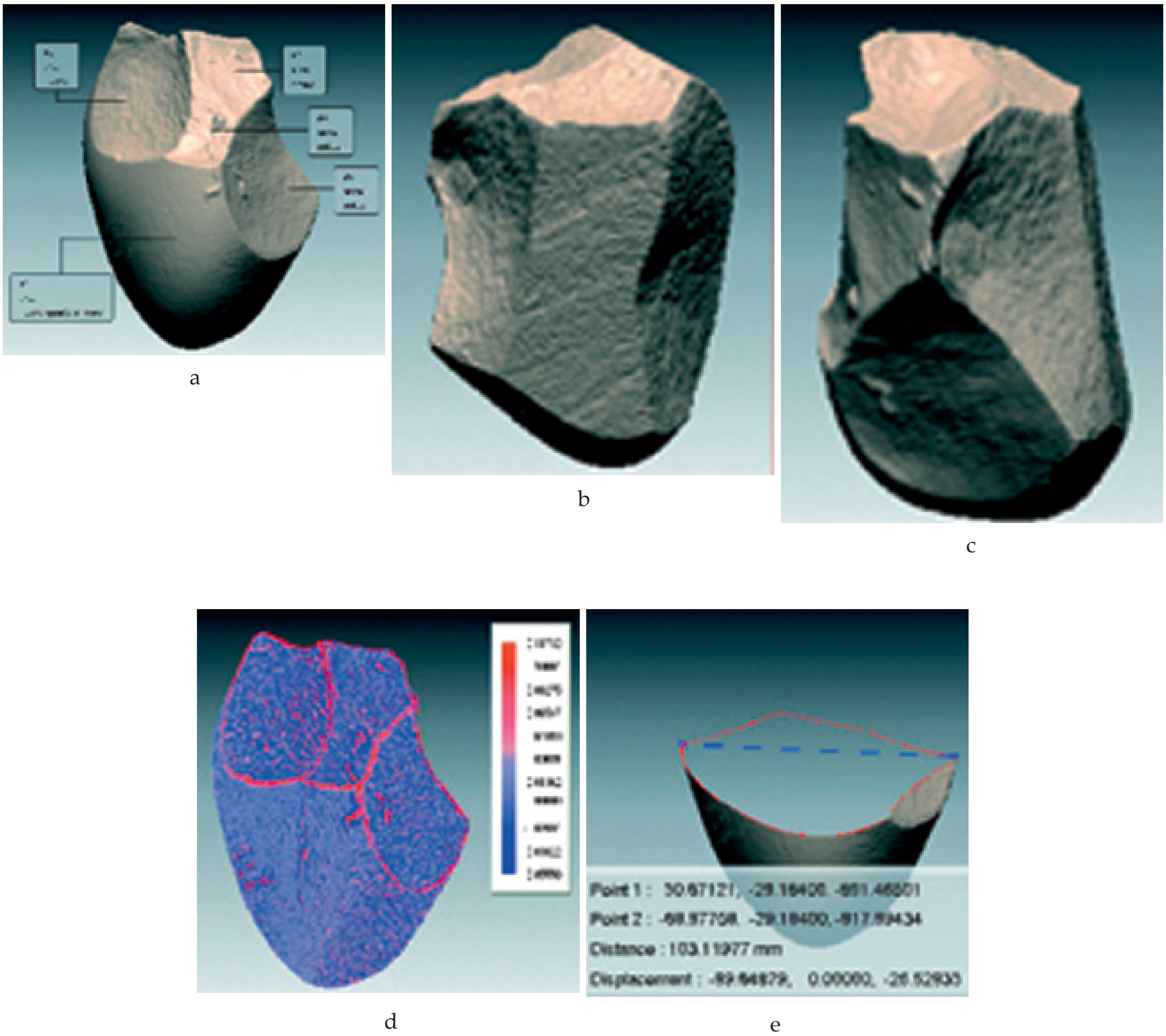

Fig. 6. a)–c) Intermediate views, d) Curvature levels, e) measured distances along line. Area of the model: 32353.27531 mm^2, Volume of the model: 421956.82194 mm^3.

– Metric equipment – calipers may damage the bone and the artefact;

✓ Non-intrusive technologies, such as 3D Graphics applications, (stereo)photogrammetry, laser scanning and computed tomography, can produce 3D virtual/physical accurate models with scalable, visual and quantitative data;

✓ Inspection, analysis and comparison of curvatures (including sections), surfaces (e.g. area, perimeter), volumes, proportions, etc.

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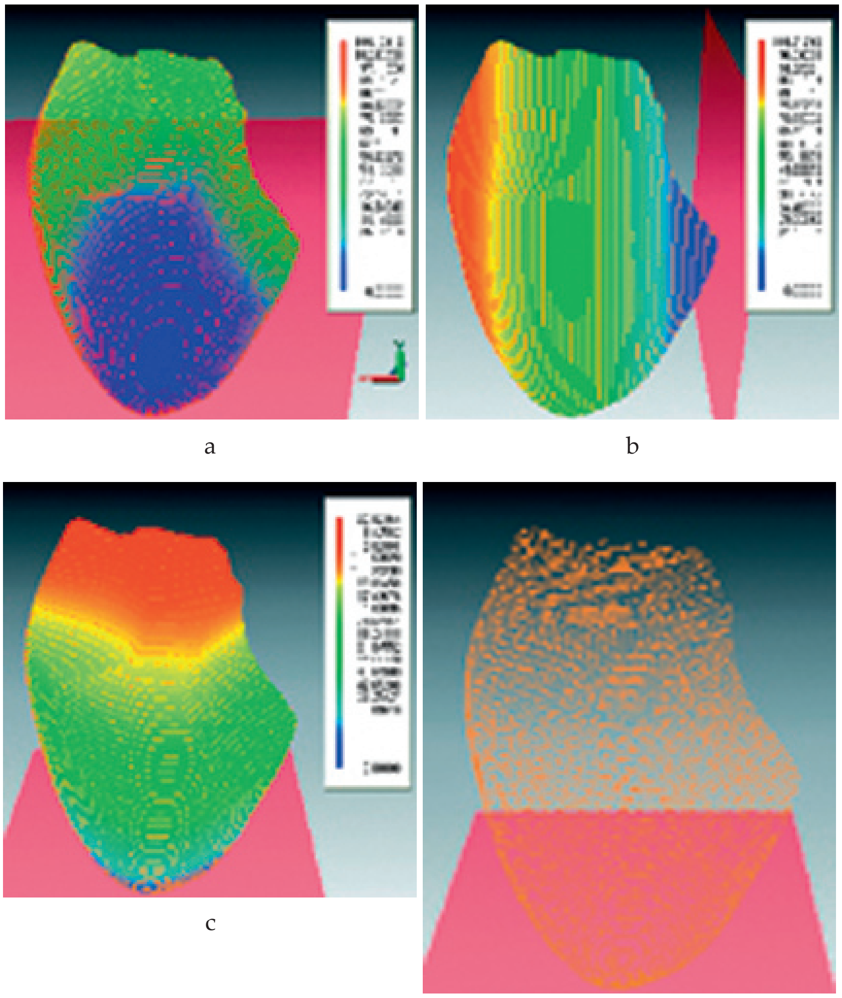

Fig. 7. Sections: a) Z axis, b) X axis, c)–d) Y axis.

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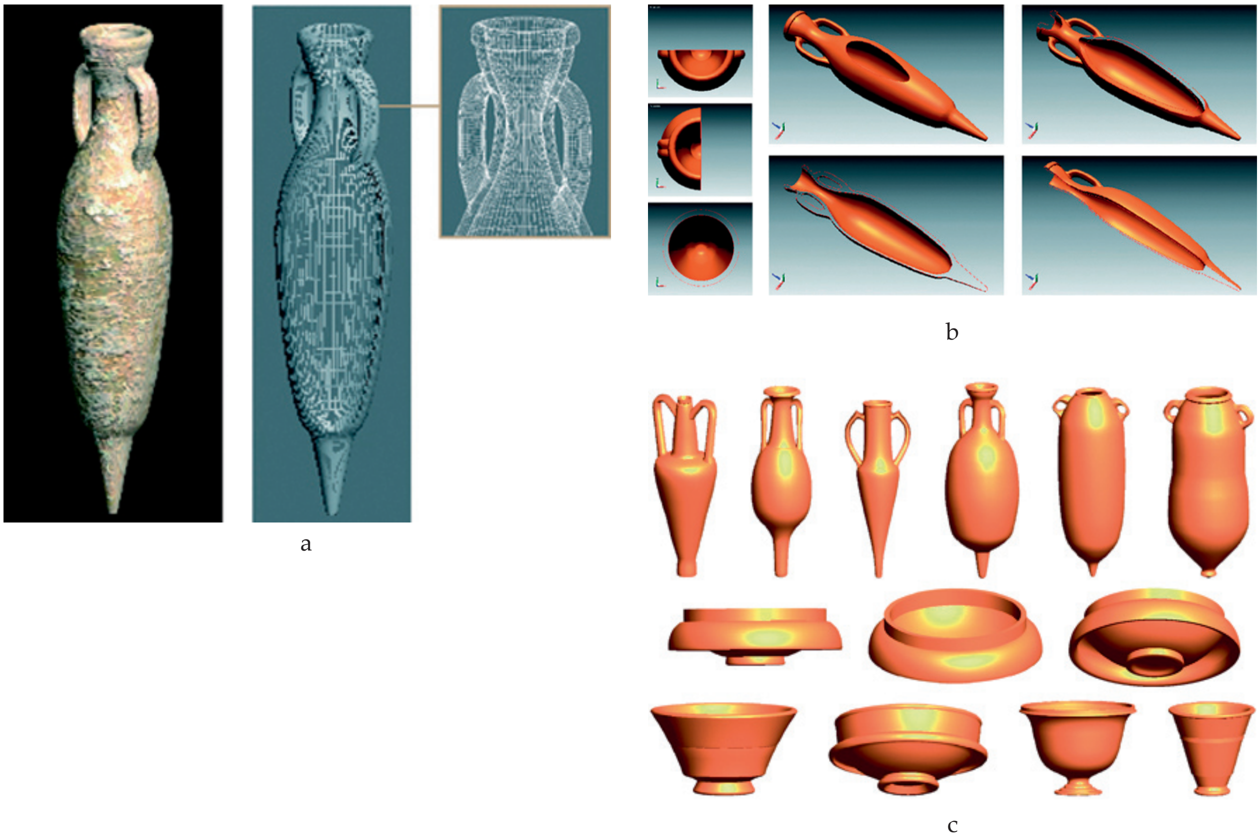

Fig. 8. Roman Pottery – a) 3D virtual reconstruction of an amphora (3ds Max software), after drawings and photographs, with texture map and wireframe, b) Amphora sections, c) 3D digital pottery models.

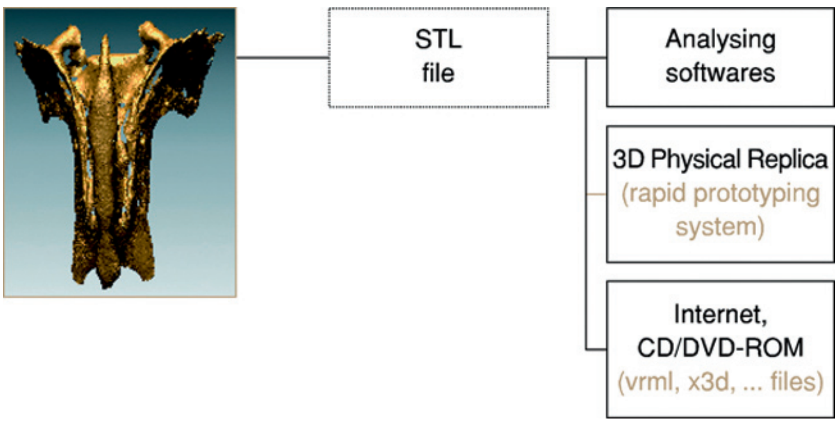

Fig. 9. Animal Bones – 3D virtual reconstruction of a deer sacrum (Gom ATOS I, stereo-photogrammetric scanner): practical applications.

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