S19 New technologies and archaeology: The impact of the digital revolution

Anne Moreau, Federico Nurra

The interest of digital technologies for archaeological data exploitation and analyse is well-known as shown by many papers at previous CAA conferences. The "new technologies" including photogrammetry, three-dimensional modeling, GIS (not so new), agent-based model, internet and its consequences—opendata, Openaccess, Geolinked data- are nowadays integrated within the archaeological research process and some of them are about to be the new tools of the archaeologist for his daily work. It is not over: we live in a time of technological transformation. What are the changes brought up by the introduction and the diffusion of the new technologies? How does it change our practices and our way of thinking archaeology? Is that better or only different? Accordingly, this session aims at focusing on the following issues:

- the consequences of the data digitalisation and the field data recording (efficency? fiability?)
- the changes raised by the new technologies in the ways of working and the organisation of work
- the way of exploring the data : spatial analyses, statistical analyses, three-dimensional modelling etc
- relationships between the scientific problematic and the tool contrived and used
- the archiving of data
- the definition of data and metadata
- the sharing of data, the diffusion of knowledge
- the collaborative working
- the training of the archaeologists
- the definition of the professions involved in producing archaeological data
- …

The session will explore the questions raised above through different cases studies exposing how the new technologies are used and what are the changes involved. One of the consequences of the widespread use of the new technologies is the ocean of data produced, forgetting sometimes that archaeology, even digital, is a human science.

S19-01 Towards a national infrastructure for semi-automatic mapping of cultural heritage in Norway

Martin Kermit, Jarle Bauck Hamar, Øivind Due Trier

Recently, the Norwegian government decided to finance a new national digital terrain model (DTM) based on airborne laser scanning (ALS) at 2 pulses per m2 in forested areas and automatic image matching above the tree line. This may open up for semi-automatic mapping of cultural heritage in any region of interest in Norway, provided that the cultural heritage being sought manifests itself in the DTM. However, this calls for the development of a national infrastructure combining the storage and retrieval of ALS data with automatic detection methods.

A pilot web portal for this infrastructure has been developed for use by archaeologists in some county administrations in Norway. The user specifies an area of interest, and selects which types of cultural heritage to look for. Since the new national DTM is not implemented yet, the user will need to upload an ALS data set. As the processing of large ALS data sets may be time consuming, the user will be notified when the task has been completed by an e-mail, which also contains a link where the processing result in the form of vector files may be downloaded.

Currently, semi-automatic detection of the following types of cultural heritage is supported: grave mound, pitfall trap, charcoal burning pit, and charcoal kiln. We plan to add semi-automatic detection of hollow ways and stone fences.

The output is one set of files for each type of cultural heritage. Within each type of cultural heritage, the detection results are grouped into six levels of confidence. The detections should be viewed and evaluated successively by an experienced archaeologist; starting with the highest confidence level.
The pilot portal is already a useful tool for archaeologists in the participating pilot counties in Norway, and demonstrates the need for a national infrastructure for processing of ALS data.

S19-02 Autonomous stereoscopic photosphere system for archaeological site virtualization
Dimitri Schreiber, Dominique Meyer, Dominique Rissolo, Falko Kuester
Over the last decade remote sensing has greatly improved in both its realism and coverage. Miniaturization and reduction in the cost of sensors, as well as game changing advances resulting from the development of new technologies have played a critical role in these improvements. This oral paper will explore an imaging technology, CaveCamX, that has been enabled as a result of these advances. CaveCamX is a small binocular two axis gimbal system used for creating high resolution 3D photospheres, combined with GPS and IMU data. This enables better coregistration internally within a single photosphere, and externally between heterogeneous datasets, including fusion with point clouds generated from Photogrammetry and Lidar. This decreases human processing time by automatically recording location and orientation of the dataset which would previously be recorded manually and therefore often left out or lost. The attitude data will hopefully enable fully automatic stitching of stereoscopic datasets without the commonly associated motion sickness by constraining the system, limiting how the software can warp the images. Its small size and low power consumption allow it to be easily taken with on field expeditions, without compromises in photo quality or excessive weight, like other systems. CaveCamX enables remote visualization of archaeological sites, allowing researchers to be virtually immersed in the captured scene without having to travel across the globe to be physically present, with high resolution (1GP sized datasets). It enables researchers to remotely view an area as if they were there (with the constraint that they are limited to a few locations in the area) with great detail, in contrast with other systems like LIDAR which provide different advantages.

S19-03 Systematic literature review on automated monument detection: A remote investigation on patterns within the field of automated monument detection
Karl Hjalte Maack Raun, Duncan Paterson
Automated procedures are necessary to cope with the vast amounts of digitized information within the field of cultural heritage. During the last 15 years, digital landscape analysis and detection of cultural heritage monuments developed rapidly especially due to the availability of LiDAR data. With the increasing amount of information, automated procedures are suitable for monitoring and surveying known monuments, as well as detecting unknown monuments. This study measures the state of automated procedures within cultural heritage detection and management, by correlating key terms for LiDAR data with academic citations of their use. Cross- referencing this impact measure with occurrences of "automated procedures" enhances our understanding of best practices. We analyze these results, using the methods of network analysis (NA) with respect to personal, institutional, and financial ties and actors involved in automated monument detection. In addition, a Systematic Literature Review (SLR) using standardized search structures on publications related to "automated monument detection" for LiDAR data from 2000 to 2015 reveals the evolution of the field. The observable trends and patterns within the combined results of (NA) and (SLR) allow for a critical assessment of current research practices. Based on these results we conclude by formulating recommendations for future implementations.

S19-04 Spatial analysis of Ancient Egyptian Monuments. Case study: Late Period private funerary monuments of Thebes

Anja Wutte, Peter Ferschin, Georg Suter

The term of rock-cut tombs describe a type of funerary monuments found all over Egyptian history. Their designs and building concepts show a strong coherency within their local occurrence, in a specific timeframe and even within a social status class. The chosen case study was analyzing private funerary rock-cut monuments of the Twenty-fifth and Twenty-sixth Egyptian dynasty, located in the Asasif, in Theben West, the modern Luxor. The major goal for this project was to obtain design principles of those rock-cut funerary architectures. The structures were digitalized and converted into a BIM (Building Information Modeling) model to be analyzed for certain architectural properties (e.g. accessibility of spaces and areas like semi-public offering places and non-public cult places, decoration positions and natural lighting). Social, local and chronological data was integrated and the models could be compared with each other on the basis of those informations. Questions like the relationship between different premises and natural lighting, the position of decoration categories or the differences of semi-public and non-public parts in ratio to their accessibility could be answered. These analytical methods offer insights into the design principals of the monuments. Additionally a Model Comparison Tool was implemented to offer interactive and visible information about the building typologies of the funerary monuments. This tool visualizes information about the buildings in combination with additional metadata (e.g. social parameters) within an abstracted spatial representation of the building. The monuments can be arranged by a set of parameters like social rank or sex of the owner, chronology of construction and land consumption. The developed tools are independent of archaeological content and type of buildings.

S19-05 Optimization in the co-registration of large point clouds for archaeological visualization

Dominique E Meyer, Jamie Hodgkins, Fabio Negrino, Christopher E Miller, Caley M Orr, Falko Kuester, Stefano Benazzi, Marco Peresani, Julien Riel-Salvatore, David Strait, Matthias Czechowski

Photogrammetry has been used in Archaeological studies to gather 3D data of sites and artifacts. Improvements in imaging systems, stitching algorithms and computation power has increased point cloud sizes and densities. Open-source and commercial softwares often cannot handle very large point clouds, making it cumbersome and difficult to combine large data sets. We propose a novel workflow to optimize the merging of large point clouds and visualizing them. Sites are often reconstructed at different scales ranging from square kilometers for environments to millimeter details on the ground. Aerial Surveys can be used to create large Digital Elevation Models (DEM) and they can contribute 3D models of buildings and architecture which is not easily accessible. Handheld photogrammetry and LIDAR scanning can be used on the ground to gather high accuracy models of structures, interiors and artifacts. A case study of the Arma Vairana Cave in Liguria, Italy, is presented where nine aerial and ground point clouds were merged into a fully immersive point cloud.

S19-06 3D survey for archaeology: When the solution can be a problem

Angela Bosco

The introduction of sophisticated survey techniques in archaeology has led to clear improvements in the acquisition process, making faster some operations and allowing unprecedented accuracy. But archaeology is really able to manage these oceans of data? Although the perspectives are very interesting and challenging for the research, the feeling of not having yet fully exploited the potential of this instrument is strong. Archaeology (among

other disciplines) insists to use the 3D as a kind of "advanced" 2D, thus losing its main benefit: the volume. On the other hand, research experience in Italian archaeological sites such as Pompeii, Herculaneum and nearby areas, allowed us to meet and deal with different issues. The article aims to address the problems of acquisition, processing and subsequent restitution of the extracted data of three- dimensional survey, whether by laser scanner or un-calibrated photogrammetry, both terrestrial and aerial. Also, issues relevant to the post-processing of the point clouds and the management of huge amounts of data are treated. Practical examples clearly show the need (i) to clarify what are the products that can be obtained from the application of each survey technique, (ii) to give information to correlate the products with the aims of the specific archaeological study, (iii) to give guidelines for the right integration of the different techniques in order to take full advantage of their potential and to allow that 3D survey will be seen not only as a container of infinite planes, sections and ortho-rectified photos, but as a real database itself, that can be queried to get 360-degree information.

S19-07 Interpolating 3D stratigraphic information from written excavation reports
Ana Predoi, Lutz Schubert, Keith Jeffery
Early excavation reports of around 1950 already employed meticulous recording techniques, yet fail to respect a lot of aspects concerning information that would help in generating relational information about a site's organization at different times, such as recurring occupation of sites during specific seasons. The interested archaeologists either have to rely on their ability to mentally visualize the information or painstakingly map it out on paper and try to generate some layout information this way. Such information is however typically not shared further and rarely takes additional concerns such as geological constraints into consideration. In this paper we present an approach that generates a rough / indicative 3d model of the stratigraphic layout of an excavation on the basis of stratigraphic profiles (along the excavation walls) and potential planar maps (insofar as they exist). The approach can take the location of finds into consideration, given that the according data (coordinates and stratigraphic layer they were found in) is reported. We propose and discuss different approaches to align the 3d model with the profile data. Obviously, the model will fail to reproduce any irregularities that were not recorded by the excavators, but we will show how geological information can be taken into consideration to improve the regular(!) properties of the stratigraphic layout, even without further information given. The paper discusses whether such models are sufficient for archaeological discussions with a particular reference to site occupation and usage.

S19-08 3D photogrammetric documentation in the archaeology of the contemporary past: Preserving the World War II landscape in North-West Sardinia (Italy)
Alessandro Panetta, Paola Derudas
Since the publication of Paul Virilio's "Bunker Archäologie" in 1975, there was an increasing interest in the archaeological study of the 20th century wars, especially WWII. This research take into account a database of nearly 200 surveyed and inventored military buildings and pillboxes built in 1943 for the coastal defense of the north-western Sardinia (Province of Sassari). Our aim is objectively documenting this particular archaeological record looking at its preservation both as a material and as a cultural heritage of european history, objectively, by the study of topographical organization of these buildings, their relationship with landscape and their internal space division according to their different tasks. We need to document this fragile heritage in his 'becoming archaeological', recognizing the historical and archaeological dimension of these often considered simply 'old' concrete buildings scattered in the countryside, before they becomes 'ruins', with their slow steady consumption. For this

reason the target of the research is the preservation of the memory of war, by the preserving and knowledge of its physical scars like these buildings are. To do that, we propose the use of 3d documentation technique, for the development of this 'en plein air' museum, making it accessible also by remote devices, due to the often difficult access to them on the ground. The 3DHOP presenter was chose to reach the goal. It is a flexible framework that allows to manage and handle 3D contents, also big ones, in a very easy way and through a series of ready-to- use templates. It will possible to take digital tours of the buildings, both outside and inside of them and the visit will be enriched by connecting multimedia data, such as related historical information and images. Some details will be highlighted through zooming tools, useful to catch and direct visitors' interest to the main contents.

Cancelled **S19-09 Letter from the trenches: Challenges and strategies in the development of a digital collection management architecture**

Torkel Johansen

The paper discusses current challenges and strategies being implemented in the ongoing renewal of the national, digital collection management infrastructure in Norway. For the past decades, the archaeological museums in Norway have cooperated in the development of digital solutions for collecting and managing archaeological data. Several projects have been conducted, renewed or replaced during this period, both at a local and a national level, rendering a complex inheritance of systems, practices and data-sets. Simultaneously, the rapid development of new documentation technologies and -practices are posing significant challenges to traditional curating practices, such as the systematical collection, management, preservation and dissemination of the source material involved. Arguably, these challenges cannot be solved through technology alone, but rather through the development of persistent enterprise- and information architectures that support traditional museum objectives.

S19-10 A proposal for a collaborative Web Mapping for archaeological spatial data: OpenArcheoMap

Federico Nurra

This contribution would present the results of a research project developed during a PhD thesis: an open and collaborative Web Mapping platform on a global scale based on XML interchange protocols and accepted standards, in cartographical terms but also from an archaeological point of view. The last thirty years of computer applications dedicated to the detection and positioning of archeological findings have produced a multitude of information systems for the storage, systematization, publication and sharing of spatial data. In this paper, we will focus on the minimum specifications that the archaeological data should have in order to be uniform and interoperable, and above all, on the geometric and cartographic characteristics that would allow the production of a homogeneous archaeological mapping. Until this moment, the proposals for the production of archaeological cartography have been developed at local, regional, national or, with rare exceptions, continental scale. Thanks to recent advances in information technology, it is now possible to create an open platform for the implementation, storage, exchange, discussion and verification of spatial archaeological data on a global scale. We will identify the primary categories for the acquisition of archaeological data, by defining the minimum standards of compliance of the data, without, however, trivialize the data themselves, with a consequent dangerous loss of historical-topographical information. It will be fundamental to identify the four coordinates of objects acquired and a minimum data set of attributes, plus a set of metadata, essential in order to recognize the origin of the data, their nature, their authorship, production, quality and reliability. The proposal will be therefore the development of a Web Mapping platform, open and collaborative, for positioning and representation of archaeological remains, a sort of

"cadaster", and an analytical and detailed knowledge base to assist, support and address each territorial study.

S19-11 HumanOS Project: A nomadic osteological inventory

Rozenn Colleter, Guillaume Roy, Thierry Gaugry, Jean-Baptiste Barreau

Three computer specialists and an anthropologist have created and developed an application called “HumanOs” to facilitate the registration of human bones from archaeological sites. This is a simple osteological data acquisition and management tool to deal with significant quantities of human skeletal remains, count and locate them.
An intuitive graphical user interface has been developed, allowing to add osteologic items in a dynamic and ergonomic way. The application is intended to be free, open source, nomadic, intuitive and suitable for any device support with an online version that operates on Google Chrome, Firefox, Internet Explorer and Safari. An offline version, that can run on any local web development environment, is also downloadable to work when the archaeological site has no network connection available. The Université Paul Sabatier - Toulouse III will host the source code.
Regarding the use and after filling out the name of the archaeological site, the number of burial and skeleton (if several are available), the operator can easily record the presence and state of conservation of each bone with a specific color code (green : preserved to over 50%, orange : less than 50%, red : undetermined or white : missing). The user can move or zoom on the skeleton to reaveal underlying bones (cervical vertebrae under the skull and thoracic vertebrae under the sternum and the manubrium) with a mouse or with fingertips on tactile supports. The name of each bone appears as a banner on the support to confirm identification in order to help the operator, for example in the case of carpus bones. This application also allows to itemise the number of the skeleton conditioning bin and a commentary. All these information allow to rapidly process the material at the time of the study or delivery of collections to the State. The preservation schemas can be exported as vector image SVG files that can be used by all CAD softwares.

S19-12 Using GIS to study ancient landscapes. The case study of the Pisa centuriation (Italy)

Arianna Commodari

The utilisation of GIS and spatial analyses help answer the phenomenon of an ancient agrarian system's transmission from Roman period to ours days in the plain of Pisa. The paper, in the first section, describes the methodological approach used to collect, to manage and to explore the data base consisting of cartography, archaeological, geological and hydrological data, in a GIS system. The study of the form and structure of the agrarian landscape carried out on various documents (aerial photographs, modern and ancient cadastres, satellite images), and the analyses of hydrological and environmental characteristics realised whit the utilisation of GIS permitted understand the conditions and the process of transmission of the centuriation (ancient agrarian system) over the centuries. In the second part are showed the spatial analyses (DTM and interpolation analyses) which bring new elements to the reconstruction of the ancient landscape. The last section focuses on the statistical analyses realized on the agrarian and urban parcels inside the centuries, to solve historical and morphological problems. In conclusion, the "new technologies" apply to the archaeological research permit to collect and manage different informations, to propose new interpretation and are fundamental tools for an interdisciplinary approach on the study of the ancient landscape.

S19-13 Discerning and explaining shape variations in Later Stone Age tanged arrowheads, South Africa

Ilan Ryan Smeyatsky, Karim Sadr, Patrick Randolph-Quinney

Over the past decade a new method of statistical shape analysis, geometric morphometrics, has been applied to the study of artefact shapes. Later Stone Age (LSA) tanged stone arrowheads have been analysed with geometric morphometrics and reveal spatially coherent variations in their shape. These spatial variations may indicate stylistic or other kinds of boundaries between different elements of prehistoric San populations, and understanding them can shed light on the social and economic organization of southern African hunter-gatherers during the later Holocene.

S19-14 Structuring data from documentary study and archives for spatial studies. Examples from funerary archeology

Jean-Philippe Chimier, Matthieu Gaultier, Isabelle Pichon

Several archaeological studies have recently been conducted in the region of Tours (Val-de-Loire, France) on village cemeteries. They consist in assessments carried out through small excavations, mechanical test pits and construction monitoring. The field projects are associated with a study of archives (written and cartographic sources) and a documentary study (old excavations and discoveries, documents, local knowledge)

The usual documentary study aims at guiding the implementation of the excavation. The latter then provides most of the information. In certain cases, such as ours, the old documentation allows to understand the remains which result from limited observations.

The spatial study of these sites occupied in the long term requires the management of the archaeological documentation in a database or directly through the GIS software. This is also the case of the information given by archives and documentary studies that needs to be structured beforehand.

Nevertheless the structuring of the data is not an obvious fact. It only proves useful when georeferencing the information. The old documentary or archive studies performed without SIG locate the information in the form of a map while the current studies tend to spatial analysis.

This new approach requires the establishment of a catalog of datas aimed at their ranking according to their attributes, intended for analyse. The preliminary definition of attribute information is based on questions derived from a problem that must be mastered beforehand.

Village funeral groups of the diocese of Tours are particularly well documented by the textual and archaeological sources and have been sufficiently studied for the last twenty years to introduce changes in the structuring of the data from archives and documentary studies toward the systematic use of GIS, particularly in preventive archaeology.

POSTER

S19-P1 From the field to the showroom: The Augmented–Reality Kilns ExhibitiOn (ARKEO)

Alexis Gorgues, Florent Comte, Sonia Syllac

In 2015, the four years old LABEX Bordeaux Archaeological Sciences (LaScArBx) inaugurated an exhibition summing up its first and main results; among these, the results of the investigation project "The pottery in the Ancient Mediterranean: the Iberian Case". One of the main action of this program consisted on the excavation of the 3rd-1st cent BC Mas de Moreno (Teruel, Spain) potters' workshop. During this excavation, and since 2012, a 3D scanner was used for recording excavated structures (mainly kilns) as well as some artefacts (pots, loom weights, toolsÔÇª), in order to optimize the quality of the archaeological data.

These data have been first used for scientific purposes (as support for virtual experiments), then for communicating scientific results in an academic context, and, least but not last, as a medium for augmenting an exhibition aimed at a wide audience, on the specific context of the exhibition we previously referred to. In this poster, we would like to present the process we used, from the field recording to the elaboration of easy-to-use 3D models. The presentation will be subdivided into 3 different parts. Part 1 will document the field recording with an Artec EVA scanner. Part 2 will analyze the data processing phase, and present the first experiments of field-data-based infography, aimed at a scientific public. Part 3 will consider how we "reconverted" these documents in interactive, augmented reality models within the exhibition. These models, imported as assets in Unity 3D, were accessible through tablets, thanks to the Vuforia Platform, and allowed the integration in a panel-based exhibition of "virtual objects" (a kiln, a potter's stamp, a pot, a tool), that could be manipulated and closely examined by the visitors, thus enhancing their experience.

S19-P2 Roman archaeology and GIS visibility studies
Mar Zamora Merchán
Since the introduction of Geographic Information Systems (GIS) in archaeology, the study of visibility from (and around) a particular viewpoint has been one of the most popular GIS applications. This poster deals with the study of visibility through GIS in Roman archaeology. The poster will show a numerical (and graphical) review of GIS visibility applications in roman archaeology (viewshed, Line of sight (LOS) and related tools). The main aims pursued are as follows: - identifying preferred application contexts; - to assess the impact of this kind of GIS tools in the research of the Roman period.
Papers published on the past CAA proceedings will have a particular treatment.
The poster is intended for researchers interested on viewshed and related tools, specially for those working on Roman archaeology, and also for students involved with GIS learning (since an array of different GIS applications related to visibility studies will be mentioned).

Cancelled **S19-P3 Digital strategies and workflow. Case studies from large scale excavations in Central Norway**
Raymond Sauvage, Magnar Mojaren Gran
Ever since the typewriter gave way to the PC, there has been a rapid increase in new digital ways to produce, record and process archaeological data. We now seem to have reached the point where the analogue way of doing things has become a major speed bump in the workflow of archaeological excavations. One example is digitalization of analogue data, which makes for double work hours and illustrates the need for a total digital strategy and workflow, for on site as well as off site work.
To develop new strategies and better workflows for digital documentation, we need to recognize not only the potential for use of new technology, but also it's limitations. We need to consider the level of quality we wish to achieve as the end result of our excavations ÔÇô not only the efficiency compared to already established methods.

S19-P4 Why 3D printing technique is the useful tool for artifact conservation
Wuyang Shui
Artifact was one of most important and valuable resource of cultural heritage. Only a limited number of artifacts were exhibition in other museums considering safety and precious, therefore it was a good solution to provide replicates for publics visit. Many of artifacts were still broken and needed artifact conservators restoration, therefore the new techniques should be considered to improvement the restoration speed and reduce prevented further damages. Hence, artifact conservators faced two tasks: how to easily and accurately to replicate artifacts

and how to produce physical model of missing region to restore the damaged artifact.
In last two decades, 3D laser scanning technique has acquired both geometry and texture information of object and three-dimensional printing technique (3DP) has successfully converted the digital model to lifelike physical model. Therefore, the hybrid technique combining digital modeling, geometry computation and 3DP has gradually application in various applications. In this paper, we firstly reviewed the laser scanning and 3DP techniques, and analyzed the advantage and weakness of 3DP. Then, we described the technique pipelines of geometry computation and 3DP applications, especially the computation of missing region in detail. Finally, three case studies were illustrated, including artifact replicates(such as Wa dang, Chinese architecture), guiding heavy fractures reassembling (Terra Cotta Warriors and horses) and missing regions production(damaged bronze Gu of the Forbidden city), which described how laser scanning and 3DP techniques were implemented to support artifact conservators to overcome the limitation of traditional manual technique. With the cost of 3D printer and printing materials falling, printing precision improving and printing materials developing, we considered more and more artifact group require 3DP to help them.