

## **S12 Documentation interpretation and communication of Digital Archaeological Heritage**

*Carlo Bianchini, Alfonso Ippolito, Carlo Inglese, Luca James Senatore*

Any comprehensive knowledge concerning Archaeological Heritage can be reached only through the development of different investigation activities belonging to a very wide range of disciplines: archaeology of course, but also history, chemistry, physics, architecture, and so on. In the last two decades, this whole research field has experienced (like the majority of human activities) a massive transition from analogic to digital tools, data, information. While this transition can be considered by now almost concluded, nevertheless many problems remain unsolved especially concerning the way Archaeology is digitally documented, how this information is elaborated and finally how it is communicated. For instance, digital surveying technologies have produced important changes in the study, analysis, and interpretation of archaeological elements and the growing demand for realistic 3D models enabling the cognition and popularization of archaeology represents one of the most clear consequences of this process. Furthermore the opportunities disclosed by the digital revolution are deeply influencing even the management and preservation of Archaeological Heritage by now inextricably connected with the innovative processes of acquiring, organising and using digital information. In this framework, the multidisciplinary and multilevel approach that allows us to document, study, interpret, manage, preserve, and popularize archaeology implies the structuring of an innovative system of knowledge where all these phases are not only connected but also balanced among each other enlightening in this way a new image for Digital Archaeology itself. This session will thus not aim at focusing on a specific technique/technology but instead on state-of-the-art projects and investigations showing the integration of digital techniques, tools and methodologies necessary to understand, represent, spread, communicate and explore Archaeological Heritage. Contributions to this session will discuss the use of integrated and multidisciplinary approaches in archaeology, use of digital data acquisition technologies, data processing and communication. The focus will be on: 2D and 3D data capture methodologies and data processing in archaeology, 3D GIS, BIM, use of different system to document and explore archaeology, archaeological and historical research, standards, metadata, ontologies and semantic processing in cultural heritage, data management, archiving and presentation of archaeology content, innovative topics related to the current and future implementation, use, development and exploitation of the innovative technologies, on-site and remotely sensed data collection, innovative graphics applications and techniques, libraries and archives in archaeology, diagnoses and monitoring for the preventive conservation and maintenance of archaeology, information management systems in archaeology.

### **S12-01 Multi-shape archaeological modeling and communication**

*Carlo Bianchini, Giulia Pettoello*

Fragmented, faceted and often even undisclosed, an archaeological site is perhaps one of the most heterogeneous piece of Cultural Heritage. Its multiple layers can be though classified into three main categories: completely visible, partially visible and not visible. The last one represents an element of special interest being related to the reading of an observer and his/her subjective background and ability in collecting, interpreting and elaborating a variety of data and information. Anastylis operations are thus the product of this process of merging/filtering of information: data coming from fieldwork, surveys, documental sources, comparative analysis and so on. Too often though the results seem to address exclusively scholar and experts while a wider communication of new information and content is neglected or underestimated. The project we are presenting, focusing on the archaeological site of Vulci in Tuscany, has instead tried to balance the two previous aspects (scientific consistency and

communication effectiveness) exploring the potential of several outputs: video trailer, smartphone application, real-time model, 3D PDF and digital brochure. The research has taken into account both the nature of the archaeological site and the generic visitor's need designing a tailor made communication project according to a specific object, the Great Temple in the Vulci site. Intangible aspects have besides taken into great account: while in fact the communication of tangible elements is easier, intangible is instead difficult to be analyzed and transmitted. Our research has tried also to deal with these issues not only providing a virtual reconstruction of something that actually is just a memory (the Great Temple) but also of the "overall picture" of the cultural landscape the building used to be part of: a work possible only analyzing and interpreting the existing traces "in situ". The result is a flexible communication grid which is at the same time very simple and intuitive. The cultural interaction between user and archeological heritage becomes a mutual exchange. Memory "takes" shape to return to existence again virtually.

## **S12-02 A methodology for the analysis of graphical representations in archaeology and some preliminary results**

*Ruth Varela*

Nowadays, archaeology and its related disciplines face interesting challenges from the graphical point of view. The most relevant of these challenges revolves around the visual language used in graphical expression, and aims at finding the most suitable system of representation for each form of representation and for each stage of the knowledge generation process, especially in those methodologies that generate or manage a large quantity of data. The main visual communication problem stems from the incorporation of visual languages linked to other disciplines with a lesser tradition of graphical expression, such as statistics, without a proper adaptation to the visual needs of archaeology and archaeologists. This results in much of the displayed graphic information being visually encrypted and, therefore, difficult to interpret. Additional problems exist in relation to the lack of expressive autonomy of many graphical representations.

With the aim to understand and solve these problems, a method of analysis has been designed where a systematic analysis and description can be carried out of graphical variables and graphic elements intervening in the construction of archaeological graphical representations, as well as of the elements employed for their interpretative support. Regarding the graphical variables, aspects such as the type of graphical process, the structure of the composition, the narrative structure, the level of abstraction, the viewing distance, the temporal treatment or the intentionality, etc. are studied. Within the graphic elements, the graphical representations are dissected in order to reveal the typological units and graphic objects with true expressive autonomy.

This approach was employed to analyse a sample of 1,200 images from 8 benchmark publications in archaeology and related disciplines. The obtained data provides a comprehensive view on the suitability of archaeological graphical representations with regard to issues such as information acquisition rate, legibility, visual cogency, the ability to generate meaning, and the symbolic or tropological potentiality.

In the next stage of our research, systematic criteria will be set to help us select or develop graphical representation systems for quantitative methodologies in archaeology.

### **S12-03 Developing a workflow for analysing and annotating reconstructed models of underwater sites**

*Vid Petrovic*

The challenges inherent in the study of remote underwater sites require the development a systematic workflow to maximize the usefulness of the data collected on-site. In this work, we investigate techniques for allowing researchers to work virtually 'hands-on' with the data collected, interactively exploring and elaborating the complete site model within a single virtual environment. Building on a software platform (developed in-house) enabling the visualization and manipulation of massive point clouds, we develop highly interactive tools for the virtual inspection and annotation of the site model. Finds within the site can be selected and marked up directly using programmable brushes--whose specific action is scriptable at run-time--allowing both qualitative and quantitative analyses to be performed conveniently within the virtual environment. Marked-up finds within the model can be extracted as sub-models for further study, or viewed and analysed in-place within their spatial context. We evaluate the results of these experiments and discuss planned future work.

### **S12-04 Emerging technologies for archaeological heritage: Knowledge, digital documentation, communication**

*Martina Attenni, Carlo Bianchini, Alfonso Ippolito*

Knowledge of archaeological artefacts at various representation scales is today required of any three- dimensional models. The significance of constructing digital models in the domain of archaeology is a well-established idea and only reinforces the theoretical bases of survey and representation, conceived as structured systems for organizing and communicating information, and as the databases for critical analysis that optimize the results obtained from the concerted work of archaeologists, architects, informatics experts, etc. Presented here is a study of the Etruscan Sanctuary of Pyrgi (Santa Severa, Rome). Most of its archaeological material derives from ancient excavations. Only a few structural remnants have survived in loco, and numerous fragments of the decorative apparatus are partly exhibited in Museo Nazionale Etrusco at the Villa Giulia (Rome) and at the Antiquarium (Santa Severa). The aim is to start a process never applied to the data on the Sanctuary. The objectives have been the following: documenting and unifying information obtained from various excavation campaigns at different times with surveying techniques that ensure an a-critical cognition of the analyzed object; present a digital reconstruction of the sacred area based on philological analysis of data; apply digital technologies for dissemination of information. The core of the work is mainly based on the definition of 3D/2D/1D models based on several surveying and representation techniques (3D laser scanning, image-based modelling, semantic structuring). Attention has been focused on scientific advantages, costs, precision level guaranteed by various techniques as well as on digital visualization as the fundamental element of communication strategy. This research illustrates a complete methodology for the virtual assembling and the communicating of dismantled archaeological elements. The study includes a wide classification of elements of tangible and intangible heritage within a digital platform used as the place of expeditious consultation of heterogeneous data taking into consideration various user typologies.

### **12-05 Towards a European standard for spatial data management for archaeological heritage: Experiences in France and Italy**

*Anne Moreau, Federico Nurra*

Archaeological heritage is most of the time linked to space. That is why this communication will focus on spatial data and the way we manage them for documentation interpretation and communication, through two European case studies. The issue of homogenization and

harmonization of spatial data in archeology has become by now central to the scientific debate. The explosion of GIS, first, and Web Mapping, later, requires constant reflection on the standards to be adopted. This paper aims to make a point about the situation of two European Countries, Italy and France, which have faced the problem in a different way, in the field of preventive archeology: the first through the testing module SITAN/MODI of MiBACT at the Department of Architecture, Design and Urbanism of the University of Sassari (DADU); the second through the structuring of a Spatial Data Catalog at the French National Institute for Preventive Archaeology (INRAP). INRAP has strengthened in recent years the use of GIS in archaeological practice; it has invested heavily in the training of archaeologists and has produced a considerable amount of data. The DADU has focused on the theoretical aspects functional to the construction of a metasystem able to dialogue with the several ongoing trials in Italy. The common attempt was to arrive at a minimal form of implementation, storage and representation of spatial and topographic data without losing the important informative supply related to the attributes. The informational architecture of the system will therefore be explained in the paper. Despite the obvious differences between the two contexts, the paper will seek the common meeting points that enable to launch a proposal for homogenization and standardization of production of spatial data in archeology. The proposed challenge is in fact to overcome national boundaries, make borders permeable and work towards a common platform, open and shared, for the interchange of spatial data in archeology. An important step towards a shared knowledge and an active protection of the European cultural heritage.

#### **S12-06 Comprehensive field survey: Multidisciplinary approach for a field prospection**

*Julia Maria Chyla, Marzena Ożarek-Szilke, Wojciech Ejsmond*

Since 2013 the goals of the Gebelein Archaeological Project are to recognize the potential of the site complex, to show the most threatened areas, to document the visible archaeological features and to summarize its more than 100 years old research history. Our aims lead us to the simultaneous management of different kinds of data, which were not only collected and post-processed but interpreted as well. The amount of information collected from different sources, resulted in the development of a new method for gathering information from the field, open source databases and archives. We would like to present the results of the past two years of testing this new approach on the examples of northern cemeteries of Gebelein. This area was chosen for several reasons. One of them is the tomb of Iti- a grave of a high official from the late 3rd millennium BC. Iti's tomb was excavated by the Italian mission at the beginning of the 20th century and its area was researched later on in 1990s. During our research we discovered numerous archaeological features unmentioned in earlier publications. This situation provided us with a suitable area for testing the new method comprising of: the gathering of archival data about the excavations previously conducted in this area, the analysis of the necropolis' destruction through satellite photos and a field survey with the use of mobile GIS focused on anthropological data ( such as sex, age, paleopathology, osteometry), ceramic (type, part, dating) and archaeological data (type of feature, is it threaten, etc.). The results gained gave us a new view on the context that the Iti tomb was localized in and on the northern necropolis.

#### **S12-07 New actualities for Mediterranean ancient theatres: The Athena Project lesson**

*Carlo Bianchini, Alfonso Ippolito, Carlo Inglese*

Ancient Theatres are in many ways one of the most extraordinary legacies that past civilizations have left us: from a cultural standpoint, because of the importance that these monuments had in the social life of each community; from the environmental standpoint, because of the enormous skill that went into controlling the structures' territorial and urban

impact; and finally, from a 'technological' and functional standpoint, because of the excellence of their distribution patterns and acoustics, hard to equal even today. No less extraordinary is how well this architectural type is distributed around the entire Mediterranean basin, or the number of theatres that regularly host performances and shows. Prospectively, though, the survival of Ancient Theatres oscillates between a contemporary reuse that keeps their functions alive along with their overall relevance (but in the long run will lead to decay) and an uncompromising conservation that by eliminating all manmade pressures would indeed be effective in preserving the structure but would nevertheless condemn it to an inexorable death, culturally, socially and economically. A third factor, the widespread lack of awareness among the communities (local, but not only), has increasingly demonstrated its relevance in the process, pushing a number of activities to address not only the "knowledge" phase but also the issues related with communication and dissemination of content and information beyond the traditional cluster of experts. In this framework we shall present the activities developed by the Ancient Theatres Enhancement for New Actualities (Athena) Project funded by the EU within the Euromed Heritage IV Program. A project addressing six famous sites on both shores of the Mediterranean (M├®rida, Petra, Jerash, Carthage, Cherrhell and Siracusa) providing a special focus both on the documentation, the reading and finally some innovative ways to involve also the general public through user-friendly instruments and outputs.

### **S12-08 Handle digital data to turn them into immersive experience using the augmented reality**

*Donato Maniello, Valeria Amoretti*

Thanks to the ease of use and dissemination of 3d scanning, are becoming increasingly popular cultural artifacts that appear on web platforms for free download. This allows to easily share online 3d models and create virtual galleries. Museums that are thinking of future, have departments dedicated of digital cataloging of their tridimensional collections. It often happens that the experience remains only virtual and you have a large amount of data, which are not used for anything real. It's possible to use this large amount of data in order to achieve a thematic collection, printing in 3d the collections when you do not have the archaeological pieces. The next step is the communication of the subject reconstructed through the use of augmented reality, understood as video mapping. A process entirely open source that can provide new avenues of study, preservation and use that see in this type of temporary collections a way not to replace the asset itself, but to strengthen it in its communicative aspect. This thing allows the visitor to be able to see live archaeological normally not visible because situated in other collections or museums. The use of a video mapping documentary on a perfect 3d printed copy underlines the great perspectives in museum communication and didactic. The aims of this article is to demonstrate the potential of this type of musealization through case studies carried out by the authors of this article.

### **S12-09 Interpretative 3D mapping of large urban archaeological landscapes: The use of ESRI CityEngine for the interpretation of Ground Penetrating Radar data**

*Valeria Poscetti, Juan Torrejón Valdelomar, Alois Hinterleitner, Wolfgang Neubauer*

Large scale archaeological prospection (i.e > 1 km<sup>2</sup>) using high resolution Ground Penetrating Radar (GPR) systems start to become a standard method for the investigation of archaeological sites and landscapes. By using motorized multi-channel GPR systems, several hectares per day can be prospected with a spatial resolution of few centimeters (e.g. 0.08 x 0.08 x 0.04 m) resulting in stacks of high definition images, which permit the detailed 3D interpretation of the buried remains. By interpreting the GPR data in a GIS environment, typically in ESRI ArcGIS, the creation of detailed 3D interpretation models, especially for

large urban areas, is a time-consuming process. The ESRI CityEngine software based on procedural modeling is designed for the efficient 3D modeling of urban areas. In the presented work, we tested CityEngine for the interpretative mapping of a part of the Roman town Carnuntum (Austria), recently investigated with multichannel GPR systems by the Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology. Compared to methods we applied earlier, like the 3D editing in ArcScene involving the use of extruded polygons and multipatch features, the study applying CityEngine shows a great potential for respective applications. The possibility to extrude polygons interactively results for example in a more intuitive mapping process. The variability of file formats that can be imported, including the largely used OBJ file format, allows for a efficient combination of the 3D interpretation model derived from the GPR data with virtual reconstructions produced e.g. within 3D Studio Max in the GIS environment. Concerning the 3D virtual reconstruction within CityEngine, basic CGA rules were efficiently applied to generate reconstructed buildings from the buried Roman town. The present work has preliminary character and should be improved in the future, by focusing on the creation of custom rules for a more efficient 3D mapping and virtual reconstruction.

### **S12-10 Multimodal data fusion for the non-destructive assessment of the Baptistery di San Giovanni in Florence, Italy**

*Michael Hess*

Three-dimensional data capture has long enabled visually compelling renderings of target environments, but in most cases the generated data are not utilized to their fullest potential for scientific analysis and interpretation. In addition to realistic rendering, 3D data streams from techniques like laser scanning and photogrammetry can be used for analysis of raw 3D point data and they can also serve as a digital scaffold which can be used to spatially anchor other data streams into one holistic model that serves as the digital surrogate. A case study at the Baptistery di San Giovanni in Florence, Italy is discussed here, wherein multiple 2D and 3D non-destructive techniques were used to digitally document the monument in order to study its construction. Terrestrial laser scanning (TLS) was used to measure accurate, high-resolution geometry throughout the structure. Portions of the raw data were analyzed in order to quantify and visualize the effects of centuries of structural changes and aging. The dense set of 3D coordinates also serves as the geometric scaffold used to anchor thermal imaging, ground penetrating radar and photogrammetry data. The analyzed point data as well as the data from the other imaging modalities can now be visualized together within the entire laser scanning model of the Baptistery. The utilized visualization environment allows for interactive exploration and manipulation of the holistic digital surrogate. Interactive visualization of the data enables more effective communication of the imaging results to stakeholders and facilitates collaboration with different domain experts for further analysis and interpretation of the multimodal data. The presented methodology for multimodal data fusion can be repeated to incorporate other data types and the flexible visualization environment supports the evolution and growth of input data.

### **S12-11 The Exedra of Goreme OAM: An ocean of points to be explored**

*Marco Carpicci, Carlo Inglese, Fabio Colonnese*

From 2013 the research unit of Rome has been developing the architectural survey of the Open Air Museum of Goreme in Cappadocia. After examining individual rock-cut complexes, this unit is currently focusing on the spatial and functional relationships of homogeneous structures. This paper deals with a specific area located in the southern part of the Museum: it is a semicircular rock cliff that separates the inhabited area from the plateau. This sort of natural exedra is characterized by the presence of several artificial cavities, including

churches, refectories and service areas which by virtue of their typological variety, constitute autonomous groups and form a sort of urban settlement. The churches are the settlements' key elements around which communities built their meeting and shelter facilities. In many cases the identification of the functions and connections along the paths allows to mark sharp separations between the groups. This is the case of Cariali Kilise, the Karanlik Kilise and S.Onofrio; in other cases, such as the Pantocrator Kilise and Malta Hacli Kilise, their widespread distribution tempers this separation. The tufa surface of the exedra has been surveyed through laser scans assembled into a single point cloud. The texture of the painted surfaces has been further surveyed by recording the reflectance value during the night time in order to prevent the chiaroscuro data distortion caused by sunlight variations. Downstream of the surveying activities, the group is working on specific representations, such as plans for contour lines and sections for equidistant plane curves. This kind of representations is particularly effective for the rock-cut habitat, because it allows an objective reading and clearly shows the constructive and distribution relations among the rooms separated by meters of rock.

### **S12-12 Enhancing archaeological interpretation with volume calculations. An integrated method of 3D recording and modeling**

*Giulio Poggi, Mirko Buono*

Digital surveying technologies have nowadays found extensive application in Archaeology, enhancing the quantity and quality of data collected in the documentation of the archaeological assets. Besides the great communicative qualities, 3D data stores precisely the geometric information of a scene, enabling area and volume calculations.

In this paper we present two case studies in which area and volume calculations (on data from 3D survey and on 3D data processed and modeled through the tools and the principles of Virtual Archaeology) have achieved consistent results for the research and the archaeological interpretation. Moreover, the 3D modeling process creates virtual reconstructions that are essential to verify the likelihood of some hypotheses and represents a powerful means of communication for disclosure.

In the first case we studied a rocky outcrop by the medieval archaeological site of Canonica di San Niccoló (Montieri, Italy) where the particular shape of the context was, at first, interpreted as a mine entrance. The integration between different data coming from the 3D documentation of the outcrop, the excavation and the geological analysis has allowed the 3D reconstruction of the original shape of the outcrop, which must have looked like a wide rock shelter, today collapsed. This new interpretation was enhanced and confirmed by area and volume calculations, which have enabled the accurate quantification of the amount of space available for a living floor in the rock shelter.

In the second case the method was applied in order to study the relations between the collapsed parts of a productive building and the destruction layers in the deposit of an archaeological excavation. Without any archaeological comparison for this type of building, the volume of the layers was used to estimate the volume of the collapsed parts and to reconstruct in 3D the original height of the walls and their complete shape.

### **S12-13 A new approach for the study and presentation of an archaeological context not traditionally exploitable. Applying a fast but extensive 3D survey to the Bisarcio case study, a Medieval and Post-Medieval cemetery (Sardinia)**

*Paola Derudas, Maria Carla Sgarella*

For some time, photogrammetry and 3D modelling have imposed themselves as prominent among the modern technologies applied to archaeology. Nevertheless, three-dimensional survey of the archaeological heritage hasn't reached, yet, its informative potential in the study

phase, due to the fact that its use has been generally restricted to those cases characterized by their exceptionality and monumentality. Digging the Bisarcio (Sardinia) late- and post-medieval cemetery was an important opportunity to 3D survey experimentation as a daily instrument for documenting the stratigraphic sequence. Differently from what happens in the most common practical cases (where it is focused on specific findings or areas, or to a specific time frame of the excavation), the 3D survey has been carried out extensively with respect to both space (covering the entire excavation area) and time (daily, throughout the excavation), with the main aim to totally substitute the two-dimensional survey. 3D modeling, which allows a very accurate and complete recording of the archaeological context, has been useful both in the documentation and analysis stage, and also in the interpretation stage. It has been complemented by the use of the 3DHOP presenter, a helpful tool for the visualization and web publishing of high resolution 3D models, connecting them to the large amount of data collected and interpreted during and after the excavation process. This tool gets an added value for the case study here presented: a cemetery context, for which it's not possible to imagine and define a "classic" musealization. Thanks to the presence of the 3D models, and the use of 3DHOP, it was possible to "re-use" the survey data to create an interactive web-based presentation aimed, this time, to the public, to provide a viable way to present and disseminate the results of the excavation to non-experts.

### **S12-14 Digital Archaeological Dissemination: Eleniana Domus in Rome**

*Tommaso Empler*

The research project has the aim of a virtual reconstruction and dissemination of Eleniana Domus in Rome through the use of Digital Technologies. The historical site, associated to the excellent state of preservation and the musealization process, makes the Eleniana Domus a great subject for developing innovative research and applications of virtual reconstruction and interactive dissemination directly on the site. 3D modeling is done with Blender, an Open Source 3D modeling software, which has in its structure of programming a "game engine", that can simultaneously handle multiple events, which allow a display/navigation in "real time" of the Domus. Interaction enables new ways to visit and learn, through the use of instruments that can detect the actions and movements of the visitor/scholar himself, turning them into human/machine instructions. The procedure, developed in a digital way, allows multiple exploratory permutations/variations of informations on a single object, for a better understanding of the phenomena and/or nature of the object itself. The procedure at the base of this pipeline includes a series of transactions that are connected one to the other: 1) detection of the object or area of interest using a 3D laser scanning survey. In this way it is possible to obtain a 3D model with the double function of representing the object itself and, at the same time, allow the use of Cartesian coordinates (x, y, z), of each point of the model, to plan the mode of interaction of the scholar on the site; 2) development of an interactive design application and set up an effective interface of interaction man/machine; 3) creation of human/machine interaction by the use of tools created for video game, as a Kinect or a leap motion; 4) preparation of a stage where occurs the release of the interactive information, defining the interactive area (box, corner, wall) and placing in tools of input/output (projector, kinect, Leap 3D motion).

### **S12-15 Integrated methodologies for knowledge and valorisation of the Roman Casinum city**

*Michela Cigola, Arturo Gallozzi, Leonardo Paris, Emanuela Chiavoni*

Focus of this article is the documentation, interpretation, valorisation and communication of Archaeological Heritage of roman Casinum city site. Nowadays this important archaeological area is little known and appreciated. The city of Casinum is particularly flourishing in



Republican and Imperial Roman period. From this period are the remains of the Roman via Appia, the Theatre (27 BC.-14 AC), the amphitheater (I century AC), the nymphaeum (I century BC-I century AC.) and the tomb of Ummidia Quadratilla (I century BC-I century AC) Casinum Archaeological Heritage includes tangible and intangible goods. Keeping this site from the present for the future is connected with actions such as Identification, Analysis, Preservation, and Restoration, with specific technical meaning. Each of this area of intervention includes not only technical actions and expertise but require also of more cultural evaluations as in respect of the concept of Archeological heritage. Summarizing in short, Casinum Archaeological Area can be also understood as a complexity of activities in a very wide range of disciplines whose aim is to identify, evaluate, and preserve past achievements for the benefit of next generation in having memory of the past and inspiration from it for future enhancements and appreciation of current results. Our research includes several integrated methodologies. The main part involves a laser scanner survey of the whole area. There are many others steps that include digital processing about documentation, interpretation and communication of Casinum Archaeological Area. The research group is formed by DART: Laboratory of Documentation, Analysis, Survey of Architecture and Territory of University of Cassino and by LRA Laboratory of Architectural Survey, CRITEVAT Center in Riety, Sapienza University of Rome. The Cassino National Archaeological Museum "G. Caretoni" and the "Archaeological Park of Casinum" are involved and collaborate in the research.

### **S12-16 An exploratory use of 3D for investigating a Prehistoric stratigraphic sequence**

*Giacomo Landeschi, Jan Apel, Stefan Lindgren, Nicolò Dell'Unto*

Re-interpreting documentation that has been produced in the course of an archaeological excavation is always a challenging and tricky task. Several problems occur when archaeologists are dealing with datasets created by different authors at a different time in the past. As Shanks and Tilley recall (1992) the fullest understanding of an archaeological dataset is totally related to the context being investigated. The purpose of a research recently started at Lund University was to test the use of 3D technology as an exploratory tool for data analysis. The combination of advanced 3D acquiring techniques and the setup of GIS systems capable to deal with geometrically-complex 3D information has been tested to investigate one of the most outstanding archaeological sites in Scandinavia, the cave of Stora Fårvar in Stora Karlsö, Gotland (Sweden). The main part of the cave sequence was excavated between 1888 and 1894 but in the summer of 2013 the project conducted a small excavation of the cave floor and undisturbed cultural layers with flint tools, fish and marine mammal bones were recovered. We also recovered human remains in the form of a tooth, skull fragments and a foot bone. Unfortunately the original field report of the 19th-century excavation was written 50 years after the excavation by archaeologists not involved in the field work. However, unpublished photos and field documentation material is available at Antikvarisk Topografiska Arkivet in Stockholm. During the excavation in 2013 we collaborated with the Lund University Humanities Laboratory and 3D-scanned the complete cave with a high resolution scanner. The idea that has been developed was to integrate the 3D models of the cave in the GIS platform and to combine it with hand-made drawings made by archaeologists in the early 20th century. As a result, digital layers (that were excavated with the arbitrary layer method) were reconstructed in the form of three-dimensional vector features and the original stratigraphic sequence integrated in GIS based on the geometrical reference provided by the cave 3D model. As a future development, part of the artefacts documented during the early 20th Century excavation will be connected to their original stratigraphy. Hopefully, it will be possible to recreate a three-dimensional archaeological sequence in which the original spatial relations among the artifacts will be highlighted and

possible patterns related to the Mesolithic occupation of the site put in light through the use of advanced analytic tools available in GIS environment.

### **S12-17 The building survey of Kaasan Church**

*James Miles, Hembo Pagi, Andres Uueni, Jüri Pärtna*

Kaasan Church, in Tallinn, Estonia was built during the time of Peter the Great (1721) and is the oldest wooden sacral building in Tallinn. A building survey was conducted in January 2015 where a laser scan and photogrammetric survey was completed. One of the aims of the recording was to document the current situation of the building including the structure's interiors and exterior. The end product being a spatially georeferenced point cloud which was used for plans and drawings, as well as 3D modelling and other interactive outputs. The paper will discuss the advantages that laser scanning and photogrammetry offer when compared to traditional survey techniques. With both types of recording taking place, the combination of the data has allowed for a precise and accurate representation of the church that goes beyond any form of recording that has previously taken place. The paper will therefore discuss the digital applications that these different methods provide when combined and it will show their usefulness in recording historical structures for Building Information Model (BIM) extraction. Using digital frameworks has provided sufficient and adequate information for further reconstruction and conservation planning and has been used in addition to the previous work carried out on site, such as dendrochronological recording. As our models were combined, the results gathered were used as a basis for a BIM, CAD model, drawings, cross-sections and a video animation as well as panoramic photography to enable 360 degree views. Rather than limit ourselves to one technique, the combination of various methods has allowed all aspects of the church to be recorded and the data gathered will be used for future renovations. Each of the stages used will be discussed as will the difficulties associated with merging these data types. Particular attention will be given within the discussion of the production of the BIM model. This will develop into a further explanation of how BIM can be used within cultural heritage and it will point out the advantages that can be gained for future archaeological research. The paper will not only highlight the end results produced but it will also discuss the workflow methodology used in combining the different data types to extract the BIM.

### **S12-18 A virtual reconstruction of the sun temple of Niuserra: From scans to BIM**

*Angela Bosco, Andrea D'Andrea, Massimiliano Nuzzolo, Rosanna Pirelli, Patrizia Zanfagna*

In 2010 an Italian team started new investigations in the Sun Temple of Niuserra at Abu Ghurab, south of Cairo, Egypt. The archaeological survey of the site was planned in order to re-examine the temple more than one hundred years on from the discovery by German archaeologist L. Borchardt in 1898. The investigations is mainly aimed at a general re-evaluation of the archaeological data still available on the site in order to establish a new plan of the temple by means of laser scanner and photogrammetry. The sun temple of Niuserra, sixth ruler of the fifth dynasty (about 2400 BC), covers an area of about 8800 sq m. More than 130 scans of the temple have been acquired so far. Some parts of the area have also been rendered by un-calibrate photogrammetry. At the beginning of the project a Zoller and Froilich Imager 5003 was used, while in 2014 the scans were acquired by Faro Focus 3D X130. In the last campaign also an image-based technique was tested. All data have been aligned and merged. The model has been referenced, firstly according to a local grid and then geo-referenced. In order to check the hypothesis made by Borchardt, the digital replica of the still visible rests of the monument have been processed by BIM (Build Information Modelling), an approach currently underdeveloped in archaeology. Thanks to this new methodology, it is possible to produce categories of environmental and technological objects and sub-systems, which represent the 3D semantic of the acquired model. The paper deals with all the recent achievements and technological issue, especially as concerns the analysis of the orientation, sun positioning and wind. Furthermore, the paper focuses on the analysis of the bearing structure and its components.

## **S12-19 Virtual Cilicia Project: Digital globes for communicating digital archaeological heritage**

*Susanne Rutishauser, Ralph Rosenbauer, Tim Arni, Fabienne Kilchör, Alexander Sollee*

Surrounded by the Taurus and Amanus mountain ranges, the fertile alluvial plain of Cilicia Pedias in modern Turkey is a true treasury of important monuments from numerous ages. Hittite and Assyrian rock reliefs serve as representations of power at this connection between Anatolia and the Levant. Since it relies on Google Earth, the Virtual Cilicia Project is able to show these monuments as well as the ruins of Bronze and Iron Age settlements like e.g. Karatepe with its world-famous carved orthostats in their natural environments.

To visualize the development of this region during different epochs and to provide a better understanding for laypersons, new approaches are necessary. Virtual globes give users the chance to interactively explore different sites and the interplay between environment and settlement patterns. Since Google Earth uses KML 2.2, an open standard XML notation, it is simple to add one's own content. In addition, KML became an increasingly common standard within geographic information systems and online tools, therefore becoming a well-documented future-proof solution. The integration of a timeline directly into Google Earth makes it a perfect instrument for the visualization of historical developments.

The Virtual Cilicia Project's goal is to document the vast diversity of Cilicia's history and to present this cultural heritage in the context of its ancient and modern landscape to the expert and the layman.

## **S12-20 Representing Archaeological Architecture—RAA**

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Representation analysis and interpretation of elements of archaeological heritage is a painstaking activity. It also includes a wide range of interdisciplinary subjects and competences. Innovative tools which are constantly being developed make it possible for the researcher to adopt an integrative approach favorable to all the figures involved in the whole process of documentation. Close collaboration of architects and archaeologists made it possible to understand the key elements of archaeological heritage based on considerations extracted from historical analysis and to have at disposal a large quantity of information gathered by taking advantage of the potentialities of technologically advanced tools (3d laser scanner, systems of massive acquisition of photographic data, modeling systems of image based, etc). The significance of constructing digital models in the domain of archaeology is already a well-established idea and only reinforces the theoretical bases of survey and representation. Unlike archaeologists - whose research is mainly aimed at reconstructing the historical process and collocating artifacts within a precise frame of reference - architects investigate the form, reconstruct the process of designing, and study formal, proportional laws and spacial aggregations of various elements. The interrelation between the two disciplines opens up the possibility to achieve complete results as far as documentation, analysis and interpretation of the so called archaeological architecture (AA) are concerned. On one hand, archaeologist can use explorable and measurable 2D and 3D high precision models, which realistically show surface qualities; on the other hand, architects can turn to advantage archaeologists' extensive knowledge to interpret correctly data in their historical and metric framework and to verify interpretative hypotheses. The proposed paper, starting with the integrated survey of archaeological structures of high historical and artistic importance, like Colosseum, Pantheon and Arch of Janus in Rome, analyzes the possibilities offered by the survey of archaeological architecture at different scales.

## **S12-21 Visual stratifications: Different levels of representation in relief of archaeological heritage**

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The learning and the use of new survey technologies based on massive acquisition of metrical information, leads to a simple and immediate exploration of digital 3d models, like the first output about a new representation that leaves the quality reason in favour of a quantity reason. The temptation to identify the result of massive capturing data with the object of survey, is due to an apparent completeness of information of digital 3d model, obtained through digital representation techniques by Image Based Technologies (photo-modeling) or on Engineering Reverse (laser scanner), particularly in archaeology, where there is a high material decay and frequently shapes and volumes are unrecognizable. Considering the representation in a larger interdisciplinary work aimed at producing the knowledge of the archaeological heritage, only with the presence and the personal interpretation of a trained operator, it is possible to give a critical contribution to the survey, transforming discontinues information in efficient documentation, expendable in both the operative and communicative environment. The analysis of the current representation modalities leads to a consideration about the inversion of the following processes of capturing and working data: - Two-dimensional measurements and processing that lead to three-dimensional objects through the construction of simplified geometric models; - Simplification of complex geometric models to get a two-dimensional canonical representations; The intent of this work is to analyse different levels of representation often used in archaeological studies corresponding to different objectives and exigencies, considering the advantages and disadvantages of each method.

## **S12-22 3D model of Roman architecture in Lusitania. Archaeology and classification of architectural heritage**

Antonio Pizzo, Carlo Inglese

In recent years archeology tries to incorporate in to the traditional survey methods a set of tools from other disciplines to get more precise results and execution times smaller. In this sense, the use of different methods of investigation for the knowledge of architectural artifacts, such as 3D scanning, new surveying instruments (Range-based Modeling) and digital photogrammetry (Image-based Modeling), received a remarkable impulse, often with contradictory results. In recent years we have often questioned about the relationship between quantity and quality of data acquired with different instrumental survey methods and their interaction and integration through the all-digital procedures in continuous and rapid evolution. The recurrent use of new technologies in survey operations, has increased the separation between the objective step of acquisition of data, and a second, interpretative, of restitution of data through the creation of traditional or computer model. In our proposal we present the first results of a research project developed in collaboration between Institute of Archaeology (CSIC) and the "Sapienza" University of Rome on the digitization of the built heritage of the Roman period in Lusitania. Two are the objectives of the proposed research:

1. In the first phase in wich we surveyed a series of complex buildings, the provincial Roman bridges, we obtained data that, in some cases, moving procedures of 3D Scan survey in the field of pure representation to the diagnostic analysis, increasing the possibilities of archaeological interpretation.
2. This research offers the possibility of establishing, at the management level of regional heritage, a standard protocol of survey and constructive analysis of the monuments to be included directly on a GIS platform managed by the institutions responsible for the heritage protection. The dissemination of a standardized survey and the precision obtained could facilitate a correct presentation of data on the web and, above all, a greater diffusion of the architectural heritage of Roman region.

## **S12-23 Virtual Reconstruction Information Management (VRIM): Some considerations on scientific 3D models**

*Fabrizio Ivan Apollonio, Elisabetta Caterina Giovannini*

The large use of 3D models in Virtual Reconstructions of Archaeological Heritage artifacts is nowadays a common tool to communicate Archaeology. 3D models became a new tool to think, interpret and visualize knowledge. Academics and Scholars largely discuss about the need of new standards and scientific methodologies able to systematize the 3D Virtual Reconstruction process and its transparency. Even if some guidelines as the "London Charter for the Computer-based Visualization of Cultural Heritage" (2006) and "The Seville Charter: International Charter for Virtual Archaeology" (revised version, 2012) are available, the debate is still ongoing and shows the necessity to pass from the singular case study vision to a general one. The problem of interpretation that characterizes reconstructions where multidisciplinary approaches are required, is crucial for the re-use of informations by users that own a different background and for next generations. The methodology proposed, "Virtual Reconstruction Information Management" (VRIM), has the intent to systematize some general processes related to 3D VR models construction data informations and their management. The Research Methodology is divided in five fundamentals phases: \_ Collection \_ Acquisition \_ Analysis \_ Interpretation \_ Representation For each phase, a set of procedures is proposed, following that approaches and concepts widely accepted and used by scholars in recent years of scientific debate: metadata, paradata, controlled vocabularies and notations, ontologies and a visualization tool to depict uncertainty. The 3D VR model structure follows the VRIM schema organization that clarifies the relationship between research sources (collection), implicit knowledge (acquisition and analysis), explicit reasoning (interpretation), and 3D visualization-based outcomes (representation). The paper present the use of VRIM on a case study: Porta Aurea in Ravenna. The Roman Gate, built in 43 A.D. with the behest of roman Emperor Tiberius Claudius, is a no longer extant monument that has always aroused the interest of many scholars and archaeologists. The existence of a large and not heterogeneous documentation available allows the possibility to investigate the theme of subjective processes and their management trying to close the gap between original data and associated interpretations.

## **S12-24 After the paper: Potential and problems in the documentation and communication of archeology in the Information Age**

*Luca J. Senatore*

The paper used as the traditional medium for the representation and communication of archeology, today can potentially be replaced with digital media, offering the user a number of alternatives to the understanding of the objects of study.

The contribution focuses on this sensitive theme, through some examples of archaeological survey, highlighting the potential but also the limitations of this new approach to knowledge. Through a series of examples and related workflows, it will be analyzed the expressive possibilities offered by the digital medium and, a methodological approach in order to make the processing represented digitally, scientifically valid and that can be immediately used by the researcher.

Due to the increasingly common use of image-based acquisition techniques and the implementation of real-based models used for a deep knowledge of the artifacts, the contribution it will analyze the new relationship of digital interface with the data. The interactive nature of the digital models highlighting a new approach to data acquisition and construction of models which requires the inclusion of the technical parameters, necessary for the correct reading of the models made for this purpose.

In particular the definition of the geometrical and perceptive limit of the model (the scale of the digital model) and some characteristics associated with the construction of the model become, in this new scenario, key elements necessary for the correct reading of the data, that can provide the researcher a coherent model of the reality.

### **S12-P1 How to classification?—A trial examining the effectiveness of an elliptic Fourier descriptor for Japanese archaeological studies**

*Akihiro Kaneda*

The purpose of this study is to examine the effectiveness of an elliptic Fourier descriptor (EFD) for archaeological studies. Typological study is essential to the classification of artifacts in archaeology. It is based on observed similarities in shape, color, etc. However, many Japanese archaeologists make use of a sensory classification system. This often creates confusion with archaeological classifications by other researchers, as the descriptions are often based on subjective observations. Thus, we must develop a method of reproducible classification for use with artifacts. Today, elliptic Fourier descriptors (EFD) are used as an effective method of classification in several fields, such as biology and medical science. This method can evaluate the shape of an artifact and is able to reconstruct the artifact's shape by the inverse Fourier transform. For this study, we examined Sue ware, a kind of Japanese stoneware. A common artifact from the eighth to the eleventh century, it can often be found at archaeological sites in the Japanese Archipelago. This type of ware was fired in a kiln with a large, long chamber. Many archaeologists, including the author, think Sue ware was made by specialized potters. Therefore, an examination of this type of artifact can reveal not only indicator dating, but also the spread of the potter groups and techniques in this era. Among Sue ware, the long-necked jar exhibits different characteristic styles depending on production area. It is therefore suitable for classification and examination to show the utility of EFD. This study demonstrates that EFD classification of jars shows a difference in shape by production area, and the technique can reconstruct modes of technological dissemination of Sue ware.

### **S12-P2 Urbanism in the Cilician Plain from Chalcolithic to Byzantine Period**

*Susanne Rutishauser*

The fertile alluvial plain of the Cilicia Pedias is surrounded by the Taurus and Amanus mountain ranges in the West, North and East and the Mediterranean Sea in the South. Since the Neolithic period the Cilician Plain was an important connection between Anatolia and the Levant. This paper examines the settlement history with a focus on urbanism of the Cilician Plain based on survey and excavation data, written sources and remote sensing data. Thus, a database was built with up to 1000 sites from Neolithic to the Byzantine period. This dataset is combined in GIS with an analysis of remote sensing data such as Corona and TanDEM-X to reconstruct also the natural environment of the Cilician plain.