How Can Bioarcheology of Medieval Slavic Populations in the Central Europe Profit from 3D Technologies?

Petra Urbanová[1], Miroslav Králík[1], Pavel Fojtík[2], Adela Hupková[1], Mikoláš Jurda[1]

[1] Department of Anthropology, Faculty of Science, Masaryk University, [2] Institute of Archaeological Heritage Brno

Introduction

In the 11th century, Central European Slavic settlements played an important role in the expansion of the Early medieval states. In Czech territories Slavic populations represent the roots of societal development during the subsequent millennium, i.e. the so-called Přemyslid state. It is presumed that Slavs had undergone relatively rapid social changes and distinct demographic shifts which together with natural, socioeconomic and other factors resulted in significant differences in living conditions. This project has focused on excavating and examining skeletal remains of early Medieval Slavic populations from two archeological sites, Dětkovice and Vídeňská Street, Brno (Czech Republic). So far, more than 600 skeletons have been proceeded to anthropological examination. Our main objective has been to reconstruct living conditions and social environment from an archeological context and uncovered skeletal remains. It has been our primary goal to employ modern imaging and analytical techniques which have advanced in the last decade into affordable systems easily applicable on sites or in other out-of-lab situations. This paper provides an overview to currently available 3D technologies applicable in a routine anthropological examination.

On-site Documentation

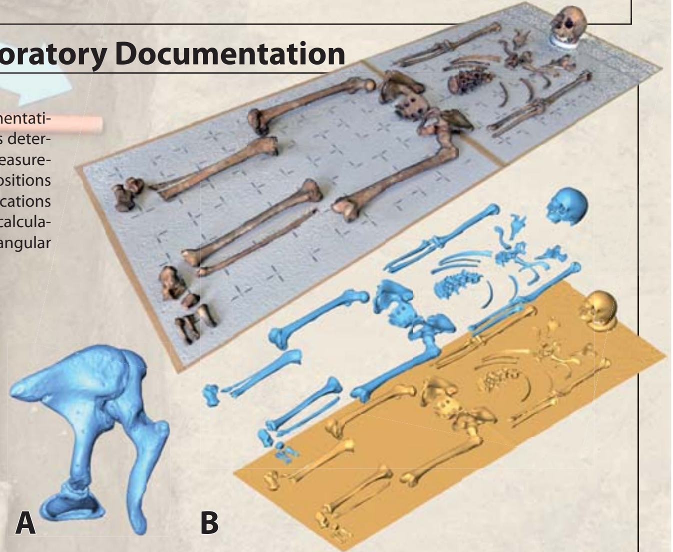
Photogrammetry

Photogrammetry represents the cheapest and easiest documentation technique applicable on site as well as in laboratory. It allows determining three-dimensional coordinates of discrete points by measurements made in a series of photographs taken from different positions and viewpoints. Commercial and freely available software applications (Autodesk 123D Catch, AgiSoft PhotoScan etc.) are capable of calculating dense clouds of points and if polygonized generate 3D triangular mesh representing object's surface.

3D optical surface scanners

Existence of portable contact-free 3D optical surface scanners applicable in outdoor situations (Fig. A, an excavated grave recorded with ZScanner® 600) has opened new possibilities for on-site documentation. Real sized 3D surface models capture depth data which are irreversibly lost in conventional 2D photography. In layer-by-layer excavations 3D models create true digital representations of the sequential destructive procedure (Fig. B, three subsequential layers of an infant's grave as captured in the process of excavation).

Laboratory Documentation



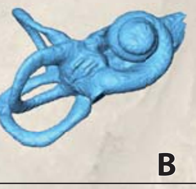
3D laser scanners

The conventional two-dimensional photography serves commonly as an essential documentation technique, but in many instances the two-dimensional photographic projections fail to extend analytical options. The true 3D nature of examined objects can be recorded with 3D laser scanners or photogrammetry (bones or arranged skeleton, Fig. B). Both technologies create very realistic digital records of findings. More expensive, but highly accurate industrial systems reaching accuracy of less than 20 µm are now accessible for tiny bones (Fig. A, middle ear ossicles recorded with ATOS 3D scanner) .

Laboratory Recovery

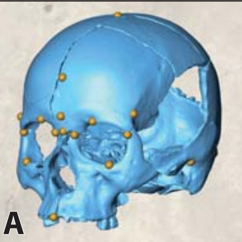
Biomedical imaging

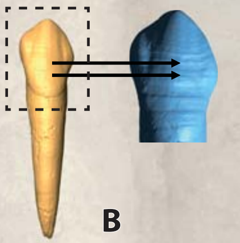
Surface models register external morphology and photographic texture but information underneath the surface is inaccessible. CT-3D volume reconstructed data obtained from CT images are capable of displaying hidden or uneasy to investigate anatomical sites.



Small-sized, neglected, but persistent elements can become very informative in regards to sex , age or state of health (Fig. B, inner ear structures – cochlea and vestibular system generated using a cone-beam CT unit).

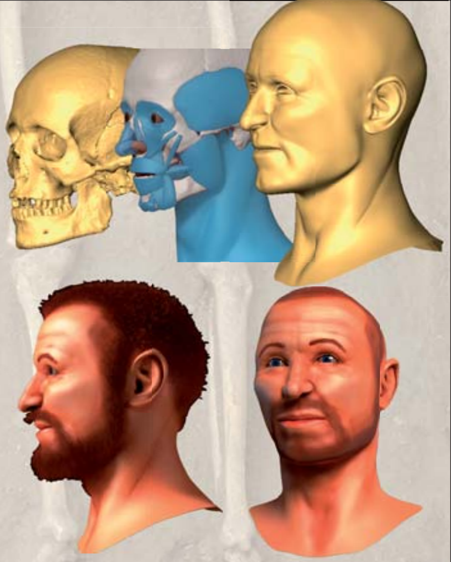
Visual and Metrical Analysis





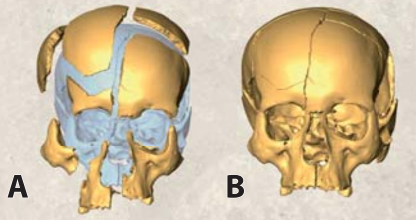
Virtual models are point clouds admissible to further data processing (metrical/visual assessment, color maps) as virtual substitutes for physical bones (Fig. A, a cranium with placed landmarks collected for comparing inter-landmark distances). In small-sized objects, such as teeth, 3D model may even uncover subtle, otherwise unnoticeable morphological details (Fig. B, transversal grooves forming hypoplasia of enamel recorded with ATOS 3D scanner).

Facial Reconstruction



PC-aided facial reconstruction substitutes traditional materials (clay, cast) with 3D graphic tools. In the process 3D elements representing soft tissue pegs are placed on a virtual skull and scaled according to the most appropriate tissue depth (in regards to sex, age and ancestry). Based on the soft tissue data major masticatory and facial muscles together with skin are sculpted, modeled and shaped. The figure shows a facial reconstruction for a male, aged to mid-40s, for which the entire reconstruction was carried out in open-source software Blender.

Virtual Restoration



Skeletal assemblages are usually fragmented and/or their preservation is variable. Both surface and volume CT-generated meshes (Fig. A, skeletal fragments scanned with NextEngine laser scanner) are usable for PC-assisted (virtual) restoration techniques, where each piece is placed, arranged and combined entirely in virtual environment (Fig. B, fragments rearranged using environment of AMIRA software). An unprecedented advantage of PC-assisted restoration over physical cast and glue procedures is that a virtual fragment can be adjusted (rotated, translated, scaled) to any position necessary, mirrored to compensate for missing paired parts or even modified if certain form of taphonomic factors had affected the remains. Plus, an unlimited number of scenarios can be produced.

Conclusion

Nowadays, 3D technologies provide us with a visual and descriptive platform on various levels of resolution. While reconstructing living conditions from morphology of skeletal remains bioarcheology can profit greatly from PC-assisted 3D techniques. Many of the techniques are affordable, inexpensive, and easy to be incorporated into a routine anthropological examination even in less equipped laboratories. Others, albeit costly, can add priceless insight into skeletal biology.

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Contacts
Laboratory of Morphology and Forensic Anthropology, Department of Anthropology, Masaryk University
Web site: http://anthrop.sci.muni.cz/page.yhtml?id=557
Address: Kotlářská 2, 611 37 Brno, Czech Republic