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Benefits and risks in virtual anthropology

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Advances in information technologies during the last decades have led to tremendous changes in investigative standards in anthropological research. Many scientists have entered new grounds in human biology studies utilising high-end computer applications, e.g. computer tomography (CT), magnetic resonance imaging (MRI), and 3D-surface topometry systems. These modern imaging techniques combined with three-dimensional analytical methods, such as 3D-Geometric Morphometrics (GMM), opened novel investigation opportunities for studies in comparative anatomy, growth, and human evolution. Complex architectures of hard and soft tissues can be visualized, measured and mathematical-statistically compared on a computer screen. Rapid developments in the storage capacities of IT-systems augment the basis for the establishment of large data archives, such as NESPOS (www.nespos.org) a digital online database for Neanderthal studies, storing, organizing and providing datasets of specimens for the scientific community. The digital images and virtual reconstructions of hominid fossils and modern specimens are available through internet access for researchers all over the world after registration in NESPOS. In the preparation for this pioneering online archive many discussions within the scientific and virtual anthropology community fathomed the needs, demands and requests. As a result many options, such as regulations for data use, copyright of data, consideration of acknowledgement etc. are kept open, and can be organized individually by the users feeding the archive. NESPOS is real, and it can be tested and improved in the everyday life by a large community of users.

International consortiums, such as the European Virtual Anthropology Network (www.evan.at), a group of scientists from fifteen partner institutions of six countries funded by the European Union, adds digital data and supports to improve the digital database NESPOS. The European network EVAN consisting of universities, research institutions, museums, clinics, and private companies is educating a new generation of scientists in virtual anthropology, from 2006 until 2009. Young researchers are trained in medical image processing, 3D-digitization, modelling and software programming, and make a common cause with a reconciliation of interests in virtual data processing and archiving.

In many publications researchers have pointed out clear benefits of digital archives and the use of digital image- and 3D-applications for anthropology. However one should not dismiss that there are also risks, which should not be concealed, but rather discussed in a scientific manner.

Without a doubt one of the major benefits in virtual anthropology is the use of so-called non-invasive methods, such as CT and MRI, to acquire structural data from specimens at previously non-accessible regions of interest. Before the digital era started it was impossible e.g. to reconstruct and measure the auditory canals of the inner ear, or the tooth root canals of fossil hominids. Today, it seems just a matter of which µCT-technique is used and how much time one spends in the segmentation processes for generating a model of the cochlea, or even the architecture of tooth enamel. Almost monthly announcements in scientific journals report about modern comforts in digital 3D-imaging.

The use of non-invasive techniques is something virtual anthropology advertises; but nobody has really studied the effects of intensive X-ray exposure to a fossil specimen. Whatever future studies will tell us about X-ray effects there is one important advantage of CT and surface scanning over conventional measuring instruments, such as calliper devices. The original specimens can be stored in the safe, while researchers taking their measurements from digital images on screen after CT-scanning. This method prevents specimens from further damage by applying mechanical measuring devices. Usually the specimens are touched only twice during the process of digital 3D-data acquisition: first when they are positioned in the CT for 3D-scanning, and second when they are taken out of the CT system after completing the recording. Afterwards, surface and volume reconstructions are performed in the computer and virtual specimen models should be available for further investigations, if the data acquired are good enough for proper model generation. Primarily, the quality of digital models depends on the specimen preservation, because in some cases diagenetic processes, such as remineralisation during fossilisation, usually alter external and internal properties and structures.

However, the data acquisition is the first step in virtual 3D reconstruction followed by at least three more steps of data processing, such as enhancement, editing and visualisation, towards a final virtual reconstruction of a specimen. All four steps can further influence the quality of the digital data and include risks for data alteration. Therefore each of these processes should be taken very seriously. The first step is the most important procedure, because all post-processing steps rely on the raw data sets acquired, and usually one has only one chance to work with an original fossil and a CT system at the same place.

Further it is essential that the person who is post-processing the data has all information about the setup of the acquisition system, such as accuracy, resolution, and other scanning benchmarks. All too often there is no information about the accuracy of the scanning system available for the user. This information should be provided by the developers of the system and passed on by the processing person in a data processing protocol together with all steps and parameter for data enhancement and editing, etc. The user should know what kind of processes have been applied to the original data, because many 3D-programs provide tools for compression, reduction and smoothing, which can lead to a change of surface structures. Only, if the complete protocol of the data processing is noted for the user, can he make up his mind if the data are useful for his purposes or not. One should keep in mind that 3D-data can only image structures of original specimens, and the quality of a 3D-model primarily depends on the quality of raw data and the applied preprocessing jobs.

Actually, an optimal situation in the 3D-lab would be that one does the processing and visualising of digital data on screen, while having the original specimen on the desk in front of you. In reality this situation takes place very seldom, because usually digital data are further processed back in the institute, frequently far away from the originals. Therefore it is very useful to have at least a high quality cast and also good photos of the original available. Furthermore, the person who does the data editing should be familiar with the preservation and appearance of the original specimen. This reduces the chance of accidentally editing alterations.

Nevertheless 3D-data processing requires much experience; most of the software packages provide a large choice of tools for data enhancement, editing, and visualisation, requiring the processing person to decide e.g. which filters should be used for producing a high quality reconstruction.

If all these risks are critically considered by the researcher applying measuring tools and other algorithms to a digital dataset, then virtual anthropology can demonstrate all its power and benefits for the study of human evolution, and also for other disciplines; additionally digital data archives, such as NESPOS and others, are greatly supportive to augment and to disseminate our knowledge, providing large samples of digital specimens for comparative and quantitative studies.

There is no doubt that the application of modern 3D-computing methods and the establishment of digital archives with access to virtual specimens and raw data create new perspectives for anthropological, medical and for industrial studies, as long as we do not forget to be critical with digital results and keep control of the quality of our data produced.