Editorial

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Digital Archaeology

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Research in history spans the incredible time span of 5.300 years allowing insights in many aspects of the changes and constants in culture. However, the written word might not always tell the truth nor is it available for all regions and time periods. So archaeologists investigate material remains and create insights into wide variety of topics like production techniques, trade, migration, climate change and many more.

As archaeological research is related to the Humanities it organizes itself typically according to certain regions and/or time periods starting with prehistory, which is probably closest to natural science in contrast to classical archaeology having a strong bias towards art history. Having adopted mathematical and statistical methods in substantial amounts for archaeological research the path for including computer science was prepared quite early. This can be dated at least to the 1960's introducing a New Archaeology by Lewis R. Binford and David L. Clarke as well as early works by Clive Orton and Nick Ryan. These formative years continue in the early 1970 s where a small group of archaeologists and mathematicians founded the *Computer Applications and Quantitative Methods in Archaeology* (CAA) group. It organized its first annual conference in 1973 in the United Kingdom. From this on the CAA became gradually an international association with a German chapter founded in 1981 having its own workshops since 2010. In recent years more national chapters were founded, which have an important role to acquaint students of archaeology to digital methods. Due to this organic growth terms like Archaeoinformatics, Computational and Digital Archaeology have been rather coined than defined. By present day the latter seems to be the more prominent and overarching.

As archaeological research with digital methods in focus has steadily increased the teaching curricula has changed more subtly than in the Digital Humanities. One could say that there is less hype about digital methods in archaeology, which can be seen in the denominations and requirements of posted positions as well as the development of study programs. However, this complex and long history of Digital Archaeology as a science of its own is currently explored on the occasion of the 50th CAA conference. An accompanying publication about the CAA's history has already been announced and is in preparation.

The articles in this issue are samples of most recent work done by archaeologists and computer scientists mostly based in the German speaking parts of Europe, while their research domain are more divers in time, geographic location and methodology. As first article we start with an extensive survey on digital pottery analysis, as it concerns one of the most relevant types of archaeological findings with Stephan Karl as an expert in this field. Together with colleagues from archaeology and computer science he analyzed and categorized more than 200 publications from 1997 to 2021. The list of references is available as digital supplement.

In the second article one very novel digital method for pottery is presented by Stefan Lengauer and colleagues from computer science at TU Graz and the University of Chile as well as archaeologists from Graz University. Similar to annotating documents the annotation of decorated pottery is a crucial task to answer questions about pottery manufacturing or stylistic changes being relevant for chronologies. So *Convolutional Neural Networks* (CNNs) are trained to assist the archaeological workflow of annotating patterns on ceramics. This work is part of the PhD thesis of Stefan Lengauer, which will become available in 2023. Additionally, benchmark datasets and results of the according competitions are presented. It has to be stressed that there are barley any archaeological datasets available for benchmarking. This makes the presented work a very unique opportunity for computer scientists to join and advance Digital Archaeology.

Next is an article by Mike Lyons, another young researcher, and his colleagues from the *German Archaeological Institute* (DAI) in Bonn. They are pushing forward the use and integration of digital methods into the daily in situ work at archaeological excavations. This work started in 2017 at the Honduras excavation adapted low-cost 3D acquisition for pottery documentation. By present day, this has been extended to digitally document the whole excavation site using *Structure from Motion* (SLS) as well as *Light Detection And Ranging* (LiDAR) for the surrounding

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area. Finally, a very new approach for pottery classification is shown using Deep Learning of thin sections images of ceramic fragments. This adds an additional layer of information to the 3D datasets representing the shape of a vessel.

The fourth article is an introduction for non-archaeologists to Airborne LiDAR data in landscape archaeology by Benjamin Štular and Edisa Lozić from the *Research Centre of the Slovenian Academy of Sciences and Arts* (ZRC SAZU). Their work is the analysis of the largest traces of human activities, i. e., changes to the landscape from faint roads to architectural remains. Those features are typically hardly recognizable from the ground. So early archaeology was using the birds eye view from airplanes, while this article shows the digital means to analysis *Digital Terrain Models* (DTMs). In addition to technical and archaeological aspects, the references in the article include a number of relevant and comprehensive works for further reading.

Within the fifth article by Irmela Herzog, an applied mathematician being responsible for the *Scientific IT* at the *Rhineland Commission for Archaeological Monuments and Sites* (LVR-Amt für Bodendenkmalpflege im Rheinland), we have an interesting example for in depth computational analysis of landscapes as DTMs. This research is motivated by the question about ancient boundaries, which were not as precisely defined as we are used today. So computational approaches towards the understanding of past boundaries is presented with a case study based on archaeological and historical data in a hilly region in Germany. The article is also an excellent example for the use of *Geographical Information Systems* (GIS) being a major component in archaeological research.

These five articles cover a lot of ground in terms of relevant topics from high resolution images of smallest pottery details to determining boundaries of ancient settlements. However, there are much more topics, which pose interesting challenges requiring a lot of team work for researchers in all career stages. Examples for further topics are digital art historic research on statues, analysis of tools from stone or metal, virtual reconstructions of buildings, and text bearing objects like inscriptions or cuneiform tablets – just to name a few. I hope this issue will spark more interest and interdisciplinary developments by computer scientists and engineers together with archaeologists.

Bionotes

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JProf. Dr. Hubert Mara studied Computer Science at the Vienna University of Technology followed by a Marie-Curie fellowship in the Cultural Heritage Informatics Research Oriented Network (CHIRON) at the University of Florence in 2007 and 2008. In 2009 he joined the Interdisciplinary Center for Scientific Computing (IWR) at Heidelberg University where he finished his PhD thesis in 2012. In 2014 he founded the *Forensic Computational Geometry Laboratory* (FCGL) at IWR funded by the DFG's German Universities Excellence Initiative. In 2020 and 2021 he was the administrative director of the *Mainz Centre for Digitality in the Humanities and Cultural Studies* (mainzed). Since winter term 2022/23 he is a junior professor for eHumanities at the Institute for Computer Science at Martin Luther University Halle-Wittenberg. Since 2016 Hubert Mara is a member of the board of advisers for the German chapter of the Computer Applications and Quantitative Methods in Archaeology (CAA) association. His interests lie in 3D computer vision and machine learning for cultural heritage. His work combines Digital Archaeology and Digital Humanities typically for text-bearing and decorated archaeological findings. Parts of his work on analyzing high resolution 3D-measurment data are available in the Free and Open Source GigaMesh Software Framework.