



VIRTUAL ENVIRONMENTS AND PEDAGOGY

APRIL 3, THURSDAY

VIRTUAL ENVIRONMENTS AND PEDAGOGY

Chair: FLATEN, Arne R.¹ – GILL, Alyson A.²

Increasingly, three-dimensional virtual reconstructions are used as instructive tools in the classroom. From short “featurettes” (eg. the History Channel) to online classroom connections, digital models can aid significantly in the student understanding of three-dimensional space. While some of these applications are problematic for various reasons (accuracy, methodology, accessibility, etc.), digital models can offer an unparalleled opportunity for students to visualize the past in an immediate way. Moreover, the building of three-dimensional models in a teaching environment allows for a deeper understanding of architecture and engineering problems, and provides unique collaborative opportunities in the Humanities in the areas of art history, classics, computer science and web design.

The organizers of this session are interested in the diverse perspectives offered by data providers, producers, and end users of 3D models with respect to problems and possibilities presented by virtual reconstructions as educational tools. This session is intended to foster discussion between these groups, and papers should focus on the ways in which 3D models might be used in an instructive manner, or the presentation of a specific 3D project that models a specific pedagogical tool

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Platforms for Virtual Environments

(long paper)

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Keywords: virtual environments, education

The use of virtual environments (VEs) for learning archaeology and history is gaining acceptance in universities and schools. But how can academic developers of VEs, constrained by a lack of resources, meet the high expectations of students who have grown up playing multi-million dollar commercial games? “Platforms for Virtual Environments”, a two-part presentation by Richard Levy and Kevin Kee, will analyze the problems and present the possibilities for the development of VEs for learning.

The potential to explore, educate and excite the public about ancient sites and civilizations has sparked interest in building virtual worlds by members of the academic and museum community. Many researchers encouraged by advancements in video gaming are now employing game technology to accurately render in real time complex scenes complete with intelligent characters that present the life and times of past places and civilizations. Levy’s presentation focuses on the range of hardware and software solutions that can be

employed to build virtual environments for teaching, research and public engagement. Though any project strategy must first begin with a clear outline of educational objectives, ultimately, the choice of tools will pivot on the price, the capability and the hardware platform available to the end-user who will eventually explore these interactive worlds. This presentation will first consider the specific needs of researchers in the creation and display of accurate reconstructions of worlds from the past. In particular, rendering in real time objects and terrain created from 3D imaging is a challenge not usually encountered by game makers creating worlds for the commercial market. Finally, the educational market is characterized by limited financial support for product development and by end-users who have only limited access to the most recent generation of computer hardware, presenting other challenges not found in the commercial game market. Ultimately, the development of a plan to deliver virtual worlds for teaching and exploration of archaeology will require close examination of the costs and capabilities of applications designed for game makers when applied to the needs of researchers, curators and educators in the field.

Kee's presentation will address the development of VEs for students, and the development of VEs with students. This paper will focus specifically on: i. a VE focused on the 1884 smallpox epidemic in Montreal, produced by Kee (which will be released in tandem with a documentary film broadcast on the Discovery Channel); ii. virtual reconstructions that have been developed by students in his classes, including projects about the War of 1812 (which may be found at <http://www.brocku.ca/iasc/niagara1812/>), and the economy of the Niagara region from 1700 to the present (currently under construction).

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MNEME: A transportable virtual exhibition system for Cultural Heritage

(short paper)

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Keywords: Virtual reality, virtual exhibition, virtual museums, 3D scanning

Topics: - Virtual museums and public archaeology applications

- Authenticity and accuracy of virtual reconstructions – a critical approach

This paper reports on the results of a research project aimed to promote a knowledge path for the history of ancient Calabrian peoples, through the development of a transportable virtual museum system. The general objective of this project was to spread knowledge about the Enotrians and the Brettians, an underrated part of the rich historical past of

Calabria, overcoming the obstacles which prevent the fruition of the archaeological finds (such as the geographical distance and the scattering of the archaeological items in various museums) using Virtual Reality technologies. This system allows the user to enjoy the exploration of a unique collection of pieces that are scattered in various museums, immersing him in a fascinating and appealing virtual environment, giving information about ancient Calabrian customs and culture, the historical and geographical collocation of Brettian and Enotrians, their techniques of artisanship, and illustrating to the today's population their rich historical past. The 3D models were carefully reconstructed and subsequently became an element of the Virtual Exhibition System, called MNEME (from the Ancient Greek 'memory'). This system is composed of a multimedia software application and a visualization device. A synergy has been created between a team of archaeologists and historians, a team of 3D modellers and graphic technicians. The first unit took care of the selection of the pieces, designed the layout of the user interface and provided all the informative material needed to ensure the transfer of information. The second unit granted a photorealistic reconstruction of each piece, through a long work of careful 3D modelling and texture-mapping, done with 3D Scanners and high definition cameras. The third unit designed and assembled the stereoscopic vision system, putting together all the contributions of the two other units. The external look of the system is that of a cube with a huge screen on the front and a command console fitted in a column, at nearly two meters of distance from the screen. The user interacts with a stereoscopic multimedia software application that incorporates videos, pictures, music, and 3D animations. This allowed us to include the archaeological finds in a larger and more spacious context, giving to the user the historical and geographical information through an audio comment. Four MNEMEs have been installed in several Calabrian towns, in the Great Hall of the University and also at several national events in Italy, including the Mediterranean Bourse of Archaeological Tourism held in Paestum (Italy, 15-18 November 2007) and the LubeC – Technologies applied to Cultural Heritage in Lucca (Italy, 16-17 November 2007). MNEME has proved to be appealing to tourists, to the locals who are not aware of their past and to everyone who has an interest in history, archaeology or new technologies. It has also demonstrated to be useful, apart from promotional purposes, to make people regain the possession of the archaeological treasures that are not anymore on their soil.

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Mobile guidance on Cultural Heritage sites – Application for alterable contents

(short paper)

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Keywords: Mobile guidance, Flash

During recent years there has been a number of different mobile phone applications designed for guiding visitors on cultural heritage sites and museums. Most of the applications have been programmed for certain purposes – for individual sites or museums. Tailored features are usually expensive and the amount of costs has limited the use of mobile phones.

The aim of this paper is to present MOP-project (MOP is short for the Finnish words mobile guidance), which has created an application for mobile guiding. The project's goal has been to produce platform independent application, whose contents could be altered without editing the actual code. These features aim to reduce the costs of implementation.

The MOP application was build with Adobe Flash and it can be used on phones with free Flash player. The application is controlled by XML files, which define how files containing the information are loaded from the server into the user's device. Those museums who are willing to create their own routes or guides can add contents onto the server.

Once the application was ready, it has been given for free to all Finnish museums. It is possible to create thematic routes with limited IT-skills and even very small museums can use mobile technology to disseminate their cultural heritage information.

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The Travel in Europe project: MMOG and Cultural Heritage promotion

(long paper)

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Keywords: pedagogy, online VR model, online game, European Cultural Heritage

The Travel in Europe project regards a virtual world where young people and the curious can enjoy challenging and engaging travels through European heritage. The idea is to challenge the success of other Massive Multiplayer Online Games like Second Life or World

of Warcraft. The project is developing an online environment where users can live through game experiences by interacting with virtual representations of European heritage. The player moves in a 3D space representing the map of Europe. The player obtains scores through visiting some cities where trials are to be faced. The Trial games are contextualized and concern the local artistic heritage. We are also building a Creative Toolkit – accessible from the TiE website – through which all users (not just computer experts) will be able to collaboratively build their own trial games, which, after a sound review process, will be playable online by all users. This will allow the game database to be continuously increased through the creativity and the enthusiasm of users, stressing the idea that learning takes benefit from constructive experiences.

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Interactive multimedia exhibition – A day in the life of an Eneolithic community

(short paper)

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Keywords: Gumelnița, interactive, Eneolithic, Romania, pottery.

One of the most flourishing civilizations from the last half of the 5th millennium BC, Gumelnița Culture, is presented in a bilingual (English and Romanian) multimedia application that is trying to show a glimpse from the daily life of an Eneolithic community.

By the end of Gumelnița civilization most of the natural resources in the areas of the principal settlements had diminished. This situation, accompanied by the general human tendency to expand into new territories, led to the colonization of the small river valleys from the Danube catchment area. This is the case of the Neajlov valley in Southern Romania. The river valley had been known for a long time by prehistoric populations, but only from 4200 BC onwards it begins to be intensively occupied by small communities.

Our researches concentrated during the last 10 years around Bucșani (Giurgiu County), on the Middle Neajlov River.

The application CD-ROM opens with a chronological sketch that shows where the Gumelnița community from Bucșani is situated in time, as well as the general historical and natural setting. The main content is represented by the 3D reconstruction of the main site and surroundings, as well as insights of the houses and activities from the site. The application's menu offers details of daily and seasonal activities, for instance of agriculture, fishing and hunting, wood carving or tool making. Most of the processes shown have photos and drawings and also short footages taken during the re-enactment of various activities.

All descriptions of the archaeological discoveries such as pottery, bone and antler tools, flint stone, stone and metal (including gold) artifacts are accompanied by photos, drawings and footages.

Our application is mainly dedicated to children but also to students and specialists that will hopefully use our way in presenting the life from an Eneolithic community

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Ashes2Art as pedagogical experiment

(long paper)

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Keywords: pedagogy, reconstructions, models

Digital models and reconstructions are becoming increasingly mainstream, frequently animating television programs and movies. While digital models are not without their critics for various reasons (accuracy, methodology, accessibility, etc.), they offer opportunities to visualize the past in three dimensional space. Given their use in media outlets, it is no surprise that online reconstructions and virtual environments have begun to find their way into university and secondary school classrooms, often used as a means of disseminating visual information in much the same way that slides were used a decade ago. Ashes2Art, an innovative collaboration between Coastal Carolina University and Arkansas State University, takes the intrinsic, if sometimes problematic, value of such resources and inverts the pedagogical model.

Ashes2Art is the digital reconstruction and documentation of ancient monuments and urban spaces by undergraduate students under close faculty supervision. Students create 3D models which are based on published archaeological reports, build flythroughs and digital panoramas, take onsite photographs when possible, write topical and site-specific essays, and document their work online with extensive primary and secondary source bibliographies. Every facet of the project, including web programming, is designed and implemented by undergraduates, and overseen by a board of site-specific experts in various fields.

Beyond the implicit teaching and learning advantages associated with hands-on research and faculty-student collaboration, Ashes2Art aims to build a valuable online resource for discipline specialists. With the support of a Digital Start-Up Grant from the National Endowment for the Humanities, the program currently is examining the 4th century B.C.E.

Greek sanctuary at Delphi. This paper presents an overview of Ashes2Art and examines some of the unique problems and opportunities inherent in the program.

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Visualizing the Roman City: Looking at the past through multidisciplinary eyes

(short paper)

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Keywords: 3D visualization, digital reconstruction, pedagogy, interdisciplinary

In the spring of 2007, laser scanning and digital photogrammetry data were collected to document Late Republican architecture at Ostia Antica, the harbor city of Ancient Rome. These data were collected in preparation for a two-semester honors colloquia, currently offered at the University of Arkansas. This course, *Visualizing the Roman City*, is targeted toward students at the undergraduate level and seeks to teach principles of 3D data acquisition, processing, and virtual reconstruction. To accomplish these ambitious goals effectively we moved beyond traditional disciplinary boundaries, drawing academic expertise from the disciplines of archaeology, architecture, classical studies, and geosciences to create a more holistic way of exploring and imaging the past, an infrequently used pedagogy in the American higher education system. The course provides an overview of the history of Ostia, and imparts basic skills in laser scanning, photogrammetry, and architectural drafting and 3D visualization software. However, the goal of this class is not simply to learn computer programs, but to explore how 3D visualization can help us better imagine and understand Roman urban life. It is our hope that *Visualizing the Roman City* will serve as a setting to nurture this collaborative effort and to help students develop a broad perspective and set of skills.

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**Historical and territorial analysis:
A contribution to the study of the defence of the
city of Lisbon – The Peninsular Wars**

(short paper)

RUA, Helena

Keywords: Archaeological-environmental patterns, ancient scenarios, 3D model, virtual reality.

The historical episode of the Peninsular War (during the French invasions) marked the beginning of the defeat of Napoleon. That brake to the expansion of the empire, which occurred simultaneously in various battle fronts (from Western to Eastern Europe), happened due to a negative conjugation of bad decisions and errors of military strategy. However, in the case of the conquest of the city of Lisbon, it was due to the success of a plan carefully projected and executed, constituted by two lines of defense that surrounded the city, designated by Lines of Torres Vedras.

The use of information technology made it possible to repeat this historical set (without the drama that happened), namely building a Digital Field Model and place the hillforts that constituted the lines of defense, which allowed us to take measurements and obtain data about its edification, which would allow to obtain true data from this episode.

Although the study is not concluded and it is not yet possible to identify accurately the author(s) and the time of the elaboration of the project and the construction, this research allowed us so far to carry out various experiments, such as giving the chance to the media visualization of historical moments. This kind of communication normally is not allowed by most modulation softwares, where the information system requires too much memory.

This presentation aims to present how the user-friendly interfaces developed for a scientific model can be used for the social divulgation, as well as in the implementation of future didactic models.

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An epistemological approach to the representation of tangible Cultural Heritage objects in museum environments using ICT

(short paper)

HERMON, Sorin

Keywords: presentation of Cultural Heritage, museums, ICT

The paper will start with a discussion of the meaning of Cultural Heritage and how it is perceived by different international bodies, as conceived by their published definition on CH, moving forward towards a discussion on the role of CH objects in museum environments, how they are presented to the public and the information they are accompanied with. The main claims of our paper is that while all agree what is Heritage, there is a confusion of terms related to Culture, and, as such, to the term “Cultural Heritage”. What is preserved for future generations largely depends on the relevant scientific communities, administrators of CH and politicians, even though “culture” is created by members of a culture, and Cultural Memory, through Cultural Heritage, is aimed at the members of that culture and for other cultures as well. However, members of that particular culture are seldom asked what should be preserved and how. The second issue to be discussed in the paper is the way tangible Cultural Heritage objects are presented in museum environments: as decontextualized objects, losing their original “nature”, thus becoming “objects-for-object’sake”, symbols of dominating ideologies, objects to support an intentional “historicity” or tools for motivating a particular ideology. Moreover, the traditional and still dominating representation approach is the historiographical one, tending to ignore the multi-facet nature of Cultural Heritage objects and ignoring other interpretation paradigms. Finally the paper will propose a working framework, taking into account the new literacy approaches, through Information Communication Technologies (ICT), the nature of Cultural Heritage objects and the museums as social spaces.

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Renaissance architecture in Hungary – A multilayered method for an exhibition project of the Hungarian National Museum in 2008

(long paper)

VASÁROS, Zsolt

Keywords: virtual reconstruction, exhibition display, renaissance architecture, spatial analysis

The perceptual and theoretical reconstruction of architectural structures resulting from archaeological excavations goes hand-in-hand with scientific publications, different presentations and exhibition displays.

The project aims to digitalize and archive the architectural heritage of Renaissance Hungary and to work out display methods adapted to different user groups. Although subsisting ruins and architectural remains are extremely fragmentary, theoretical reconstructions with a certain level of probability are possible and desirable. Order of rhythm and proportions, the typical, still specific use of materials and structures facilitate notions of reconstruction; however, over-viewing buildings and comparing spatial structures takes quite an effort. Considering the great number and diversity of architectural structures the working-out of a multilayered system seemed to be practical.

However, the majority of the issues and problems lie in the algorithm of the process. The layout of the structure that is to be reconstructed emerges on the basis of the thorough analysis of archaeological remains. Are we allowed to create the overall extension of a structure that is problematic even from the point of view of its ground plan, let alone create its photorealistic reconstruction? These questions are definitely justified. The issues at hand are both practical and ethical. In addition, there are the expectations of those who view the product: visitors demand high-quality interpretations, and professionals are also curious concerning a possible reconstruction. In the majority of the cases, these presentation methods enable us to give an account of the validity – or the doubtful validity – of the reconstruction in question only through the applied graphics.

As a new thing you will be able to use the same software for elaborating and visualizing your project. Moreover, for displays of different level and complexity you are provided with adequate documentation and virtual model that can be developed from sketch-up level to photorealistic views. Different ways of displaying and the range of tools make it possible to adapt the project to different databases. It is important that you can develop alternatives in the database and on the models as well, giving new perspectives for research.

The integration into an exhibition's display is an interesting challenge in the field of virtual reconstructions. A new and progressive view was needed to communicate a great deal of information comprehensively and to provide an attractive show at the same time.

Interactive presentation of archaeological objects using virtual and augmented reality

(long paper)

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Keywords: ARCO, VR, 3D presentation, reconstruction, educational games

The paper presents a system, called ARCO (Augmented Representation of Cultural Objects), which enables museums to build virtual exhibitions of artefacts based on virtual and augmented reality technologies. The forms of virtual reality exhibitions can range from simple three-dimensional presentation of digitised objects, through interactive presentation of 3D spaces such as reconstructed interiors or architectural objects, to highly-interactive 3D educational games. With augmented reality it is possible to build exhibitions that present selected virtual objects in the context of real objects or real places, enabling a user to interact with the virtual object in a natural way. These new forms of highly interactive presentation of cultural objects offered by ARCO are interesting and engaging for museum visitors, especially for young generations. Importantly, ARCO provides innovative technologies and tools that allow users without experience in programming or 3D graphic design to quickly and easily create such virtual exhibitions.

Using the ARCO system museums can present countless artefacts that could not be exhibited directly to the public due to limited space, the fragility of the items, or the prohibitive cost of creating and managing appropriate displays. Moreover, ARCO enables the creation of exhibitions that draw on multiple collections, without the expenses associated with transporting and insuring priceless objects. Virtual exhibitions accessible over the Internet enable different audiences, including the disabled and students of all ages, as well as the general public to remotely access and interact with vast numbers of objects scattered among various localities.

The ARCO system has been deployed in several museums with very promising initial results. Examples of virtual exhibitions built with the ARCO technology as well as their practical use in the museum context are presented in the paper.

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**3D DATA CAPTURE AND VISUALIZATION IN
ARCHAEOLOGY AND CHM**

APRIL 3, THURSDAY

3D DATA CAPTURE AND VISUALIZATION

Chair: MUDGE, Mark

Digital recording projects at the Vasa Museum

(short paper)

ENGSTRÖM, Arvid – ROA, Eduardo

Keywords: 3D scanning, digital documentation

This paper is intended to give an overview of the ongoing 3D measurement projects at the Vasa Museum. Items such as sculptures, gun carriages and even Vasa's longboat have been documented using 3D Scanning and FaroArm techniques. The digital recording field is constantly developing and we have to adapt the methods for our needs.

Over the years there have been problems with salt and sulphur outbursts on some items. The aim with the 3D Scanning is to duplicate the delicate features of the sculptures. The replicas can either be milled or printed out in three-dimensional form. The FaroArm is used to document a wide range of objects in the Vasa collection. It combines high accuracy with high speed, thus improving both the quality and efficiency of documentation. From this data we can produce digital and graphic reconstructions of the form and appearance of the original objects.

The digital recording results, which are relatively small files, can be stored electronically or printed out. FaroArm is most suitable for recording structural timbers and other objects with clear edges and plain surfaces. Scanning is used where a full surface recording is needed. Digital recording also makes it possible to publish objects on the internet more readily. Our online collections database will in future include 3D documentation results. As a research method this type of documentation is very useful to preserve and understand the context of the ship.

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3D modelling of complex archaeological features: A case study from Abony (Hungary)

(short paper)

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Keywords: late Copper Age bothroi, complex internal stratification, animal and human skeletons, layers and spits, from manual drawings to 3D visualization

The remains of a settlement from the 4th millennium BC have recently been excavated at Abony, Site 36, Hungary. Beside the domestic and economic units of the Copper Age village, the “sacral district” of the settlement was unearthed as well, comprising of nine pits with special functions. The layers of these sacrificial pits contained pottery depositions, animal skeletons and complete and partial human skeletons. Based on the excavation photos and drawings, as well as the geodesic documentation of the features, we prepared a 3D model of the archaeological remains found in two of the bothroi.

The interpretation of the internal connections of pits with complex stratification is hindered by the limitations of excavation and documentation techniques. The excavation and documentation of lower layers are obviously possible only after the removal of the units above them, during which the information regarding the relationship between the two layers may be endangered. In many cases, the excavated spits do not necessarily coincide with the original layers of the fill, the latter usually comprise multiple excavation spits.

In our paper we would like to present step by step the process through which the manual drawings documenting the excavation layers are transformed into a 3D model that can be examined from many perspectives. The AutoCAD layer drawings, which are based on plans drawn manually during the excavation and the GPS-enhanced geodesic documentation of the layers, already determine the spatial arrangement of the layers. After importing the layer drawings into a 3D modelling software, an exact 3D image of the pit and its layers, and the phenomena observed in them, can be created. The animation of this model enables us to examine the whole context and various smaller scale issues at the same time. This provides enormous help in the simultaneous study of the contexts belonging to different layers and helps us understand complex archaeological phenomena.

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Reconstruction and 3D-modelling of a unique Hungarian Conquest Period (10th c. AD) horse burial

(short paper)

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Keywords: 3D reconstruction, animation, horse burial, 10th century, Hungary

In 2003 the Archaeological Institute of the Hungarian Academy of Sciences and the Móra Ferenc Museum, Szeged carried out an excavation at the already known 10th-century AD, Conquest Period cemetery near Szentés, Southeast Hungary. During the excavation the disturbed grave of an older man was found, who had been buried with his weapons. The two longer sides of the grave were formed in a step-like fashion. This rather rare grave-form of the period yielded another novelty: a partial horse burial, which was placed on the step along the northern side of the grave. There is much literature on early medieval graves with steps from Eastern Europe, the steppe and the Volga-Kama region, which usually explains this phenomenon – which can be observed in many periods and cultures – as the support for the cover (roof) of the grave. With the help of the 3D-modelling of this new grave from Hungary we tried to test this hypothesis and tried to reconstruct the process of placing the excised horse hide and skull into the grave during the burial ceremony.

In the presentation the authors will describe the grave, the process of the modelling, its phases and technical details, and the result of the analysis. The first step is the processing and resizing of the excavation drawings, then the process and details of the spatial modelling of the field elements will be presented (3D Studio Max). This is followed by the modelling of the human skeleton and the horse hide (Poser, Studio Max), and finally comes the modelling of the folding and placing of the horse hide into the grave with the help of a physics simulation software (Reactor, 3D Studio Max). The authors will present all the work phases through an animation.

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Considerations on technical sketch generation from 3D-scanned Cultural Heritage

(long paper)

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Keywords: automated documentation, non-photorealistic rendering, 3D scanning

Among the different techniques for documentation and publication of archaeological finds technical sketches are most prevalent. They are highly stylized and simplified, but still convey a lot of information about the object's shape, manufacturing process, surface treatment, ornamentation and preservation. These images are intended to be read easily and quickly, nevertheless they are merely abstract and symbolic. Since technical sketches are drawn manually, their quality and precision varies with the experience and individual skills of the illustrator who furthermore is subject to interpretive influences making some properties more visible than others without giving the viewer the opportunity to retrace this process. In addition, manually drawn sketches have to be digitized and revised in several steps. This flow of work is not only very time-consuming and expensive but also another possible source of error.

Hence, our aim is to derive meaningful undistorted images directly from the models of 3D-scanned objects with minimal interaction in order to rule out inaccuracies and for the first time to provide drawings that are really objective. We therefore employ both realistic and artificial lighting models to emphasize the object's plasticity and overall shape. At the same time, details such as rills, ornamentations and patterns but also breaking edges are highlighted by a local surface analysis. According to many consulted archaeological experts the resulting images, each rendered within a few seconds, meet and even enhance the conventions of the traditional drawings. Moreover, lots of other stylizations are conceivable depending on the intended purpose.

In case of pottery it is common practice to also depict a cross-section of the object next to the technical sketch. Having already a 3D model, such cross-sections are trivial to extract. The same applies to unwrapped images, which are very difficult to draw accurately but can easily be derived from the model by a simple coordinate transformation.

All the results obtained by our system are comprehensible and reproducible. Since the whole process solely works on digital data, it shortens the time required for sketch generation by factor 5 to 10 compared to the traditional method. The new approach has proven to be applicable in the daily work at Saxony's Archaeological Heritage Service for more than two years and will soon replace the conventional drawings entirely.

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Coin data acquisition for image recognition

(short paper)

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Keywords: Numismatics, Image Enhancement, Image Segmentation, Pattern Classification, Optical Character Recognition

Numismatics deals with various historical aspects of the phenomenon Money. A fundamental part of a numismatist's work is the classification of coins according to standard reference books. Reference numbers make the full description of a given coin type (including accurate dating, the distinction between minting places or any available political background) obtainable for everyone. The classification of ancient coins is a highly complex task that requires years of experience in the entire field of numismatics. Computer Vision explores the theory and technology to obtain and interpret information from images. For the application of ancient coin classification, image processing techniques like Image Enhancement, Image Segmentation, Pattern Classification and Optical Character Recognition (OCR) are investigated. Numismatics is at a point where it can benefit greatly from the application of computer vision methods, and in turn provides a large number of new, challenging and interesting conceptual problems and data for computer vision. The recently started European project COINS combines these two research areas by developing a vision based system for automated coin identification. Identification, in contrast to classification, deals with the mapping of a coin image to a certain individual coin, not to an entire coin type. Digital image acquisition of coins is the first step in the processing pipeline: when making a digital photo of a coin, the setup of the image acquisition system determines the quality of the image. If images of coins are processed by image recognition methods, the accuracy of the results is highly related to image quality. For example, a method for automatic classification of ancient coins has to extract details from the image which could get lost if inadequate illumination or low resolution is chosen. This paper is intended as a technical guide for an optimal acquisition of ancient coins. For that purpose, it provides an explanation of basic principles of digital photography and describes an adequate acquisition setup with respect to numismatists needs. Furthermore latest results on the automated recognition of coins are presented.

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A skew detection technique suitable for degraded ancient manuscripts

(short paper)

KLEBER, Florian – SABLATNIG, Robert

Keywords: automated document processing, skew correction

In order to preserve our cultural heritage and for automated document processing libraries and National Archives have started to digitize historical documents. Automated document processing can comprise tasks like character/word segmentation, text extraction, text line segmentation and layout analysis. In the case of degraded manuscripts (possible cases: mold, humidity, bad storage conditions) parts of the text disappear (e.g. are washed out) and therefore only fragments of an entire page are still visible. Due to the digitization process of ancient manuscripts/documents an rotation angle is introduced to the captured images in relation to the original image axes. The automated skew correction of documents is necessary because algorithms for document processing are sensitive to the page skew and the amount of pages is too large to do it manually. There exist a wide range of skew detection and correction algorithm based on the Hough transform, projection profiles, nearest neighbour clustering, the Fourier transform and e.g. cross correlation techniques. These methods are designed for either typescript or handwritten pages but are insufficient for degraded documents, where different parts of the text disappeared. This paper presents an algorithm for skew estimation that can be applied to handwritten degraded documents, and also for other archaeological relevant documentations like type written cards or reports.

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Protected sharing of 3D models of Cultural Heritage and archaeological artifacts

(short paper)

KOLLER, David

Keywords: 3D models, cultural heritage, digital rights management, remote rendering

The increasing use of three-dimensional modeling and digitization techniques in archaeology has raised questions about the digital rights management of the resulting 3D models. Curators of valuable artifacts and creators of 3D models may be reluctant to openly share the digital 3D representations due to fear of misuse or theft of their data and intellectual property.

In order to address these concerns, we have investigated a number of techniques for sharing and disseminating 3D models in a secure, protected manner. This paper reviews these different methods and the means by which they address the digital rights management issues faced in digital archaeology. We have implemented and deployed one such technique, remote 3D rendering, on a wide scale. Our remote rendering system has been used to make thousands of 3D models freely available for interactive visualization, including archaeological artifacts, digitized statuary, and reconstructions of ancient urban sites, while preventing copying or other unauthorized access to the underlying 3D data. This paper describes our experiences developing and applying the system to several prominent 3D cultural heritage archives, and details new enhancements including accessibility through web browsers and interactive flythrough capabilities for large, complex virtual environments.

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High definition 3D-surface scanning and applications in arts and Cultural Heritage

(short paper)

BREUCKMANN, Bernd¹ – VÉGVÁRI, Zsófia²

Keywords: high-definition 3D scanning, Cultural Heritage

Until the invention of photography, there was only a limited possibility to record the real world in an objective way. Although photography and later on digital image processing have provided completely new possibilities for archiving and documentation, any 2D-

technique must have strong limitations to reproduce the 3-dimensional world. However, within the last 5 years, advanced 3-dimensional scanners have been developed, which are opening the 3rd dimension to image processing techniques.

Topometrical high definition 3D-surface scanners, optimized for the requirements of arts and cultural heritage, allow the 3-dimensional digitization of art objects and paintings with the highest resolution and accuracy, typically in the μm -range for the depth and up to 2.400 dpi (about 10 μm) for the spatial resolution. Moreover, the texture and/or color of the object can be recorded, offering a one-to-one correspondence of 3D coordinates and color information.

The digital models recorded with these techniques may be used in the virtual reality for visualization, documentation and archiving, or for scientific analysis. Moreover, it is possible to create scaled copies by using different rapid prototyping techniques. State of the art 3D-printers already allow a semi-automised manufacturing of colored replicas.

The presentation will start with a short overview on the state of the art of high definition 3D-surface scanners. Existing limitations and upcoming developments of these techniques will be discussed. The second part will show various applications from arts and cultural heritage, archaeology and palaeontology. It especially will present case studies with high challenges on data acquisition, environmental conditions, required resolution or surface structures, e.g. the documentation of ancient stone monuments (Deer Stones) in Mongolia and the High Definition scanning of palaeontological findings.

Finally the paper will demonstrate the use of 3D-data for the virtual and physical reconstruction of art objects, especially of the high altar of Kisszeben (supported by the National Gallery, Budapest).

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Revealing hidden structures and creating a DIGITAL FINGERPRINT of paintings by using advanced 3D-scanning techniques

(short paper)

VÉGVÁRI, Zsófia¹ – BREUCKMANN, Bernd²

Keywords: 3D infrared scanning, digital fingerprint, paintings

Beyond conventional techniques there exist a number of new optical methods for the analysis, documentation and archiving of paintings, which are presented in this paper.

It will especially demonstrate the state of the art of high definition techniques for the 3-dimensional digitization of paintings. Topometrical 3D-scanners, based on fringe projection techniques, do not only provide color data and 3D-features with highest resolution and accuracy, typically in the range of a few μm for the depth and up to 2.400 dpi (about 10 μm) for the spatial resolution. A new generation of this scanner type also allows the multi-spectral 3D-scanning of paintings in a wide range of wavelengths, from infrared to deep blue, contactless and without causing any damage to the paintings. The paper will present new results of the 3D-scanning of paintings of Mihály Munkácsy (supported by Mr Szatmari, Museum of Békéscsaba, Hungary) and Claude Monet and will discuss the following applications in detail: 3D INFRARED SCANNING to reveal hidden color structures: Mihály Munkácsy, one of the most famous Hungarian painters of the 19th century, used bitumen as a kind of paint-thinner for the oil-color, a special technique, which was based on the French and German school since 1860 in Europe. Unfortunately, after several years the pigments of the colors were diffused into the liquid dark and matt bitumen; thus, lot of the colors of these paintings are invisible nowadays. Infrared techniques offer the possibility to look through the bitumen inside the paintings and to reveal the hidden pigments. Moreover, a topometrical 3-dimensional IR-scanner should allow to measure the thickness and 3D-structure of the bitumen and the implemented colors. THE DIGITAL FINGERPRINT: Beyond the color (oil paints) and the used materials (canvas, wooden panel), the 3D- structure of the color application and the background could be the most important and unique components of paintings. By recording the 3-dimensional surface structure, the color and – optionally with IR-techniques – the hidden structures with highest definition, one gets a unique digital fingerprint of paintings, incl. the signatures of the painters and its typical colors. This digital fingerprint could be stored in a 3D-data bank, which would be accessible via internet all over the world. It allows researches to analyse the typical brush stroke of the painter in any detail and offers completely new opportunities to recognize the origin of a painting and to detect fakes.

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3D comparison and analysis of tiles, female and male mould

(short paper)

KIESSLING, Henry – REUTER, Uwe – INNERHOFER, Florian

Keywords: 3D laser scanning, 3D modelling, medieval tiles

3D-Laserscanning is a technique that is already used in archaeology in a huge range of applications, basically for excavation or even for documenting the smallest findings. This paper will present the results of the investigation of three-dimensionally captured stove tiles as well as their male and female moulds. In order to achieve this, a laser scanner for short range data acquisition is used since 2005 in several archaeological 3D-projects at the Archaeological Heritage Service and State Museum of Prehistory Dresden. The analyzed finds of tile, female and male moulds were excavated during the archaeological excavation on “Augustusplatz” in Leipzig.

The model technique is an economical practice to produce tiles for tiled stoves in the 16th and earlier 17th centuries. This procedure afforded several steps of preliminary work in which female and male moulds are intermediate products. Some comparisons are necessary to achieve results about technical processes e.g. thermal history of the object. But conventional methods are imprecise and more laborious. Therefore a 3D-Laserscanner comes into operation. Through 3D scanning the objects will be captured in 3D, and virtual 3D-models are available for comparisons and analysis.

Especially statements about technical processes e.g. the diminution of the objects which is caused by the firing process can easily be achieved by means of differences in size. The possibility to overlay the 3D-models or to measure distances quickly provides accurate information for this purpose.

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Computerized typological classification of sherds based on 3D documentation and automatic drawing

(short paper)

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Keywords: 3D scanning, pottery documentation, automated drawing

We report on a high resolution documentation system operated 'on-line' in the field during the excavation seasons at Tel Dor, Israel. The system consists of a 3D scanner and the

accompanying software that was developed for the purpose. The final products of the software are very accurate profile cross-sections of the ceramic fragments. We use these profiles to produce, automatically, print-quality drawings for publication, and to introduce new methods of computerized typology and classification. Nevertheless, the complete 3D models store a lot of morphological information that archaeologists do not have access to, using traditional methods of pottery analysis. This information enables measuring and quantifying features which might have some cultural, temporal or even individual significance.

In the presentation we shall describe the 3D acquisition system together with the main concepts of our novel software. Some results of the computerized typological classification will be presented using an Early Iron Age assemblage. The rest will be dedicated to a discussion of the great potential of this new technology to archaeological research and especially to pottery analysis.

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Documentation of Polychrome Ceramics using 3D-Acquisition and Multi-Spectral Readings

(short paper)

MARA, Hubert¹ – KAMMERER, Paul² – TRINKL, Elisabeth³

Keywords: 3D-acquisition, multi-spectral readings, ceramics, archaeological documentation

Motivated by archaeological requirements, we are developing an automated system using 3D-acquisition based on structured light for documentation of ancient ceramics. Furthermore we are developing a system for the art-historical analysis of medieval paintings using multi-spectral readings of colour pigments. The documentation of polychrome ceramics requires the combination of both systems for documentation, classification and (virtual) restoration tasks. Therefore we show the combined methods of our systems for digital, contact-free, radiation-free acquisition of 3D-models including multi-spectral readings of painted ceramics. The results are shown for a new volume of the *Corpus Vasorum Antiquorum* of the Collection of Greek and Roman Antiquities of the Museum for History of Art in Vienna (*Kunsthistorisches Museum Wien*). It must be stressed that the shown methodology can be applied to any other polychrome surface (e.g. NASCA fine ware). Finally a summary and an outlook are given.

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New paradigms for automated classification of pottery

(long paper)

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Keywords: automated classification, shape analysis, machine learning, Bronze Age pottery

Classification is one of the central tasks in archaeological research. By grouping entities into types, subtypes and variants the material becomes not only comprehensible and comparable, but also supra-regional relationships may be revealed. In the past, due to missing standards and different purposes the classification process has been rather arbitrary in most domains leading to the problem of inconsistent concepts and naming schemes and as a result potentially undiscovered coherencies.

On the other hand, 3D scanning is currently opening up a wide range of possibilities in archaeological research including global data exchange via internet, impressive visualizations and new ways of documentation and restoration. However, 3D models can also serve for morphological analysis and subsequent applications. This paper describes how feature extraction on ancient pottery can be combined with recent developments in artificial intelligence to draw up an automated, but still flexible classification system. These features include for instance several dimensions of the vessel's body, ratios thereof, an abstract representation of the overall shape, the shape of vessel segments and the number and type of attachments such as handles, lugs and feet. While most traditional approaches to classification are based on statistical analysis or the search for fuzzy clusters in high-dimensional spaces, we apply machine learning techniques, such as decision tree algorithms and neural networks. These methods allow for an objective and reproducible classification process. Conclusions about the „typability” of data, the evolution of types and the diagnostic attributes of the types themselves can be drawn as well.

We tested our system with 250 vessels from the Lusatian culture cemetery of Kötitz (Eastern Saxony) being arranged in 17 primary and more than 40 secondary types. Although these Bronze Age vessels are all handcrafted and cover a period of more than 400 years, about 90% of the unseen cases including special forms have been assigned to the correct main class. In a hierarchical process, the conditional prediction rate for the secondary step may be even higher. Last but not least, the system did also help us to uncover badly discriminated types.

Finally, we point out that the system is applicable not only for vessels, but in many other domains too, if consistent typologies exist and the relevant features can be extracted at least semi-automatically.

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A system of pottery shape recovery and repairing

(short paper)

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Keywords: Virtual recovery, Axis symmetry, Reconstruction, Repairing, Surface of revolution

Most of the excavated objects are bowl-shaped or pot-shaped, and most of the defective parts can not be found anymore. With a high value of appreciation and archaeological research, these antique have been attracting more and more attention from experts in the field of digitization of cultural heritage. Adopting modern advanced technology in the antique recovery process is a very hot topic and research area. In this paper, a new approach of virtual recovery of axially cracked relics is proposed. The method includes three parts: (1) Reconstruction of surface of revolution: it is made by using the symmetry axis and genetratrix to gain a complete model; (2) Local surface repairing: it is done for the partial recovery without rebuilding; and (3) Texture mapping: In practical application, the pottery shape can be flat or slight. Therefore circular texture mapping or cylindrical texture mapping can be used respectively to get better realistic results. A system is implemented based on the above method, which is applied to the recovery of Yao Zhou's porcelains, one kind of famous ancient porcelains in China as shown in Fig. 1.

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**DEALING WITH UNCERTAINTY IN
ARCHAEOLOGY**

APRIL 3, THURSDAY

DEALING WITH UNCERTAINTY IN ARCHAEOLOGY

Chair: VERHAGEN, Philip

Archaeology is a science of uncertain findings. Whether we are registering finds, interpreting the stratigraphical, spatial and temporal relationships in an excavation, or performing a regional analysis of survey results, uncertainty – of location, dating and interpretation – is part of the archaeologist's game. While this is generally acknowledged, the impact in archaeology of mathematical and statistical methods designed to establish uncertainty is limited. Even basic probability theory is not often used for this purpose outside the audience of CAA-conferences, let alone the application of more sophisticated methods like geostatistics, computer simulation, fuzzy logic, or Bayesian statistics.

The purpose of this session is to find out why. Is it the usual story that many archaeologists are not very analytically minded and a bit scared of numbers and technology? Is it the way in which the results are presented? Is it only useful for a limited number of questions? Or are these methods too complex and just confusing matters? Or am I too pessimistic, and are we actually witnessing a gradual acceptance of these methods in archaeology?

I would like to get together a broad selection of speakers, from various angles of quantitative/computing archaeology (GIS, virtual reality, classification etc.). Papers providing good case studies of dealing with uncertainty in archaeology are welcomed, together with theoretical papers trying to answer the question whether and when an explicit, quantitative assessment of uncertainty is actually useful for (computing and non-computing) archaeologists.

Constructing art historical definitions through a comparative database: The evidence of Old Assyrian Glyptics

(short paper)

BUCCELLATI, Federico

Keywords: Database, Glyptic, Definition Modeling

This paper proposes a method by which a database can be used to give a specific statistical and analytic underpinning to generalized definitions in an art-historical context. The case study used is that of cylinder seals and impressions of seals that form a distinct stylistic group, the glyptic evidence from the Old Assyrian period of Mesopotamia.

Standardized definitions of seal impressions are the product of a considerable body of knowledge which has been considered by a single person over a long period of time,

giving that person the intuitive ability to discern meaningful similarities and give general definitions for clusters of such similarities. When explaining a certain glyptic style, general elements and combinations are described as indicative.

The disadvantages of such a method are two. First, the gamut of glyptic elements considered are often not discussed in the context of the groupings: presented is normally a catalog of seals and impressions studied with an individual analysis, and in the end a synthesis of the grouping in a generalized way. What is here lacking is the link between the analytic study of individual elements and the synthetic thread that brings such elements into a meaningful unit; the original data is presented as well as the conclusion, but the process by which such the conclusion is reached remains obscure.

The second disadvantage of such a method is that the typological and the semiotic levels of analysis are often divorced. Publications focus on the one or the other, but the closer the two levels of analysis remain, the better the effect of the one on the other can be seen.

This paper proposes a database approach to the study of glyptics, which elucidates the link between individual elements and the synthetic whole, allows for new elements to be brought into the study on the analytic level, and ties the typological and semiotic levels of analysis by focusing on the individual elements present.

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Stratigraphic uncertainty

(short paper)

CARVER, Geoff

Keywords: stratigraphy, uncertainty, laser scanning

As part of a larger project, this paper provides an overview of a number of approaches being considered as means for solving problems of uncertainty in archaeological stratigraphy; specifically: identifying unclear layer boundaries, recording traces of post-depositional transformations and modeling any effects these may have had on the archaeological assemblage. Given the nature of these problems and the importance of stratigraphy in archaeological analysis, solutions will require a systematic approach, taking into account (traditional) theoretical and geoarchaeological conceptions of stratigraphy, ontology, 3D GIS and spatial statistics, the relations between excavation methods and documentation technologies, even reflexivity and the on-site organisation of labour. Although the solution proposed may appear complicated, it can be argued that, without some means for measuring uncertainty, the results of all archaeological investigations are - paradoxically - uncertain. This particular paper focuses on relationships between data acquisition (documentation), soft and hard biases regarding what that data should look like (recording technologies),

and the way we model the world we have documented (data formats), using the example of laser-scanned point-clouds.

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Toward handling uncertainty of excavation data into a GIS

(short paper)

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Keywords: Uncertainty, Taxonomy, GIS

Nowadays, an important topic of research in GIS Science concerns accuracy and uncertainty of spatial data. Fisher, in [Fisher, 1999], proposes a taxonomy of uncertainty in a geographical context. This taxonomy organizes the choice of the uncertainty representation theory (fuzzy sets, probability, belief function, etc.) for each kind of geographical uncertainty (errors, vagueness, conflicts, etc.)

But, even if archaeological excavation data by their location features can be considered as a particular case of geographic data, they differ by many aspects. Two of them are crucial. The first one is the large incompleteness of the information carried by the excavation data (generally only fragments of objects are found, their descriptions are partial, etc.). The second one is the nature of the temporal information. The archaeological information is considered in a long time (period) context when in classical GIS, the temporal information corresponds to a date more precise (an event).

To manage these specificities of the archaeological information compared to the geographical data, we have to organize differently the choice of the uncertainty representation theory. The aim of this paper is to expose a new taxonomy in order to choose the theory best adapted to the nature of uncertainty in archaeology. It also proposes some models of uncertain data representation for each theory in spatial and temporal context.

We use this taxonomy in the SIGRem project [de Runz et al., 2007]. The goal of this project is to store, in a spatiotemporal GIS, all the excavation data about Roman objects found in Reims. On the road to reconstructing the past, we illustrate in this paper for the Reims Roman streets the impact of spatial, temporal and shape uncertain representations of objects in some SIG requests.

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A method for dealing with chronological uncertainty in stratigraphic datasets

(short paper)

HERZOG, Irmela

Keywords: archaeological stratigraphy, monotone regression, chronology

A Harris diagram in general represents only one out of billions of possible chronological sequences of a site if one is focusing solely on the stratigraphic relationships. The archaeologist is faced with the problem of identifying the most appropriate Harris diagram, and the large amount of possibilities creates a feeling of uncertainty. As early as 1984, this problem was discussed and the term “multilinear stratigraphic sequences“ was coined. But even today no general solution to this problem is and probably never will be available, since each stratigraphic dataset has individual traits which might help to fix the floating sequences. This paper presents a method which not only fixes the floating sequences but also assigns absolute dates to the contexts provided that absolute date intervals are given for a subset of the site’s contexts. The first step of the algorithm is to combine the dates of contexts which are set equal or contemporary. In the second step, an iterative mathematical procedure known as ‘monotone regression’ is applied to adjust the dates of the contexts in such a way that the new dates are as close as possible to the original dates but contradictions between the absolute dates and the stratigraphic relationships are eliminated. An optional third step allows the user to estimate dates for the undated contexts, and based on the dates of all contexts, periods or phases may be defined. Some plausibility checks are also supported. These plausibility checks and simulation studies may help the archaeologist to deal with the chronological uncertainty inherent in the stratigraphic dataset to be analysed. In my view, new but mathematically sophisticated methods dealing with uncertainty will

not be accepted by the archaeological community unless appropriate tools are available. Version 1.5 of the freeware program Stratify includes such a tool.

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It's about time: temporality and intra-site GIS

(short paper)

GREEN, Chris

Keywords: archaeological time GIS

Archaeology is fundamentally temporal, and thus GIS approaches that ignore time are limiting. Attempts have been made to address this, but they have been case-specific or avoided the concerns of everyday archaeological enquiry. Further, they have not fully engaged with theoretical developments regarding the nature of archaeological time.

Archaeological time takes two forms: the constructed temporality of chronology; and the perceived temporality of past persons. The former is complex: multi-linear, topological and uncertain. As such, existing temporal-GIS (T-GIS) are insufficient, being based around temporally precise data. This research seeks to bring T-GIS functionality to existing GIS (ArcGIS), but based upon explicitly archaeological data and questions.

The software deals firstly with the fundamental uncertainty of archaeological dates, by comparing using several different methods the date range intrinsic to each date to the date range selected by the user. The temporal topological relationship is also recorded between each date and the time-frame selected.

The output can then normalise any spatial analysis undertaken, according to the likelihood of each date falling within the period of interest. As such, the software takes forward spatial analysis into the time dimension and forms a foundation for introducing further temporal models into analyses. It also provides a tool for moving beyond conventional chronology through weighted timelines produced from the uncertainty profiles for each date.

This software takes forward the agenda of archaeological T-GIS, by dealing with the fundamental uncertainty of archaeological dates whilst remaining within the “software horizons” of the average archaeologist. The next stage would be to produce a solution that also took account of the stratigraphic relationships between the dates plotted.

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Integrating temporal uncertainty in first and second order spatial analysis

(short paper)

CREMA, Enrico R.

Keywords: Temporal GIS, Temporal Uncertainty, Aoristic Analysis, Spatial Analysis.

Inter-site spatial analysis relies on two sets of assumptions that are often ignored in archaeological literature: i) the relationship between the archaeologically-recovered sample and the original population, and ii) the issue of site contemporaneity. While the former could be faced by adequate sampling strategy and statistical knowledge, the latter is intrinsically related to the ambiguous nature of the temporal dimension in archaeology, which is often uncertain and subjective. The potential of spatial analysis and spatio-temporal analysis are heavily reduced by such data structure and any apparent patterns remain difficult to interpret. This work investigates the application and the extension of the aoristic approaches for temporal uncertainty management by proposing a set of tools to identify first and second order proprieties of prehistoric hunter-gatherers' pithouse distribution during Middle and Late Jomon in Japan. New methods for integrating different degrees of temporal knowledge in statistical inference will be assessed and compared to the traditional analytical approaches to the temporal data in archaeology and other fields. From a methodological perspective an aoristically-weighted version of KernelDensity Estimate and Ripley's K Function will be adopted in order to detect the long term changes in spatial pattern, while a pilot application of voxel-based 4D GIS will be proposed as a visual tool.

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Uncertainty on the local scale: Defining households and task areas from complex spatial contexts

(short paper)

WHITLEY, Thomas G.

Keywords: GIS, intra-site spatial analysis, household locations, Mississippian, Riverfront Village

In many archaeological contexts the continuous occupation, or re-occupation, of a large habitation site can lead to a very complex palimpsest of features, middens, and other debris that obscures our ability to define individual households and identify activity

areas. Riverfront Village, a large Mississippian Period (1000 to 400 BP) site excavated last year on the bank of the Savannah River in South Carolina, produced more than 4500 structural features; probably indicating more than 80 houses. These features still only represented about a third of those which may have been present, as many appeared to be obscured by a thick dark midden. The households overlapped each other to such a degree that it became almost impossible to discern which were contemporary with each other over the ~600 years of occupation. This paper describes some of the attempts to identify specific households and interpret task areas across the site and in the surrounding terrain. These methods involved generating spatial algorithms and GIS analyses; some of which worked well, while others did not. Within the context of this project, our analysis modeled uncertainty on the local scale. That uncertainty is reflected both in the way in which the past residents of the village treated their cognitive landscapes and the way in which we (as archaeologists) interpret them today.

Brockington and Associates, Inc.

eWilliamsburg: Mapping spatial and temporal uncertainty for an eighteenth-century town

(long paper)

FISCHER, Lisa

Keywords: GIS, Uncertainty, Eighteenth-century, Virginia Long Paper Proposal

The ongoing eWilliamsburg project, which is being funded by the National Endowment for the Humanities, involves the creation of a GIS-based tool for mapping eighteenth-century Williamsburg. Williamsburg was the capital of Virginia from 1699 to 1780 and underwent significant changes during the eighteenth century. When the colonial government was moved from Jamestown to Williamsburg the latter was little more than a church and a college. By the eve of the American Revolution, the town had grown to 2000, half of whom were slaves. In 1780 when the capital moved again to Richmond, Williamsburg returned to being a sleepy hamlet, an act which ended up preserving 88 original buildings that survive today and leaving much of the archaeological record intact. The eWilliamsburg interactive map tool, when completed, will allow users to explore how the layout of the town changed over time and to access information about the its residents and neighborhoods.

Creating the interactive map tool involves the review and synthesis of more than 80 years of archaeological, architectural and historical research on the town. Eighteenth-century buildings and parcels are being mapped and linked to information about the residents and site usage for each property. However in reviewing all of this previously-collected information, the data can often be incomplete, inconclusive, or even contradictory so the researchers are forced to interpret and hypothesize about the layout and dates of particular properties and structures. For each feature, three types of uncertainty are being quantified:

spatial, both size and location, and temporal. Based on specific criteria, uncertainty is assigned from one of five levels, ranging from Definitive to Unknown. This approach to mapping uncertainty builds on one developed for a previous project, which will also be discussed, in which the town's residents were mapped using a list of people affected by a 1747/8 small pox epidemic. Without confronting the issue of interpretive reliability and attempting to qualify what is known and what is not, the eWilliamsburg map tool could present a skewed view of the town. The resulting interactive tool, which will be launched in 2009, will use visualization techniques for displaying the uncertainty levels but will also allow the end user to control for reliability so that s/he can choose to view only what is definitely known or can display the more subjective interpretations.

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The bumpy road to incorporating uncertainty in predictive modelling

(long paper)

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Keywords: predictive modelling, Bayesian statistics, Dempster-Shafer theory, uncertainty

One of the key problems of predictive modelling is the lack of tools to incorporate and map the uncertainties of the predictions made. As the models are usually based on archaeological and environmental data of varying quality, without an explicit description of biases and errors in data recording, there is a real risk that statistical methods may come up with predictions that are far off the mark. Because of the lack of adequate descriptions of bias and error we are therefore often forced to rely on expert judgment for prediction. In early 2005, a case study was carried out to find out whether expert judgment could be quantified in such a way that predictions could be made that would satisfy the experts' views, and at the same time quantify the uncertainties in the experts' opinions as well as in the available data. It was decided to test two potentially useful techniques for this, Bayesian statistics and Dempster-Shafer theory. Both are well-developed statistical techniques, but have not really found their way into predictive modelling yet. The results of the case study were on the one hand encouraging, as it proved possible to produce maps of uncertainty of the predictions made. However, we are now facing new questions regarding the utility of uncertainty mapping in archaeological heritage management. Which of these methods used is best suited for heritage management purposes? And what will it take to actually implement uncertainty mapping on a larger scale? While not pretending to have the ultimate answers to this, we will try to highlight the main issues involved. These are centred around the complexity of the techniques themselves, the question of what to do with the knowledge

of uncertainty, the need for adequate software tools to apply and visualise them, and the enduring problems of funding and the organisation of archaeological heritage management in the Netherlands.

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**LANDSCAPE ARCHAEOLOGY AND THE
EMERGING NEW LANDSCAPE OF THE
DIGITAL WORLD**

APRIL 3, THURSDAY

LANDSCAPE ARCHAEOLOGY AND THE EMERGING NEW LANDSCAPE OF THE DIGITAL WORLD

Chair: LASZLOVSZKY, József – SZABÓ, Péter

Landscape archaeology has made a spectacular development worldwide during the last two decades. From a relatively limited methodological approach within archaeology it has quickly developed to an independent field as well as a crucial framework of interpretation for all periods of archeology. Significant elements of this development process can be attributed to the growing importance of new data-collection techniques and to new analytical schemes. Remote sensing technologies, GIS and digital landscape modeling have transformed landscape archeology from the point of view of methods and approaches. At the same time, historical concepts connected to past landscapes (landscapes of memory, landscapes of power, sacred landscapes, monastic landscapes, etc.) have started to dominate the interpretation and evaluation of landscape archaeological publications. The papers of this session will present and discuss new methodological approaches in this field, while the round-table discussion will explore the theoretical and practical issues deriving from recent development trends in the frameworks of interpretations. The dichotomy between the increasingly technical issues connected to data collection and the traditional historical interpretations of landscapes will be one of the key problems of related discussions.

GIS and chronological classification of pre-historical burial grounds

(short paper)

LÖWENBORG, Daniel

Keywords: GIS, Landscape Archaeology, Settlement Analysis, Statistical Classification

The Mälardalen area in central Sweden is an excellent playground for settlement analysis studies, due to the large number of pre-historical burial grounds visible in the landscape and available in a digital monuments record for analysis in a GIS. These more than 10.000 burial grounds could be of great value in order to understand changes in settlement behaviour and the social dynamics of especially the Iron Age. In order for this to happen it is necessary to establish a chronology of the use of the individual burial grounds. Such an attempt was undertaken in the late 1970s, but since then much more information has been made available, primarily through large scale rescue excavations. Further, the development of GIS technology and the availability of a large number of digital databases on both cultural

and environmental data gives that it is now time to revisit the chronological classification and see if the new technology can provide better results.

Taking a starting point in the excavated burial grounds, an attempt is made to date the rest of the burial grounds in one district in the area, Västmanland, based on the characteristics of the individual burial grounds and a few variables that describe some aspects of the physical landscape at each location. This information is then used in order to classify the burial grounds chronologically. The aim is to try a few different statistical methods, such as stepwise regression, in order to compare the results of different methods of classification. This paper will present the methods and some preliminary results of this project.

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Explicit theoretic pipeline: GIS analysis and data integration for archaeological landscape interpretation

(short paper)

PESCARIN, Sofia

Keywords: GIS, landscape archaeology

The paper presents a theoretic approach to archaeological landscape interpretation. GIS digital pipeline will be described with some examples of its use, in the generation of Potential Landscape, with particular regards to spatial analyses. The definition of this pipeline was done with the goal of defining a possible and more general indication for ancient landscapes reconstruction, through the use of a discrete and explicit formal process that makes use of connected algorithms. This process, although with some risks, allows a good control, step by step, of each different phase of interpretation and, in the meanwhile, it allows us to modify the final result of the reconstruction, when the initial datasets are modified or new data introduced. In this way it is possible to obtain interdisciplinarity, reliability and updatability.

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Ancient woodland, landscape archaeology and GIS: Towards an integrated approach

(short paper)

SZABÓ, Péter – MÜLLEROVÁ, Jana

Keywords: woodland, landscape archaeology, GIS

Since the 1970s, there has been a growing interest in Europe to explore long-established (ancient) broadleaved woodland with landscape archaeological methods. More recently, historians, archaeologists and ecologists have started close co-operation to try and understand how past management and its physical remains influence present vegetation and biodiversity. A further challenge is how to use up-to-date IT methods in data storage and interpretation.

This paper will focus on an on-going research project in the Czech Republic (Lowland woodland in the perspective of historical development), which tries to integrate natural sciences, humanities and IT in a number of intensively researched woodland sites. The main questions we will address are:

- Which are the landscape features characteristics for ancient woodland in the Czech Republic?
- Are there any features detectable through remote sensing? How can the analysis of historical and contemporary aerial photographs help with the interpretation of artificial and semi-artificial landscape features? (e.g. abandonment of coppices, presence of charcoal hearths, presence of deserted settlements)
- Can GIS be a useful tool in connecting ecological and archaeological data? What are the methodological problems arising from the simultaneous interpretation of data on natural conditions (vegetation) and artificial landscape features?

Although the project is in its initial phase, partial results are available from several areas, and one study site (Mt. Děvín in Pálava Protected Landscape Area) have been analysed in more detail. Most of the examples presented in our paper come from this site.

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**Archaeological landscapes through GIS and Virtual Reality.
A case study on the monastic site of Jure Vetere
(Calabria – Italy)**

(short paper)

ROUBIS, D. – SOGLIANI, F. – GABELLONE, F. – GNESI, D.

Keywords: landscape archaeology; GIS; 3D model; virtual reality.

Thanks to recent archaeological research in the area of Jure Vetere, located near San Giovanni in Fiore (province of Cosenza, Region Calabria – Italy), a monastic site was discovered, founded by the monk Gioacchino da Fiore (end of the 12th century – first decades of the 13th century). The multidisciplinary research, carried out by IBAM-CNR during four field excavations (2002–2005), put in evidence a remarkably sized ecclesiastical construction that features two different building phases. This essay examines how the territory of Jure Vetere was exploited during the medieval era, processing data by the computer application (GIS platform). The processed data on GIS help us to recognize the main areas where the materials which were so necessary for monastic life came from. Thanks to this study, we can imagine where the quarries for building material and the kilns for lime were located, together with the water supplies area, the areas used for grazing and wood exploitation. Combining a classical approach with a scientific and technological one, this paper examines how to transfer all the information collected on the site of Jure Vetere into 3D, processing the data for educational purposes. What you see here is a moment in the life of Jure Vetere medieval monastery, taken by a virtual camera that portrays the remains, found as they really were and how the monastic structure was built and then never completed. Finally the virtual reconstruction of the ancient plant environment, where the monastery was founded, offers a 3D model of a medieval landscape at the beginning of the 13th century.

IBAM – CNR

Modelling colluviation: Land use and landscape change in the South Cadbury Environs

(long paper)

LOCK, Gary¹ – POUNCETT, John¹

Keywords: colluviation, modelling, South Cadbury Environs Project

An extensive programme of test-pitting has been carried out in the immediate vicinity of the Iron Age hillfort at South Cadbury, Somerset, UK under the auspices of the South Cadbury Environs Project. The deposits of colluvium (hillwash) and erosion surfaces recorded during the course of this test-pitting represent an ideal dataset with which to develop and test a model for colluviation. Six discrete phases of colluviation have been identified from the Mesolithic onwards, with increased intensification of colluviation as a result of the widespread adoption of mechanised farming during the late eighteenth and early to mid nineteenth centuries. Algorithms developed for the purposes of hydrological analysis and morphometric surface characterisation are used to develop a model for colluviation which seeks to both identify the areas which contribute to the accumulation of deposits of colluvium in individual phases of activity, and manipulate the digital elevation model to reflect the cumulative impact of erosion and deposition in successive phases of activity. Areas of net erosion or net deposition identified using these algorithms can be correlated with the test-pitting data to test the validity of the model. Changes in land use identified on the basis of the differential patterning of colluviation can in turn inform understanding of the development of the archaeological landscape around the hillfort.

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Analytical approach for representing the ancient water landscape evolution in Samarkand Oasis (Uzbekistan)

(short paper)

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Keywords: Irrigation Systems; Settlement Dynamics; Oasis; Samarkand; Analytical Methods

Like for other cities in arid areas, the growth of Samarkand depends on the development of an artificial irrigation network capable of ensuring both the urban water supply and that necessary for agricultural purposes. The study of ancient hydraulic works is therefore a

key-topic in the understanding of the evolution of the city and its territory. In Samarkand's oasis the water supply depends on a complex system of artificial channels of different sizes that enclose the region in several mesopotamias, each one with its ecological and environmental characteristics. Important questions related to the origin, chronology and use of this hydraulic network remain open. For this reason, by combining the results of Soviet research with those of French, Italian and Uzbek teams currently active in the region (Archaeological Map of the Middle Zeravshan Valley Project - AMMZV), we are able to propose a number of new hypotheses and considerations, concerning water landscape evolution. The AMMZV project is based on a multidisciplinary approach involving remote sensing, field survey, stratigraphical excavations and GIS data integration and analysis. The present paper focuses on the methodological framework employed to represent the water landscape evolution, including both natural and artificial watercourses, through the analyses of the relationships between settlement pattern dynamics and water management. Because of the lack of historical sources, the history of irrigation can be reconstructed only by a spatio-temporal taxonomy, combining archaeological data and palaeoenvironmental evidences, for dating the ancient artificial channels. For that reason, the paper proposes a chrono-typological classification of the archaeological sites (settlements-mounds), starting from the representation of morphological and mereological aspects, obtained throughout cinematic GPS survey and detailed topographical maps. Finally, a matrix of the irrigation network dynamics will be proposed, combining the archaeological classification and the traces of the watercourses detected by remote sensing and field survey.

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Evolution of environmental settlement strategies in the territory of Sagalassos (SW Turkey) from Hellenistic to Early Byzantine times

(short paper)

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Keywords: Settlement analysis, Settlement strategies, Monte Carlo simulation, GIS

In this paper, a statistical Monte Carlo simulation approach is applied to study location preferences, i.e. settlement strategies, of people in the territory of Sagalassos (SW Turkey) from Hellenistic (ca. 330 BC) to Early Byzantine (ca. AD650) times. For this analysis, information gathered during various field campaigns and digital topographic (e.g.

altitude, height difference relief energy, slope, visibility and orientation), environmental (e.g. distance to nearest spring, distance to nearest permanent river, distance to nearest natural corridor, lithology, geomorphology and solar insulation) and remote sensing data (e.g. landcover) are used in a GIS environment. Only the locations of newly founded sites were possibly defined by taking into account important characteristics of the physical environment and therefore reflect real environmental settlement strategies. The investigation of abandoned sites, in addition, provides information on aspects that were avoided during a particular period of occupation. The analysis shows that “distance to nearest natural corridor” and “height difference relief energy”, i.e. locations just below hill tops, were the most important factors defining the location strategy in Hellenistic times. A major break is observed at the onset of the Early Roman-Middle Roman (ER-MR) period. While in Hellenistic times, settlement strategies were mainly directed towards strategic location, i.e. locations close to natural corridors, permanent rivers and mountain tops, in ER-MR times, they were most likely highly orientated towards agriculture and trade. New sites in this period were concentrated on gentle slopes, in the plains, on low altitudes and nearby water (near springs as well as permanent rivers) and natural corridors. During Late Roman and Early Byzantine (LR-EB) times only minor changes took place. Evidences of a defensive settlement strategy are the establishment of settlements on slightly higher altitudes, local changes in the position of settlements within the landscape and a transition from plain locations in ER-MR times towards foot slope positions in LR-EB times.

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The making of the Roman landscape: Conceptual investigations into the genesis of centuriated field systems

(short paper)

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Keywords: landscape, Roman, centuriation, viewshed, conceptual

The body of late Roman documents known collectively as the *Corpus Agrimensorum Romanorum* has proved an invaluable source for the study of the development of centuriated and other Roman field systems from a technical perspective. However, over-reliance on the corpus as an analytical source has resulted in the idea of a landscape defined under the Roman land surveyor’s technical criteria. Roman surveying text interpretations have also promoted the application of rather rigid parameters in the morphologic analysis of these

structures. In this paper we would like to move beyond the practicalities of Roman field surveying applications and explore the concepts and ideas behind the making of a centuriated landscape, of which the city layout was an essential part. Through a combination of GIS-based archaeomorphological research, 3D landscape modelling techniques, and visual analysis we aim to show the centuriation as a land appropriation process in which cultural and religious factors played an essential role. Particularly, this landscape appropriation draws its basis in a complex cosmogonical conception related with the foundation rite of Roman colonies. This paper will finally try to demonstrate the flexibility and adaptability of the Roman land surveying techniques. Their application, rather than being a rigid one, will allow overcoming the physical environment constrains in developing a truly Roman landscape.

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**VISUALIZING ANCIENT SPACES:
VIRTUAL RECONSTRUCTIONS OF
ARCHAEOLOGICAL SITES**

APRIL 3, THURSDAY

VISUALIZING ANCIENT SPACES: VIRTUAL RECONSTRUCTIONS OF ARCHAEOLOGICAL SITES

Chair: GILL, Alyson A.¹ – FLATEN, Arne R.²

Over the past decade various digital technologies ranging from three-dimensional reconstructions or models, laser scanning, GIS databases and digital mapping have been used to contribute to our understanding of various aspects of ancient sites. In some cases these tools have led to the creation of three-dimensional virtual models of buildings or of entire sites, while in others they have been used to address specific archaeological problems.

Digital technologies can be an exceptionally powerful tool when used in reconstructions, and there is information that can be gained from them that is not available through traditional archaeological means. Virtual reconstructions allow scholars to consider theoretical issues including sight lines, the ways in which space would have functioned in antiquity, and how buildings would have interacted with each other. Three-dimensional digital models also allow us to engage a diverse set of experimental architectural problems, including lighting and ventilation reconstructions and engineering issues.

The organizers of this session are interested in the diverse perspectives offered by data providers, producers, and end users of three-dimensional models with respect to problems and possibilities presented by digital technologies as research tools in archaeology. This session is intended to foster discussion between these groups. Papers should focus on the ways in which digital technologies might be used as research tools, or the presentation of a specific project that models a specific digital research tool or set of tools in the study of an archaeological problem or site.

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A computer aided study of Late Iron Age buildings

(long paper)

TIMÁR, Lórin

Keywords: Late Iron Age, settlements, building types

As a result of the excavations at the Late Iron Age site Sajópetri-Hosszú-dűlő (Hungary) ranging from the year 2002 to 2004, more than 40 buildings have been unearthed. The analysis of the building structures made us able to study them in detail and to draw certain

conclusions which may represent a new addition to our knowledge about Prehistoric architecture.

Among the pit-houses a special building type could be identified which seems to be a workshop. This building type has a floorplan which is different from what the dwellings have, and there is a small number of other examples of this building type from other archaeological sites but their function has not been identified yet. The site of Sajópetri Hosszú-dűlő was not just rich in buildings: in many cases the finds inside the building remains as well as the joining structures (eg. pottery kilns heated from a workshop-type building) helped us to understand their original function. We could also make some observations on the pit-houses which are worth displaying.

The presentation would like to focus on the different approaches to understanding the building remains and to show the results which can give us a base for the theoretical reconstruction. There is little need to explain how the use of the computer aided design became indispensable in this phase, because the handling of the 3D building models ensures precise results. Another important feature is that the digital processing of the excavation plans is getting more and more widespread: computer-based visualization is a logical consequence. This is a process beginning at the digitalization of archaeological objects and ending with a reconstruction which has to represent how we could understand the finds.

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Towards the 3D GIS: The information system of the Insula Orientalis I at Herculaneum

(long paper)

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Keywords: 3D GIS; Cultural Heritage Management, Herculaneum, Virtual Reality, Archaeology and Conservation

The Herculaneum Conservation Project (HCP) is a collaborative venture between the Soprintendenza Archeologica di Pompei the Packard Humanities Institute and the British School at Rome. The project aims to halt the progressive decay of the ancient Roman city of Herculaneum, and includes rescuing the archaeological remains from immediate danger and the implementation of a conservation strategy in order to favour the long-term survival of the site. In order to understand the work involved and to establish best practices, one of the first steps taken was the adoption of an entire urban block, the Insula Orientalis I,

as a case study area. HCP employed a team of multidisciplinary consultants to analyse and record the standing remains of this insula; the results of their research are providing the basis for any decision-making in the conservation, restoration and presentation to the public of the Insula Orientalis I. From the outset it was evident that a unique information management tool was needed to homogeneously record structured data collected in the field by each specialist. The Insula Orientalis Information System integrates an accurate 3D model (draped with high resolution rectified images) with a 3D layer oriented structure related to the archaeological stratigraphy and conservation data. The information system has to provide immediate access to information and a prompt answer to any query made by different specialists on any aspect of the complex. This paper shows how the Insula Orientalis Information System manages to integrate specific approaches to analysis by creating a single geodatabase which is referenced to a detailed survey of the buildings with ‘fly through’ access. It provides useful tools for administrative management, as well as powerful instruments for scientific analysis and 3D visualization of results.

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Optimized 3D models for knowledge and distribution of archaeological sites: *Villa Adriana's Serapeo*

(short paper)

FANTINI, Filippo – PINI, Stefania

Keywords: Virtual museums and public archaeology applications; 3D Data capture and visualization; Virtual reconstructions and visualization: Problems with uncertainty; Qualitative and quantitative analysis in 3D imaging – a matter of scale.

Purpose:

During the centuries, famous architects, archaeologists and painters tried to understand, through surveying and drawing the original shape of the *Serapeo* of *Villa Adriana*: many ancient and more recent reconstruction proposals currently seem to be not accurate enough because they were made with empiric or rhetoric approaches to the ancient architecture. Until now the authors who that study the monumental complex have represented the complex shape of vault and ruins in a schematic way. The studies and drawings, produced by Canina, Piranesi and French *pensionnaires* (such as Louis-Marie-Henri Sortais), put in evidence a

range of different hypotheses. However the complex shape of the damaged masonry walls and of the fallen pieces of the vault were not so easy to represent and survey. Nowadays with software from the world of digital survey and video games interactive application, it is possible to obtain reliable 3D models and also suitable for interactive applications for the web.

Advanced texturing systems, based on normal maps, allow the use of huge amounts of data, obtained by means of digital survey to improve the quality of 3D models useful in rendering application. Those models with normal maps applied, encode in low resolution a complex and accurate morphology. It is necessary not only for distribution but also for studies in which is accuracy and user-friendliness are important.

Methodology/Approach:

The main operating phase that allows us to obtain a low resolution polygonal model through geometrical information encoded from high resolution model is called baking. The output of the baking process is a special three channel bitmap (RGB), the normal map, in which is the geometrical information of the high-poly model are stored. Using normal maps instead of former bump map (one channel bitmap) allows us to obtain a better visualization quality. The normal map is the result of a non empiric process in which the first step is to define an optimized UV reference system for the low-poly model. Normal maps and colour maps, obtained by means of a photogram metrical survey, can be applied together in order to achieve a better quality of the 3D model representation.

Results:

This data processing allows us to consult the reconstructive hypotheses regarding the Serapeo of Villa Adriana using wide diffusion software. So low-poly models with normal and colour maps applied allow us to put in evidence several aspects about masonry walls, such as stratigraphy, very useful to estimate the reliability of the reconstructive hypotheses.

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**Living the past: Rebuilding and understanding
our history by use of virtual models.
The case study of the Roman villa of Freiria
(short paper)**

RUA, Helena – ALVITO, Pedro

Keywords: Virtual reconstructions, visualization: Problems with uncertainty

“Learn about our past, to better understand our present, and predict our future”

Used abundantly as a means to justify our interest in ancient societies, the phrase lacks practical meaning, due to the high degree of uncertainty which surrounds archeological studies and theories, and the fact that there is no real way to prove or validate the said theories. That is why is it so important to approach this study from a multidisciplinary point of view, providing several inputs which complement each other, and in doing so, maximizing the amount of factual information that derives from the analysis. Even so, the study will never be truly complete, because there will always be that one missing document, that small trace of an object, that still needs to be analyzed.

Even with all the information available, there will always be several hypotheses for the same subject. These exist in inverse proportion to the amount of data that we possess.

This project aims to be a positive contribution to historical investigation, specifically for the study of architectural history. Its purpose is to create a series of methods and tools for testing and analyzing theories and hypotheses, by use of 3D modeling tools and Virtual Reality engines.

The project is two-fold:

The first stage is the creation of several 3D models, each representing a different theory or hypothesis. The models will be based on accurate CAD and GIS information of the site, creating an actual, realistic representation of what exists now, and a close approach to what could have existed.

The first stage is the creation of several 3D models, each representing a different theory or hypothesis. The models will be based on accurate CAD and GIS information of the site, creating an actual, realistic representation of what exists now, and a close approach to what could have existed.

In the second stage, a simplified version of the models will be imported into a VR engine, to create the ambience of the villa at the time, allowing for a full exploration of the space, which includes adding all the fauna and flora, as well as AI-driven avatars.

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Virtual Cerrate: A DVR-based knowledge platform for an archaeological complex of the Byzantine Age

(long paper)

GABELLONE, Francesco

Keywords: 3D modelling, VR, laser scanning, digital photogrammetry, Byzantine period, Italy

This study is part of the activities organised as part of the ByHeriNet project (“Byzantine Heritage Network: Rehabilitation, highlighting and management in the Eastern

Mediterranean Basin”), which is part of the EU Programme known as INTERREG III B “ARCHIMED”.

The main objective of the activities of the **IbamITLab** within the **ByHeriNet** project is the development of integrated methods for the creation of three-dimensional models using laser scanning techniques, digital photogrammetry, 3D photomodelling and direct surveying, applied to Byzantine sites in the province of Lecce and in Basilicata, in the South of Italy.

The three-dimensional models established using these methods constitute an advanced information platform, able to represent the architectural morphology of the buildings under study with great accuracy at various scales, including both detailed elements and the monumental arrangement as a whole, as well as the textural features of the internal and external surfaces.

The main aim of this study is to enable the public to enjoy the results of archaeological and archaeometric research, via the web or stand-alone products, and to “virtually visit” the monuments using RealTime 3D visiting systems and spherical-interactive 3D panoramas. The navigation platform, based on the VirTools engine, allows the user to visualise complex scenes and DVR-based knowledge models in “full-screen mode” even on desktop computers. As well as showing the current state of the monument, the visit includes reconstructions of previous phases in its history and virtual restorations of the Byzantine paintings. All the textures were obtained by processes of photomodelling and were applied to the geometrical forms in accordance with the radiosity algorithm, with lights and shadows of the ‘area’ type. The result is extremely life-like, almost indistinguishable from the reality.

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Three dimensional reconstruction for Cultural Heritage visualization – Application to the Byzantine churches of Cyprus

(short paper)

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Keywords: 3D reconstruction, photogrammetry, terrestrial laser scanning, Byzantine churches, Cyprus, multimedia

Contemporary techniques and methods of Information Science, Computer Graphics, Virtual Reality and Multimedia Technology are developed and integrated in order to record, represent and protect Cultural Heritage. Geometrically correct 3D reconstructions have lately become feasible by the integration of laser scanner and photogrammetric data. These products may become available within a web portal to those interested (students,

researchers, scientists, tourists), using popular and freely distributed software, like Google Earth.

In this paper the state-of-the-art of 3D reconstruction techniques is summarized and its contribution to the visualization of Cultural Heritage is presented. The process for the production of 3D reconstruction of historic monuments and their integration with the necessary attributes (historical information, images, etc.) in the web, by using Google Earth Pro and Google Sketch Up software, is described.

An application of the above is made for the Painted Byzantine Churches of Troodos Mountain in Cyprus, which are included in the UNESCO list of World Heritage Monuments. First an accurate three dimensional digital reconstruction of the Painted Churches (buildings and surrounding area) at a large scale and their virtual tour and guidance in a multimedia environment is made. For the exact three dimensional reconstruction contemporary photogrammetric and terrestrial laser scanning techniques are employed, combined with virtual reality methods and multimedia techniques. The system under development is based on and contains a multitude of innovative research procedures in the field of three dimensional reconstructions, in the field of virtual and graphic representation and also in the field of personalized and adapted guidance and navigation. Then a Monument Information System, (MIS) has been developed and exposed to the web, to provide a wealth of qualitative and quantitative information. The system caters for the collection, archiving, processing, management of any kind of information and virtual touring using multimedia technology. The user also has the possibility to virtually fly over the area of interest based on suitably draped satellite images. The monuments are accurately georeferenced and appear in their exact position.

The system may operate either autonomously or in the web through the Google Earth environment. In this way the result is a unique product of virtual realism for the visualization of cultural heritage objects, while at the same time it is able to provide virtual touring services adapted to the users' needs.

Domain ontologies and 3D model: A reconstruction of a temple

(long paper)

LORENZINI, Matteo¹ – FERRANDINO, Gilda²

Keywords: open source, 3D reconstruction, BLENDER, GML, CIDOC-CRM, Sudan

The international scientific community is more and more involved in the use of open formats for fruition and exchange of data among different users. Our paper presents the 3D reconstruction of a temple of the Meroitic period at Musawwarat es Sufra in Sudan, based on the integration of the open source software BLENDER for the process of 3D data, with the GML for the management of geographic data, and the CIDOC-CRM for the ontological analysis of the monument. The model has been processed by using the GML

language, developed by OGC-Open Geospatial Consortium, which allows us to formalize data and process them graphically in a vectorial format. We chose the GML because it is an open format, standard ISO 19100 series, and it is able to store and manage great quantities of geographic information. The georeferentiation of the 3D model, through a spatial coordinate reference system assigned in the GML project, allows the model to be imported and read in any GIS system. The use of the CIDOC-CRM ontology has been employed to describe the monument according to the highest international standards for cultural heritage documentation. To combine these two formal models, GML and CIDOC-CRM, our approach consisted in aligning the GML model with its geographical and geometrical properties, with “concepts” of CIDOC-CRM that express the spatial relations of objects. In this way it was possible to build an only ontology that allowed the formal description of the monument in its geographical and decorative characteristics.

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**Surface topography and ship hulls:
The use of white-light scanning technology to capture
detailed archaeological data from the hull of the
American Civil War submarine *H.L. Hunley***
(short paper)

SCAFURI, Michael P.

Keywords: 3D; Data Acquisition; American Civil War; Hunley submarine; white-light scanning.

The recovery and excavation of the American Civil War submarine *H.L. Hunley* off the coast of Charleston, South Carolina in 2000 provided many challenges and opportunities for mapping and the recording of provenience information. Because of the nature and complexity of this site, a variety of techniques and technologies were employed at different times to collect three-dimensional data from the various parts of the submarine, including the hull, internal components, and the artifact assemblage found within it. The selection of technologies utilized was entirely dependent on the specifics of the area of the site to be recorded, and the nature of the desired data. Over the past year, the archaeological team has initiated a detailed study and analysis of the hull of the *H.L. Hunley* submarine, and investigated several possible techniques for collecting detailed mapping data.

This paper will discuss the most recent implementation of Breuckmann white-light scanning technology to capture 3D topography from the hull of *H.L. Hunley*, and compare the advantages of using this technology in contrast to other available scanning technologies. In particular, the specific benefits of the white-light scanner for this application included the collection of large amounts of data in relatively little time, and a correspondingly low level

of noise in the data set. In addition, the Breuckmann system allowed project archaeologists to simultaneously capture color photography along with surface topography, avoiding the necessity of additional software to build color 3D models. The data collected with the white-light scanner was directly applied to the archaeological team's analysis and ongoing archaeological investigation of the *H.L. Hunley* submarine.

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**Advantages and limitations of using white-light scanning technology to analyze and interpret an archaeological site:
A case study from the excavation of the
American Civil War submarine *H.L. Hunley***

(short paper)

JACOBSEN, Maria

Keywords: 3D Mapping and Modeling; White-light Scanning; Data Analysis and Interpretation; *H.L. Hunley* submarine; American Civil War.

This paper outlines the archaeological research challenges and strategies that led to the selection of Breuckmann white-light scanning technology to document the surface topography of the American Civil War submarine *H.L. Hunley*, and discusses the advantages and limitations of using the Breuckmann system to analyze and interpret archaeological data imbedded on the corroded surface layer (concretion) of the submarine's hull. The Breuckmann system was tested on its ability to capture the intricate surface details of marine organisms that once colonized the hull, document their spatial distribution, and capture the stratigraphic information also imbedded in the hull's concretion. These data are vital for reconstructing and interpreting the site formation processes.

Based on this study it is clear that the Breuckmann scanning system is a powerful tool for precision mapping, modeling, and site interpretation. It also has the unique and useful capability to simultaneously capture photographic surface data in color. However, our investigation revealed some limitation to this particular scanning technology when applied to the archaeological investigation of *H.L. Hunley*. Specifically, the photographic color data captured by the system was not of the very highest resolution, although more than detailed enough for aesthetic 3D surface rendition. Consequently, its applications are limited when attempting to use the color data for more rigorous analytical purposes.

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**INTRA-SITE ANALYSIS AND
GIS IN ARCHAEOLOGY**

APRIL 4, FRIDAY

INTRA-SITE ANALYSIS AND GIS IN ARCHAEOLOGY

Chair: KAMERMANS, Hans

Methods for the study of intrasite spatial patterning in Palaeolithic sites. A case study of level IV Bolomor Cave (Valencia, Spain)

(long paper)

SAÑUDO DIE, Pablo

Keywords: spatial analysis, archaeostratigraphy, Cova del Bolomor, Upper Pleistocene, domestic areas

Archaeological digs carried out in Bolomor Cave since 1989 have produced an extensive chronostratigraphic sequence for the middle and early upper Pleistocene. The multidisciplinary investigation of it shows the social, economic and behavioural characteristics of the hominids that lived there over a long period (350–100 ky). This work includes an archeostratigraphic analysis of the upper levels of the sequence (I to XII, 100 to 150 ka) and the subsequent study of the archeostratigraphic units identified in level IV (CBIV-1 and CBIV-2). Its main aim is to interpret the occupation strategies employed by the human groups that inhabited Bolomor Cave in the early upper Pleistocene.

The proposed intrasite methodology to the analysis of these two units, combining GIS, 3D analysis, archeostratigraphy, a horizontal analysis of levels, statistics and lithic refits, employed for the identification of latent and evident structures that confirm the existence of a complex organization of the site. The archaeostratigraphic method is based on the identification of sterile layers into homogeneous sediments. This break in the continuous vertical occupation allows the establishing of a clean limit between occupations. Geographical Information Systems (GIS) are used to analyze and represent the archaeological elements on vertical and horizontal plots, for the interpretation of diachronic and synchronic relations between them. The GIS statistics tools, like frequency maps or elements per square, can help us to interpret the activity areas in Palaeolithic sites. The 3D reconstruction of structural elements like hearths and the representation with the rest of archaeological items is an important element for see the relation between they.

CBIV-1 and CBIV-2 units have a spatial distribution that is conditioned to the rockshelter drip-line delineation that divides the occupation area in two zones with a noticeable functional differentiation in the activities that were developed in there. The identified activity areas are formed by the superposition of bony and lithic rests result of diverse daily activities developed, like food preparation and consumption, production and

use of tools, and social relations between the members of the group, typical of domestic areas. The domestic areas are the basic spatial units in both levels.

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A 3D perspective in the interpretation of living floor morphology: Intrasite analysis of prehistoric contexts

(short paper)

PIZZIOLO, Giovanna¹ – VITI, Sabina²

Keywords: GIS, 3D visualization, intrasite analysis, prehistory, Italy

The aim of this paper is to present some considerations on using a 3D approach in exploring prehistoric living floors. In particular, the authors show case studies related to the Florentine area (Sesto Fiorentino, Florence, Italy). In this context many prehistoric sites came to light since 1982 through rescue excavations carried out by the University of Siena and the University of Firenze in collaboration with Soprintendenza ai Beni Archeologici della Toscana. The authors, within the sphere of the “Progetto Sesto” (a large project related to the study of prehistoric evidence and the prehistoric peopling process of the Sesto Fiorentino Area during Holocene period), acquired the archaeological information in a GIS system and attempted the reading of prehistoric contexts throughout GIS analysis and by 3D visualization. In particular, in this paper we take into account evidences from Neolithic to Early Bronze Age.

These sites are characterized by incoherent settings given by the lack of evident structures and of a clear organisation of the space. Beside these objective constraints, the excavated area, most of the time, does not cover all the potential extension of the site but is limited to the size of modern buildings that will be constructed in that spot.

The interest to analyse the relation between the sites and to identify the process that occurred, with the attempt to distinguish the post-deposition and deposition events, has driven us to work on all the archaeological paper documentation that has been produced during 20 years of investigation.

Therefore, we needed to develop different procedures that revealed the potentiality of these datasets acquired bi-dimensionally but in which the z value has been widely registered: the features (distribution maps), the US and the contour lines.

The acquisition of this information, firstly in a CAD environment and then in a GIS application, has produced a new set of documentation that allows to achieve a dynamic and interrelated view of the living plans and the archaeological remains. In multi-stratified sites, it became particularly useful to perform interactive cross-sections in order

to iteratively explore the stratigraphic relationships and carry on a contextual reading of artefact association into the deposit. In other cases, when the anthropic modification of the surface may be strictly related to the natural morphologies, a further exploration in a 3D environment can provide us with unexplored views of the shaping of the palaeo-surfaces improving the interpretation step (these visual analysis has been preformed with ArcScene, Esri®).

Even if the complexity of the living floors cannot be reproduced in its wholeness, the adoption of an intrasite exploration reveals the interaction between natural morphologies and anthropic action related to dwelling activities, motivating interpretations which are the results of a more comprehensive way of observation. The paper focuses on the advantage of a 3D visualisation of evidences, in spite of the previous traditional documentation, at an intra-site scale.

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GIS project in Cyrenaica. From a 'macro-GIS' of the survey to the intra-site analysis of the excavation: Problems and proposals

(short paper)

MENOZZI, Oliva¹ – FOSSATARO, Domenico²

Keywords: GIS, Excavation, Landscape Archaeology, Geo-prospections, Remote Sensing

The team of Chieti University started in 1999 a project of surveying and mapping the territory of the Greek colony of Cyrene (Shahat-Libya), which is mainly focused on the mapping of the extra-urban rocky sanctuaries located homogenously around Cyrene and playing an important role in the rural and economic organization and exploitation of fields and natural resources of this rich and fertile area. Moreover, together with the intensive survey and mapping of the rural and rocky sanctuaries, the last five seasons have been also dedicated to the extensive and judgmental survey of a wider area of the territory of Cyrene, in order to contextualize more appropriately finds and sites.

During these phases of the project several rural villages have been mapped and for some of them a wider program of research is now in progress, such as for the site of Lamluda, ancient *Limnias*, which shows a long and continuous use of the site, with finds dating at least from the Hellenistic to the Late Roman periods. Moreover, an important and interesting type of site in this area are the so called *gsur*, that is fortified centres, devoted to the control and management of the rural areas nearby, and of the local road network.

The project involves the use of field survey and excavation in combination with remote sensing on aerial and satellite HD images, geological prospecting, DGPS positioning and integrated multilayer GIS database collecting the data from the 'macro-GIS' of the survey of

the *chora* to the intra-site GIS of the excavation. While for the GIS of the survey the overlay of survey methodologies and layers of the database did not give any problem, because already tested by numerous survey projects and teams; the intrasite GIS of the excavations have needed more accurate and specific resolutions in particular for the recording and representation of the stratigraphy, that is transforming it into a 3D model, as detailed as possible, but maintaining at the same time the data directly in a single table of the database.

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Predictive modelling in Swedish contract archaeology?

(short paper)

MARTINELLE, Kristina

In countries like Holland, Canada and the USA, predictive modelling is an established approach within Cultural Resource Management. For some reasons, the interest in these kinds of techniques has been moderate in Sweden. The aim of this paper is to start to investigate if and how predictive modelling can be used by archaeological contractors as a part of the inventory process that precedes all larger development projects in Sweden.

All known archaeological sites in Sweden were made available in digital form by the FMIS internet application, released by the National Heritage Board in 2004. Besides making the information more accessible, it should also make data collecting for large scale GIS-analysis easier. Will it be possible to create useful predictive models from the information from FMIS and the geographical data given to the archaeologist by the developer at the start of a new project?

Will it be possible to easily manufacture several models using the same formula for different site types?

In Sweden the Cultural Heritage Act gives strong protection to all ancient remains. From the early 1990s onward several large scale development projects have resulted in large scale archaeological projects. The sample data in this paper is from one of the largest projects in recent years, the re-route of the E4 motorway north of Uppsala, a project that was finished in 2005. Some 78 kilometres of new road were built and chartered their way over fields and woodland. Between the years 2002-2004 around 80 to 150 archaeologists excavated about 40 different sites dated from the Mesolithic to historical times.

In Sweden almost all archaeological institutions use ESRI's software ArcGIS, therefore it was an aim of this project to keep the development as much as the possible in that

framework. However, the statistical analyses were done in a different software, more exactly SPSS.

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**GIS AND RASTER DEM BASED RESEARCH IN
LANDSCAPE ARCHAEOLOGY**

APRIL 4, FRIDAY

GIS AND RASTER DEM BASED RESEARCH IN LANDSCAPE ARCHAEOLOGY

Chair: LOCK, Gary

Least Cost Path – An incomplete model

(long paper)

ANDRESEN, Jens

Keywords: Least Cost Path, Road network, Wheel-based transportation, Cost balancing

The introduction of wheel-based transportation imposed a number of constraints as to where road-systems could be positioned in the landscape. The slope of the terrain, the texture of its surface, the technology of the vehicle including its drive power, and many other parameters determined feasible locations of the road-network in the past. What is relatively new in the study of the past is that we are able to define route models using modern GIS-technology. One of the most popular route-models is Least Cost Path – a type of analysis, where the most cost efficient route between a start and a target point is computed and displayed on a map. One reason for the popularity of the model is that it really does not matter if transportation is performed by foot or by carrier – this is basically a question of adjusting the values of the parameters. But is this a valid assumption?

In this paper I will try to qualify why Least Cost Path is an incomplete model, since it does not include the costs of construction and maintenance of the road network. The model assumes no wearing of the route in repeated use, and it only looks at possible links between two points and not at the total length of a road-network between many points. An empirical study of a network of daily used rural roads serving local purposes from the 18th century AD in East Jutland, Denmark, will illustrate my argument. A very detailed digital terrain model of a 100 km² study area is combined with digitized roads from the oldest available historical maps and the location of small hamlets, single farms and manors in the area. With GIS-techniques it is demonstrated that the position of the road system partially reflects energy-economic usage (=Least Cost Path) and partially reflects juridical regulations of its construction and maintenance.

The second part of the paper is focused on the archaeological research perspective: the time-depth of the analysed road-system. Recordings of archaeological observations from the national Sites-and Monuments register are compared with the distribution of the presented historic road-network. The analyses is supported with quantitative methods and the result is that there seems to be no concordance with archaeological sites from the

Stone-and Bronze Age and the historic road network, whereas there is a strong correlation with sites from later periods. An explanation to this observation will be discussed.

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Tilt – Slope-dependent Least Cost Path calculations revisited

(long paper)

POSLUSCHNY, Axel¹ – HERZOG, Irmela²

Keywords: GIS, DEM, cost surface, least cost path modelling

Least cost path calculations have become a standard procedure in archaeology and this is why many publications simply name the GIS software package used in the analysis they perform but do not give details of the parameters selected and those inherent in the package. Most least cost path calculations rely heavily on slope values derived from a DEM of the modern landscape. This paper will show that the least cost paths generated this way will vary depending on many factors including DEM resolution and accuracy, slope calculation method, slope-dependent cost function, method for dealing with anisotropy (i.e. different costs for ascending or descending a slope), and the number of neighbours considered in the grid. For a given set of parameters, often several paths can be constructed with a total cost value identical with or close to the cost of the least cost path. Some publications address one or two of these issues, but aspects like the accuracy of the slope calculation method used or the error introduced by considering only a small number of neighbours (Queen's move, Knight's move ...) are largely neglected. This paper will give an overview of the problems encountered in slope-dependent least cost path calculations except for the selection of the cost function which will be discussed in another paper. A new freeware program will be presented which supports new refined methods to deal with anisotropy, and considers up to 48 neighbours while not skipping across barriers by long moves.

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A comparison of slope-dependent cost functions

(long paper)

HERZOG, Irmela

Keywords: least cost paths, cost functions, energy expenditure, formal/informal routes

Most results of archaeological least cost path analysis rely heavily on slope-dependent cost functions. Different cost functions have been applied for least cost path calculations: The cost function of Gorenflo/Gale has been widely used, but there has been some confusion concerning the slope parameter (given in “rise over run”, percentage, or degree depending on the publication). Alternatives are cost curves that depend linearly or piecewise linearly on percent slope. The Gorenflo/Gale formula calculates the time required for walking up or down a certain slope, but most people know from experience that walking on level ground for one hour is not as exhausting as walking up a steep slope for the same period of time. Other approaches take into account the energy expenditure based on the slope, the walker’s weight and load. It can be shown that one of those formulas published in standard GIS books for archaeologists will yield results that are at variance with intuition. If a path or road is used in both directions, the slope-dependent cost curve becomes symmetric. Two-way cost-curves based on several popular cost models will be discussed. Moreover, if mountain roads on steep slopes are to be reconstructed, turning costs have to be modeled in order to avoid small-scale zigzag routes. This idea was already published in 2000 but has not been implemented in currently available standard GIS packages. Cost curves for informal routes differ from those for formal routes: Formal routes show evidence of planning and purposeful construction like roadbeds, pavement or bridges, whereas informal routes have minimal or no labour directed to their creation or maintenance. For formal routes, part of the effort that went into the construction work must be added to the slope-dependent cost value. Finally, differences between routes for walkers and routes for horse or oxen driven carts have to be considered. Steep slopes can be mounted by walkers if stairs or even ladders are built, whereas cart routes normally ascend steep slopes by consecutive U-turns. This paper discusses the variety of cost functions available and points out the main criteria for cost function selection.

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Sound methods for viewshed studies in archaeology: The vertical angle

(short paper)

ZAMORA, Mar

Keywords: viewshed calculating, Iron Age hillforts, Digital Terrain Model

Viewshed calculation is often used in archaeology as a way to classify sites (classification according to the size of the visible area, among other aspects).

We usually limit the viewshed calculation within a particular radius. However, since every viewpoint (every archaeological site) has its particular geographical characteristics, to choose a standard radius (a common radius for all sites) for viewshed calculation is not always a good choice.

Calculating the viewshed within an unlimited radius can increase uncertainty too (in particular with regard to unreal sight distance). In both cases (limited and unlimited radius), one of the most important sources of uncertainty refers to the way we perceive through site: in the field, we perceive the visible area located just below the horizon line as a narrow line: however, when that visible line is represented on a map (seen from above), it seems to be a much more extensive area. This fact complicates the interpretation of viewshed data.

This paper explores the viewshed tool in relation to the vertical angle of vision. The aim is to identify the visible area located near the horizon. This assessment has given us a clearer picture of visibility from sites through the use of GIS.

The study refers to a group of 2nd Iron Age hillforts located in Andalusia (Spain).

The Digital Terrain Model for calculations has been obtained from 1:10.000 digital cartography including both contour lines (10 m interval) and their intermediate height points. Sites have been understood as a group of points over the hillforts' surface, as well as over their respective nearby hilltops, with a culturally appropriate offset A.

All computer tasks have been carried out using ArcGis.

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Pastoralism and peak: A GIS study into the origins of minoan peak sanctuaries in Eastern Crete

(short paper)

MEGARRY, William Peter

Keywords: Minoan Peak Sanctuaries, Cumulative Viewshed Analysis, KS Testing

The peak sanctuaries of Minoan Crete have been the subject of much research in recent decades. The prominent topographical locations of the sites, coupled with a diverse and varied material record, has led to a range of often disparate theories regarding origins and ritual practices. Many of these hypotheses have highlighted the importance of the visual connection between sanctuaries and their associated settlements/ regions. Some scholars have proposed a connection between the rise of the sanctuaries in the Middle Bronze Age and the emergence of new agricultural practices at this time. Votive offerings which survive from sanctuary sites include clay figurines depicting a wide range of livestock further indicating the importance of agriculture and pastoral activities in this period.

Geographical information systems afford a range of tools ideally suited to offer new perspectives on Minoan peak sanctuaries. Using GIS, my paper readdresses the connection between emerging sanctuaries and new agricultural practices in the Middle Bronze Age. Using cumulative viewshed analysis, landscape classification, stratified sampling and statistical testing, it was possible to show, with a .01% degree of error that Peak Sanctuary locations in Eastern Crete in the Middle Bronze Age were chosen to maximise views over potentially agricultural land. This land was classified according to slope and viewsheds were calculated using GRASS's *r.cva* command. By counting the number of raster cells classified as arable within each viewshed and cumulating the results it was possible to calculate the amount of arable land visible from sanctuary sites in the region.

A Kolmogorov-Smirnov test was then employed to test the significance of the results. Sample populations of similar sites were obtained by comparing actual sanctuary locations with geomorphic phenomena (peaks) identified on a raster DEM using a multi-scale landscape classification algorithm and seeding sets of random points at similar distances from other peaks in the same region. The results of the test showed that our sample point sets had significantly lower viewsheds of potentially agricultural land than the actual sanctuary sites.

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Reconstructing the Minoan communication network in Central Crete

(long paper)

SARRIS, Apostolos – KAKOULAKI, Georgia – PANAGIOTAKIS, Nikos

Keywords: survey, satellite imagery, GIS

The Pediada survey is an interdisciplinary project, based on fieldwork carried out between 1982 and 1989 by the archaeologist Dr. Niko Panagiotaki. The systematic survey campaign which covered a total area of 800 sq. km. in Pediada of Herakleion region in central Crete brought to light a registry of more than 2500 sites of archaeological interest spanning from the Neolithic to the Venetian period. One of the most distinct features that were recognized along the surface survey was *soroi*, a series of man made rounded pyramidal structures with a flat top, showing evidence of burned residues.

In order to test the theory suggested by Dr. Panagiotaki, namely that the above features constitute fire signalling beacons used for the communication among minoan sites, a number of spatial and statistical techniques were employed. Landsat, SPOT and ASTER images were used to investigate the spectral signature of the particular features. The environmental and spatial attributes of *soroi* were cross-correlated with the rest archaeological sites. Clustering and spatial cohesion of them was explored, compared to the rest of the settlements. Proximity distance to settlements of the same period indicated a close relation between settlements and *soroi*. The inter-visibility among *soroi* and the control of communication passages way tested through viewshed analyses. The particular results suggest a probable hierarchy of *soroi* depending on their location and size – the most significant of them being located to the west and east borders of Pediada region, controlling in this were the passages from the east and west mountain ranges. Supervised classification techniques were also applied to the satellite imagery in an effort to locate probable locations of similar features.

The above approaches support the hypothesis that *soroi* may constitute the earliest communication system in the Aegean world, playing a vital role in the minoan landscape, especially during the MMI-MMIIIA periods.

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The investigation of the Early Medieval system of signalisation in the Kislovodsk basin (Southern Russia) with help of GIS

(short paper)

KOROBOV, Dmitry

Keywords: GIS viewshed analysis, experimental archaeology

The paper presents the first results of an investigation of the Early Medieval signalisation system in the Kislovodsk basin, made by means of several visibility analyses. This powerful GIS method has many advantages as well as some limitations such as the accuracy of the 3D relief model, the determination of the points of observation in space or the maximum distance of the viewshed area. In the paper we discuss ways of solving these problems by means of *ArcGIS* software.

One of the main conditions of visibility analysis is the assumption that the sites were functioning contemporarily. In the Kislovodsk basin more than 120 strongholds were discovered. Some of them accompanied by catacomb cemeteries date to the 5th-8th c. AD. Ceramics and some metal finds found on the surface of the sites as well as in the excavation trenches proved the same date. Thus at this stage we could assume that the majority of the strongholds formed one system of Early Medieval population. This point of view will be more detailed with new chronological data.

All the sites were classified into three types using topographic criteria: forts on the top of the remnant sandstone hills, strongholds on promontories, and small fortified hills. The largest viewshed zones are observed from 20 sites of the third type of strongholds. Eight of them were found on the Borgoustan range on the northern border of the basin. They are situated at a regular distance from each other, and almost all have signs of fortification including low ditches. The same type and the equal distribution in space provide arguments to suppose a simultaneous formation of the whole system. Results of current field observations of these „signal posts” should clarify their chronology that could be different from the others.

The analysis of visibility was made including these posts and without them; it shows that all strongholds could be observed from the main fortified points with good visibility. Viewshed areas modelled with 10km limit around these points demonstrate the system of control over the whole territory of the Kislovodsk basin. This limit of observation in daylight as well as the time of transfer the smoke signal was tested during a field experiment in 2004.

Thus the use of GIS allows us to discuss the function of different types of strongholds, and moreover to make the first steps of modelling the communication system of the population inhabiting the Kislovodsk area during the Early Middle Ages.

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“r.calc.ItinerariumAntonini” – Raster based GIS survey on the Pannonian data of the Itinerarium Antonini

(short paper)

BÖDŐCS, András

Keywords: GIS, DEM, Roman road system, Hungary

The main goal of the survey of the “Pannonian” Roman road system is to identify the locations and settlements in Pannonia described by the data of the Itinerarium Antonini. Unfortunately, the settlement identifications may not be deemed reliable enough in the internal territory of the quondam Roman province, especially in modern Hungary. Road reconstructions based on pure calculations of the mileage data are uncertain because of the lack of information on the exact locations of starting and end stations. In addition, the reliability of the distance values in the ancient sources has to be questioned. Since research accepts the fact that ancient distance values are unreliable in the cases of some well-known settlements, the data of unidentified places should not be considered certain either.

One of the possible explanations for the frequent repetition of values 20-25-30 *millepassuum* is the so-called “one-day-travel-time-needs” theory. In some researchers’ opinion, the mileage data of the Itinerarium Antonini shows not the exact distances, but the distances calculated upon the travel time between two places. The description of the travel-time-need instead of real distances was in institution until the 19th century, furthermore, even travelers of the present day often calculate rather in hours needed rather than in kilometers or miles for long journeys.

This assumption raises the logical question as to what is the base unit that helped to deduce the mileage data from the travel time is.

If indeed the length was calculated by multiplying the travel-time-need by the average travel-speed, what was the latter? Could it be the travel speed of a walking man, or a horseman? Or perhaps that of the spurring courier of *cursus publicus* (the imperial post service), or the strained journey of military corps, or maybe the speed of heavily packed wagons?

My aim is to make an attempt at finding a possible answer for these questions with the help of the possibilities of raster GIS (GRASS 6.2). The attempt is based on isotropic survey derived from a DEM with 10m cell width, and the movement/travel modeling formula of Waldo Tobler, which is applied in geographical research worldwide. With this aid a few “isotemp” buffer zones were created around well-known Roman settlements in Pannonia to examine the possible distances and travel time in a 3D environment and not through a simple 2D plotting method.

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Experimental land evaluation in archaeology: An application to model the accessibility of Nuragic sites with Mycenaean materials in Sardinia

(short paper)

SORO, Laura

Keywords: Land Evaluation, GIS, Cost Surface Analysis, accessibility, Mycenaean ceramics, Nuragic period, Sardinia.

At the end of the 70s, a large amount of Mycenaean pottery and other Aegean materials were discovered in Sardinia. These discoveries have helped understand better Mycenaean and Cypriot traffic in the Mediterranean Sea and the relations between the Nuragic and other Mediterranean cultures from the viewpoint of “colonization” or “pre-colonization”, bound up with material exchange and maybe with the exploitation of the island’s mineral resources.

In Sardinia there are 14 sites, where Mycenaean pottery has been discovered. The aim of the paper is to propose a new approach for this type of research. Since Mycenaean material in Sardinia could have arrived only by sea, we need to understand the relationship between coastal sites and the sea, and the relationship between the coastal sites and the inland sites, where Mycenaean pottery has been found. The aim of this research is to understand the potential influence of the Sardinian landscape on the distribution of Mycenaean pottery.

In order to achieve this, new types of analyses have adopted with the aim to evaluate the accessibility of the sites where Mycenaean pottery was discovered. The analyses used had been tested with GIS technologies and are:

1. Land evaluation and the creation of Land Units based cartographic, geological, pedological, and morphometric data, and with a special accessibility classification system. Land evaluation used in archaeology is widely known and “tries to establish the suitability of ancient landscapes for ancient land uses” (Van Joolen E., 2003). This application with regard to the evaluation of the accessibility of a territory has no precedent in the study of the landscape of Middle and Late Bronze Age Sardinia. In this research it was decided to experiment with land evaluation to assess the suitability of the accessibility of an area.
2. Creation and development of a potential distribution road between coastal and inland sites. The distribution road was developed with Cost Surface Analysis, into which slope data and some data from a lithopedological map had been integrated. The two integrated maps, used for the creation of the CSA, will be classified numerically according to the “accessibility classification” developed for the Land Units.

The results of the trial will provide a starting point for further research.

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GIS-based investigation of influencing factors for alpine Bronze Age landuse

(short paper)

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Keywords: GIS, DEM, landscape, land use

Since 2006, the interdisciplinary project Leventina, funded by the Swiss National Fonds, is being conducted in the close cooperation of the Department of Pre- and Protohistory of the University of Zurich and researchers from further disciplines such as Geomatics, Archaeobotanics and Geography. The aim is to reconstruct the agricultural landuse in the bronze age and to evaluate the influencing factors on the spatial distribution of agricultural areas. A wide range of spatial and archaeological data as well as literature and field data describing properties of the ancient economic plants was available for this purpose. Based on digital terrain models at varying resolutions, factors which were assumed to have an impact on agricultural land distribution were derived, e.g. slope, solar radiation for different periods, terrain height and aspect. Furthermore, modern landuse was mapped and used as reference data in a first approximative approach in order to enable the extraction of influencing environmental and spatial factors by means of statistical testing. In a first step, linear weighted combinations of these layers were calculated using a range of different weights for each of the factors to evaluate the influence of single factors on the resulting potential maps. For a more statistically verified result, the factors mentioned above were introduced to a factor analysis with the aim to identify the significant factors, their correlation and to check to what degree the identified factors would describe the distribution of forest, acre and grazing land. Up to now, only the spatial factors were included in the factor analysis. The spatial resolution and the amount of detail of the existing and available plant and soil data turned out to be too low for our purposes. Therefore, we plan to use data from our own soil samples (5-10 in the vicinity of Madrano), for a more accurate combined study in the future. In our paper, we will focus on a critical overview of the available data and discuss the statistical factor analysis in terms of methodology and its application to archaeological questions.

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FIELDWALK@KOZU: A preliminary report of the GPS/ GIS-aided walking experiments for re-modeling prehistoric pathways at Kozushima Island (East Japan)

(short paper)

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SEINO, Yoichi⁵ – TAKEDA, Masayoshi⁶ – YAMAGUCHI, Hiroshi⁷

Keywords: Travel Cost, DEM (Digital Elevation Model), Cumulative Cost Surface,
Least-cost Corridor, Field Experiments.

Cumulative cost surface and least-cost pathway are widely applied analytical methods for simulating route and time for transportation between archaeological settlements and natural resources. However, little attention has been paid to verify the validity of the simulations. In order to examine the accuracy and availability of the employed functions, as typified by Tobler's Hiking Function (1993), a series of ground-truth field data were collected in Kozushima, a small volcanic island located at ca. 180-km offshore from Tokyo and known as one of the high-quality obsidian procurement sites during the Jomon (Japanese Neolithic) period.

Examinees were expected to walk from Jomon sites as given starting points to obsidian outcrops, sump water, and fishing grounds. Their walking tracks and elapsed time were recorded with handy GPS receivers. The paths were then compared with each other in regard to the differences of: (1) examinees; (2) GIS software packages; and (3) cost equations. Our comparative study shows that different GIS packages and algorithms create different least-cost pathways, regardless of the same DEM they utilize. This suggests that we should consider the accumulation of possible paths as a "least-cost corridor," rather than treat each of them uniquely. Furthermore, walking velocity is significantly affected by ground conditions such as pavement, off road, sandy beach, and rocky shore. In addition, our results indicate that other factors such as viewshed, vegetation, load, and motivation should also be taken into account for travel cost calculation.

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**DATA MANAGEMENT SYSTEMS FOR
ARCHAEOLOGICAL EXCAVATIONS**

APRIL 4-5, FRIDAY – SATURDAY

DATA MANAGEMENT SYSTEMS FOR ARCHAEOLOGICAL EXCAVATIONS

Chair: EVE, Stuart

In the course of CAA there have been a great many proposals for integrated archaeological data and project management systems of one kind or another. Many of these have been extremely successful in their implementations, although few continue in use for many years, or if so are not well publicised. Growth in web technologies and within the open source community has fostered a flourishing of the technologies involved and arguably in the wish to share such information. Indeed the UK Arts and Humanities Research Council and national bodies from elsewhere have recently funded a number of projects relating directly to these issues. The time is perhaps ripe for a critical evaluation of past practice, and a concerted movement towards more shared approaches to this crucial area. The session will be tightly focussed on archaeological fieldwork and will look to be truly international in its scope, with topics including:

- past experience in development of archaeological data and project management systems
- case studies for current practice
- emerging issues for data integration and standards
- issues for archiving and ensuring access to such data

Cultural Resource Management Medieval Team. Projects and applications in the Iberian Peninsula

(short paper)

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In this paper the Cultural Resource Management Medieval Team present different approaches to a methodology to study different settlements in the Middle Ages in the Iberian Peninsula. This kind of methodology aims to introduce a global analysis of the cultural remains at given sites in order to use the new technologies not only for learning where the medieval remains are, but also to study the morphology and try to create an integrated study of data acquisition, storage of information, analysis and scientific and popular disclosure.

These kind of techniques have begun to be applied in different forms in three important settlements in the Iberian Peninsula. The settlement of Conimbriga, which had a considerable occupation in Late Antiquity and continuously to the XIth century presents a complex evolution of structures. To create an important file of the remains, a laser-scan

is used to reproduce the ecclesiastical area (church area) and creating a GIS on the area for a complete study. With similar aims we study the complex historical evolution of the Islamic and Crusader castle of Qal'at Rabah- Calatrava "la Vieja", starting to create a metrical network in the territory and continuing with the storage of the long archaeological actuations (from 1975) to learn the potentiality of the analysis with these kind of techniques. Finally we start to work in an important early medieval church, San Miguel de Escalada in Leon, with a ground-penetrating radar (GPR) and laser-scan. An outline of our objectives in this paper would be as follows:

- Introduction.
- The aims and methodologies of the studies.
- The early analysis.
- An introduction to the archaeological sites.
- Conimbriga, Calatrava, Escalada.
- The methodological approach to Conimbriga.
- The aims and study of Calatrava "la Vieja".
- The project of San Miguel de Escalada.

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Computerised methods for storing, analysing and presenting archaeological data: Case studies from Heves County (North-Eastern Hungary)

(short paper)

DOMBORÓCZKI, László – RITZ, Henrik

Keywords: 3D animation, database manipulation, multimedia

Computerized methods and applications can aid the work of archaeologists, from the recording of data and finds analyses to the creation of 3-D reconstructions. Together they facilitate better data management and improve the way results are presented. In our presentation we would like to make a brief summary of our work at the Heves County Museum.

The simplest digital elements in archaeology are found in documentation, exhibition displays and designs. We would like to show some examples typical of our region.

We use Excel software for handling simpler archaeological inventories. This makes it possible for us to search our inventories by site name, feature, shelf number and store box. For more complex find descriptions, mass find elaborations and statistical find analyses we use DEPO software. In the ceramic database for the neolithic site at Füzesabony-Gubakút,

for example, we are able to describe each pottery fragment according to 40 major and c.300 minor typological characteristics, allowing us to utilize countless searching opportunities for the several hundred thousand pieces. Our results can help seriating site features which will provide us with clues for establishing the relative chronological sequence.

We use GPS to collect field data and produce find-distribution maps. In our presentation we show some of our maps reconstructing the neolithic settlement pattern at the Füzesabony-Gubakút site, as well as the network of settlements around it. Occasionally we rely on other methods to gain more detailed spatial coordinates. In case of the excavation at Ludas-Varjú-dűlő, covering an area of 30 hectares, for example, we took coordinates (between 10 and 100) cylindrically in Autocad format from each and every feature, to enable us to create a virtual reconstruction of the site at a later date.

Within the frames of the European Commission-sponsored Early Farmers in Europe project, we produced an interactive digital CD and an Internet homepage (www.earlyfarmers.net). The CD-ROM, designed for use in educational institutions, provides up-to-date information about the neolithic in our region. It is bilingual, provided with sound and video inserts and contains additional teaching activities. Our most recent project has been the virtual settlement reconstruction of the Füzesabony-Gubakút neolithic site. This Flash program tries to combine complex data processing, map handling and 3D animation.

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**Complex analysis of digital archaeological data.
 A digital documentation system for spatial and
 stratigraphical analysis on a multi layer
 Bronze Age settlement**

(short paper)

FÜKÖH, Dániel

Keywords: total station, onsite data recording, GIS, Intrasis, Százhalombatta, Hungary

Since 1998 the “Matrica” Museum in Százhalombatta, Hungary runs an international excavation as a part of a complex European research programme (Emergence Of European Communities). This research focuses on Bronze Age societies in Europe. The site in Százhalombatta Hungary is a remarkable Early and Middle Bronze Age tell settlement, with approximately 6 meters of cultural deposit, generated by an intensive settlement activity on a loess plateau by the Danube. The excavation, as well as the data processing and sample analysis, are using the most modern techniques, methods and instruments

available. From the wide range of integrated techniques of this research I would like to speak about the digital documentation system and how it can be applied on different levels of archaeological research.

The basic idea of archaeological, digital documentation systems is to be able to record, store and process huge amount of various kind of attribute data, combined with geographical and spatial information. For archaeologists the final product of a site database among others is the images generated by GIS application based on the combination of primary excavation data and results of different integrated sciences.

In my presentation I would like to go through the process of producing the above mentioned images. The first part is the exposition of an effective *on site data recording method*. The second part is the description of the data, and the tools of manipulation that are necessary to work with contextual relations between archaeological features. This is important to be able to build up archaeological phases of the settlement with the help of contextual relations. The third part is to put these phases on each other like bricks to be able to identify stratigraphical relations between the contextual units.

As a case study for the introduction of this process I will use the working database of Százhalombatta Archaeological Expedition (SAX Project). My aim is to introduce a method that combines several different types of data such as spatial, quantitative, and/or statistical together with other interdisciplinary results that can be used for the spatial and stratigraphical interpretation of such complex and (or) multi layer sites.

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Creation of the GIS for the archaeological investigation of a major administrative centre in the Carpathian Basin: Solt–Tételhegy (Bács-Kiskun County, Hungary)

(short paper)

HOLL, Balázs¹ – SZENTPÉTERI, József²

Keywords: onsite data recording, GIS, Solt-Tételhegy, Hungary

All archaeological excavations need to be prepared carefully and sometimes this process can precede the real date of the excavation by years. During the scientific, financial and logistical planning one must consider the geo-information preparation as well. Maps are essential for clarifying certain questions, especially in case of large-scale excavations. Here the size, shape and location of the sections could be very important. It is also vital that at development-led excavations the basis of financial settlements is the size of the territory. Therefore punctual planning and strict inventory are indispensable from the point of view of the developer. At the same time in case of scientific excavations one must also

consider territory-related cost factors (such as the cost of possible damages caused to the vegetation).

The geo-information preparation of excavations consists of two processes. 1.) The first task is to set up the geographical information system, which can receive the data of the excavation. GIS plays an important role not only during data processing but also before the beginning of the excavation. All the previous information must be used to make the opening more efficient. 2.) The second task is that surface survey must precede the excavation, since we can get information which is irrecoverable later. Field work must be scheduled, as there are phases following and excluding one another as well as tasks which depend on date and which connected to one another. It is practical to make expensive methods more efficient by using inexpensive procedures. Preliminary data define the direction of development of the GISystem. Data processed from preparatory work can modify this direction, but it is important to pay attention to the viewpoints of the whole system developed by the end of the excavation. Preliminary calculations are necessary for the whole GISystem considering resources, data and work put into the project.

The huge site located in the centre of the Carpathian Basin gives a perfect opportunity to put the elements of the above mentioned theory into practice. During the excavation of the one hundred-hectare territory of the Solt-Tételhegy we aim to develop the most modern archaeological geo-information database: starting from the marking out of the base-points, defined by GPS, through the digital processing of the photographs and drawings taken during the work, we use different technical achievements to make the complex process easier. For these we are going to give several examples, and among others we are going to show the steps of incorporating the results of geophysical (magnetic) surveys into the geo-information system.

As for the first results: during the first three years (2005–2007) of the excavation work, which has been planned for decades, we have opened almost a hundred graves of an 11–12th century row grave cemetery, and the sanctuary and sacristy of a Gothic church – together with the burial places around the church. The most important professional moment of the excavation was the cutting through of the wide ditch surrounding Temple Hill, by which it was possible to prove that the origins of the fortification (surrounded by multiple ramparts and ditches) go back to prehistoric times, and it can be connected to the Late Bronze Age Urnfield culture. The defences which were subsequently destroyed were renewed several times during the Middle Ages, and in the end of the 13th and beginning of the 14th century buildings of a settlement were erected on top of the ramparts which were by then worn down.

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Pressed towards new approaches: A Late Sarmatian pottery centre at Üllő (Motorway M0)

(short paper)

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MOLNÁR, Ferenc – NAGY, Béla – PÁNCZÉL, Szilamér – PÉTERDI, Bálint³ – SZILÁGYI, Vera

Keywords: Sarmatian, pottery workshop, GIS, interdisciplinary methods

In the course of the rescue excavations preceding the construction works of Motorway M0 encircling Budapest, a part of an outstandingly large Sarmatian settlement was unearthed. The extreme dimensions of the site (400,000 sq.m), the number of features (more than 8,000) and the huge amount of find material (more than 1 million of potsherds) demanded a completely new approach, first in the field methods and now in the course of processing the collected data. The speciality of the site situated near Üllő (the close vicinity of Budapest) is that the largest ever Sarmatian pottery workshop (with 47 kilns) was excavated here. In the Late Roman Age the highly specialised ceramic centre was producing gritty ware found at the site in an enormous quantity. However, the more or less homogenous find material is not sufficient to serve as the base of inner chronology of the settlement. We are able to make a more sophisticated dating only on the basis of field observations.

The processing of field records required the construction of a database containing the description of the features and that of the inventoried material. The categories of the database were defined according to the peculiarities of the site. Already in the process of fieldwork (which lasted for almost 5 years), we have started to create the digital data management system, which determined the organisation of field records. This database is now in the process of connecting it with GIS. The latter gives us an opportunity for the spatial and functional analysis of the settlement with a special emphasis on potters' activity.

In order to make our results accessible we prepare a printed volume of the main results supported by an on-line digital publication. This work is feasible only with a well-coordinated team, consisting of several specialists of archaeology and different sciences. The analysis of the Sarmatian pottery forms, representing the majority of the find material, is completed by the study of Roman articles supplying a firm basis for the chronology and history of pottery production at the site. The study of ceramic and metal work technologies, results of geology and archaeozoology, collected together and combined with the advantages of GIS, support the functional and chronological distinction of the spatial units of the site.

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On the cooperation of GIS and archaeology in the Szabolcs-Szatmár-Bereg County section of Motorway M3 (Northeast Hungary)

(short paper)

VESZPRÉMI, László – ISTVÁNOVITS, Eszter – ALMÁSSY, Katalin

Keywords: large-scale rescue excavations, onsite data recording, digital documentation, ITR, GIS

In 2004–2005 an intensive archaeological research took place in Szabolcs-Szatmár-Bereg County, at a total of 38.7 km long section of Motorway M3 and the bypass-road east of Nyíregyháza. Preceding the excavations and in the course of the fieldwork, in the Jósa András Museum we have built a record centre including GIS. It was formed as a result of a close cooperation between the geodesist-GIS specialist and the archaeologists.

In the course of the fieldwork we chose a square network or axis survey according to the conditions of the site. The former is shown here in the case of site 161, the latter in the case of site 181.

For the processing of geodesic data we used the ITR system: geodesic interactive mapping program. For the GIS processing we have chosen the ArcView software. It proved to be useful, first because of the relative quickness of digitalisation, and second because the program could be easily and effectively learned. Another important aspect was represented by the compatibility of the GIS with the database software (Ariadne) that was in use for a long time at our museum.

From the point of view of data processing, it proved to be very useful – mainly in the case of the cemeteries – to make height measurement in the field. Maps with highly dense contour lines were made on the basis of these measurements. This can be well combined with aerial photographs taken at an almost ortophoto level.

Experiences collected at the motorway works have been continuously used at large-scale excavations conducted since then. This is shown on the basis of the assemblage of a cemetery and settlement from the Migration Period, excavated at the site of Tiszavasvári (territory of Wienerberger Brick Factory).

It's not all academic: The Prescott Street excavation – a case study from the commercial sector

(short paper)

HUNT, Guy

Keywords: database, GIS, excavation recording techniques, data management, online dissemination, ARK

Excavations at Prescott Street, a Roman cemetery site in London, are providing an interesting test bed for L – P : Archaeology's ARK (Archaeological Recording Kit) system. Data from the project are online and available to the general public at www.lparchaeology.com/prescot. This website includes both the raw archaeological data and a wealth of interpretive texts, images and other resources. L – P : Archaeology have designed ARK to work in a wide variety of archaeological situations, but it was always intended that this system should serve L – P's own commercial (CRM-based) excavation requirements (such as maximum efficiency from fieldwork to the production of final reports, public outreach and participation). Whilst some academic research projects have embraced the idea of dissemination of data online, this type of approach is very rare in the UK commercial archaeology sector. This paper sets out some of the experience gained during the project and highlights some of the problems as well as the benefits of this approach. The paper also examines the reasons why this type of approach has not been widely adopted in the commercial sector. Finally, it investigates the issues for the long term archiving of resources such as this.

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Evaluating the archaeological potential of soil in urban context

(long paper)

LAURENT, Amélie

Keywords: urban archaeology, potential archaeological soil, evaluation, spatial analyst, geotechnic, geostatistic

Knowing the extent and thickness of cities' archaeological soil is crucial information in order to assess scientific knowledge, to value the intensity and use of the soil and to define strategies for research. Moreover, it is necessary to develop assessment methods suitable for the present heritage policy, aiming both at scientific and financial profitability.

This paper presents the results of a doctoral research. This thesis aims at answering historical questions regarding cities, by assessing the informative potential of data available to archaeologists. It consists of grasping the means of formation of the urban space and socio-spatial elements, through the characteristics of the urban soil, resulting from human activities. More specifically, the analysis focused on assessing the thickness of the volume of the urban soil and its division into distinct functional layers, in the city of Tours and sites of comparison.

The crossroads between the vision of the archaeologists and that of the geotechnician enables the setting up of models on the production of stratification (maps charting the thickness of the archaeological deposit) and methods to model the heterogeneity of the deposit. Results have revealed that a theoretical 100-m² grid is enough to understand variations in the thickness of the deposit. Vertically, the scale of analysis necessary to distinguish the so-called “homogeneous” zones is roughly 10–25 cm.

On the scale of a site, an archaeological-mechanical referential frame has been established for sites in Tours and Lyons. The study shows that the use of the PANDA penetrometer is capable of improving the characterization of the archaeological deposit. The elaboration of a common referential frame for a group of sites is, in the medium term, an issue which will allow the promotion of these advances.

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The outer yard of the medieval nunnery – Naantali Churchyard 2005–2007

(short paper)

UOTILA, Kari

Keywords: excavation, onsite digital documentation, 3D analysis, stratigraphy

In the spring of 2005 Muuritutkimus Lpc., an archaeological research company started a small-scale test excavation near the medieval church of Naantali. Soon it became clear that the site contained the outer yard of a medieval nunnery and the yard of a 16th–17th century rectory. In the summer of 2005, and later during 2006–2007, the area was excavated further to tune of some 300 m² and 80–100 m³ of cultural layers, and some 500 m² more cultural layers were documented. In Finland the excavation was one of the most extensive excavations of historical sites ever executed in one summer season. In the main excavation area ca. 3500–4000 pieces of animal bones (ca.1000–1500 in situ, altogether 400 kg) and hundreds of stratigraphical units were documented.

5–6 archaeologists (or students) were employed in the field group, all of whom could use a total station and with knowledge of the Harris matrix. The excavation (plans and sectors) was documented in the field by total station in 3D (3DWin-software) and transferred to a CAD-program together with find data for access. Harris matrix forms were filled mainly

manually, but digital recording was also tested (with tablet-PC). Pointcloud data is missing from the collected material.

Reports were made partly by CAD (drawings), Access (finds) and in Word (reports).

The scientific process and the analysis of the stratigraphy in 3D from all the excavation material will be transferred to a modelling software (AutoCad Civil and 3DMax). The modelling of the excavation units from total station measurements alone is very challenging, and to some extent the 3D data is collected from digital photos using photogrammetric methods.

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**The giant standing on soft clay legs:
Data-capturing, data-management, excavations and
protection of archaeological sites in Hungarian archaeology
in the first decade of the third millennium.**

(short paper)

VIRÁGOS Gábor

Doubtlessly, the archaeological profession arrived into the third millennium with new technologies and new methodologies. 3D documentation technologies (including the various laser scanners, LiDAR, or stereo-photogrammetry) represent a new generation of documentation systems. Similarly, the intentions to build up European, but at least national digital databases of archaeological sites do not represent the future any more. Countries and companies spend a lot of money, time and energy to develop, test and introduce new instruments, innovative technologies, systems, standards and protocols.

However, something is wrong or missing, at least in Hungary, because the whole picture remains fragmentary. We have perhaps the strongest cultural heritage legislation in Europe, approximately 150 million Euros were spent on archaeology in the last two decades, and the institutional system is also one of the most ancient and strongest on the continent. However, the country still does not have a working official database of archaeological sites, the use of high-tech instruments and generally the use of digital technology in data-capturing is rather accidental, the money spent on innovation is not effectively used, and the validity of the data (the results of an excavation) we intend to document with the most recent methods are often questionable. Therefore, the government decided in 2007 to establish a central organisation with the intention to create central power management (for man-power, innovation, standards, etc.). The presentation is going to summarise (in relation to the above aspects) the results of the first year of the Field Service for Cultural Heritage, which is now responsible for the excavations of the large investments (highway, water management or power-station constructions, industrial zones, shopping cities, etc.).

The infrastructure of the traditional manual system in documentation or in database creation is still very strong, it obviously tries to outlive any of the new methods, which intend – or at least seem to intend – to fundamentally change its practise, organisation, or system. Therefore, accepting a new methodology or a new technology is not simply a matter of fulfilling a technological prerequisite. The major question is whether a new attitude will emerge from the side of the heritage people to accept a new approach.

Mapping 38 years of excavation. The dissemination of vector-data from Elephantine, Egypt

(Short paper)

ZIEGLER, Stefan¹ – BRUHN, Kai-Christian²

Keywords: webGIS, AJAX, Java, Tomcat, WMS

The excavations of the German Archaeological Institute on Elephantine Island at the southern border of Egypt aim to fully explore the settlement's history from Prehistory to the Islamic era. The data collected during the past decades of research are widespread and heterogeneous and a lot of effort is spent to collect a set of common information on the results to enable future analysis on a consistent basis. As part of this process, all published plans of the project are under way of digitisation i.e. converted into digital vector-format. Meanwhile, careful consideration has been put on questions of archiving and dissemination of the data. One basic demand is to provide central access to and the possibility of manipulating the graphical information, including the facility to download data-sets for individual mapping (e.g. plans for publication). The Department for Geoinformatics of the canton Solothurn in Switzerland currently develops a Java-based open source solution for the distribution of vector-data collected in a webGISenvironment in pdf-format. In an adapted configuration it will serve the dissemination of the Elephantine vector data. The paper will focus on the technical details of two modules that allow the user to collect data in an AJAX-driven web front-end and a servlet in an Apache Tomcat environment to generate a pdf-file of the compiled data.

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**Mobile devices: Manage, organize and
share information from anywhere.
The example of the Great Thermal Baths of Villa Adriana**

(Short paper)

BATTINI, C.

Keywords: Cultural Heritage, Internet/Web, Archiving, Surveying

The paper presents an approach to efficiently increase the information of cultural heritage using system mobiles as pda or tablet pc. This work explains a method to take advantage of the use of this system mobile and one software of database, during the survey or study of cultural heritage. The study was conducted on the Great Thermal Baths of Villa Adriana.

In the last few years, a major shift has occurred in the number and capabilities of mobile devices. Improvements in processor speed, display quality and wireless networking make these devices useful for a wider range of tasks than ever before. Each year the gap between desktop and mobile devices continues to narrow. Mobile processor speed and network connectivity continue to improve, making web browsing on these devices a viable alternative to laptops. Previously, mobile web browsers required a special markup language, which added significant development time and effort to deploying web applications for mobile devices. Fortunately, mobile web browsers now use standard HTML and PHP. PHP is the most popular language for building data-driven web pages with over 25 million websites.

The system described aims at providing a web-based platform for collaboration and data sharing between specialists, planning agencies, citizens, and private entities. We describe the salient features to create a database that was developed by integrating Database and PHP language into a Web based client/server environment.

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Mobile data collection on the field: The RDArcheo application

(short paper)

MERICO, Davide – MANTEGARI, Glauco

Keywords: mobile technologies, survey, GPS, multimedia documentation

The availability of mobile technologies and the spreading of GPS for spatial data acquisition are rapidly changing the practices of archaeological documentation. In particular, in relation to the survey of large areas, several solutions have been developed during the last years, providing a good balance between accuracy and costeffectiveness.

Nowadays a lot of applications – e.g. databases and GIS, commonly used by archaeologist – can run on small yet powerful devices like palmtop computers. The main difficulty in using these applications is their general purpose nature, which makes it difficult to configure them for the specific needs of a research project. This process often ends up with an arrangement/workaround solution in contrast with some research needs, because a desired functionality is not available and/or difficult to implement.

Different interesting experiences in the field of mobile applications for archaeology have been carried out, from the adoption and partial configuration of existing applications to the development of specific softwares (see, for example, the Field Map project). These experiences show that some programming work is necessary to fit the possibilities offered by technology to the needs of archaeological research.

Starting from these considerations, the NOMADIS lab in the University of Milan Bicocca (<http://www.nomadis.unimib.it>), which focuses its research in the area of the applications, methodologies and technologies for mobility and navigation, started the development of an application for archaeological surveys, named RDArcheo, which was tested in two survey projects, on the island of Pantelleria (Italy) and in the Zeravshan Valley (Uzbekistan).

RDArcheo runs on palmtop computers with a Windowsbased OS and it is conceived as a special purpose data management system. The application allows collecting data on the field using some forms specifically developed for each project and to automatically associate, by means of a bluetooth GPS device, the geographical coordinates to each survey unit. Some other functionalities include the possibility to link audio notes and images to relevant elements of the dataset and synchronization facilities to easily download and update data in a central database on a desktop computer.

The paper aims at describing the framework of the application, its technical components and the results of the experiments in the field. Particular attention will be given to the discussion of the critical elements that we noticed using RDArcheo, such as the problems related to the hardware and to the software components as well as the adequacy of this application to archaeological research needs.

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Digital Pens and Paper – a high tech development of a familiar low tech recording tool

(short paper)

RAINS, Michael

Keywords: Digital Pens, Site Recording, Silchester, VERA, IADB

This paper will report on an experiment in the use of digital pens and paper for excavation recording during the 2007 season of excavations at Silchester Roman Town in Hampshire, England. This experiment was undertaken as part of the UK JISC funded VERA (Virtual Environments for Research in Archaeology) project, a joint project between the University of Reading, York Archaeological Trust and University College, London. One of a number of approaches to direct digital data gathering tested as part of the VERA project, digital pens and paper are a recent “high-tech” development of something which, from the users point of view, is reassuringly familiar and “low tech”. Topics covered in the paper will include a brief description of the technology of the digital pens and paper, their integration into the Silchester site recording methodology which has developed over many years (including questions of user acceptance), comparisons with other approaches to direct digital data recording (including questions of usability, reliability and cost), transfer of data from digital pens to the Integrated Archaeological Database (IADB) system used at Silchester, and issues surrounding the checking, validation and preservation of records created with the digital pens. The paper will conclude by outlining plans for further and expanded use of digital pens and paper during the 2008 and subsequent excavation seasons.

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Unresolved problems of large-surface excavations preceding linear track and green-field investments

(short paper)

KOCSIS, László

Keywords: large-scale rescue excavations, onsite date recording, digital documentation

Archaeologists working with spade and shovel could no longer keep the tempo with the powerful machinery of the constructors, therefore archaeological excavations themselves had to be realised on an industrial level.

Excavation technology in the last quarter of the 20th and the first decade of the 21st century had to break away from the refined technologies formed over decades. The so-called “archaeological excavations” remained only a mere name, in reality, “excavation technicians” are performing the soulless “rescue work” degraded to the level of semi-skilled routine following the machine-driven detachment of the productive soil layer. In this way the heavy-duty machines set the area free of the mould and archaeological layers confine activities to open up and document only the features deepened into the subsoil.

This approach leads to the falsification of history and is practically destroying the sites themselves.

One of the possible solutions to this problem is to give more emphasis to preparatory work preceding the archaeological excavations proper.

It is suggested, though, that by a better and more conscious application of existing equipment and techniques the professional level of excavations can be essentially raised, new methods and equipment could be developed and archaeological scientific activity could be restored to its proper course.

The preventive excavations at Tiszagyenda between 2006–2007 can be regarded as a case study for resolving this problem: prior to excavations, besides traditional archaeological preparations (field surveys), the above techniques – aerial and spatial photography, magnetic measurements – were used and evaluated as a test of the hypothesis.

The author is presenting a case study concerning the application of various GIS methods for the large surface excavations conducted by the Hungarian National Museum around the village Tiszagyenda, using:

- spatial and aerial photography to identify archaeological features along the track
- geophysical survey data to assess site intensity
- GIS based mapping used for the archaeological excavation

Hungarian National Museum

ARSOL: An archaeological data processing system

(short paper)

HUSI, Philippe – RODIER, Xavier

Keywords: site records, stratigraphy, pottery, processing data, spatialisation

The ArSol system (for Soil Archives) has been developed since 1990 by the Laboratory “Archéologie et Territoires” (CNRS – Tours University) with the aim of processing archaeological data. It can be used for all stratigraphic excavations and has a double purpose of data management and research. It was built up as an open system that is flexible and above all not conditioned by the integration of a predefined thesaurus. The system client-server of ArSol is designed to integrate data from different sites. It includes two main components:

- The module *Archives of excavation*, based on the stratigraphic recording system used since 1970, concerns stratigraphic data and artefacts for site analysis. It offers tools for data management location and spatial analysis;
- The module *BaDoC*, a pottery database, can process the data according to different quantitative techniques independently of the diversity of the typological assemblages and of the scale of archaeological contexts. This database can be used to manage large quantities of pottery artefacts, but it has been developed primarily for research in this field. Results from queries made in the database are automatically exported into a spreadsheet in the form of data matrix, including all the information (positive values or null), a prerequisite for any statistical data modelling. This database allows the integration of external information, such as results of statistic model for dating, and exports other information such as dating of archaeological contexts from pottery.

The location of data stored in both modules, *Archives of excavation* and *BaDoC*, is based on a chain of acquiring and processing spatial information which associates stratigraphic data and digital survey in a Geographical Information System. The GIS is based on a link between software 4th Dimension™ and ArcGIS™ through an interface ODBC (Open Database Connectivity).

For excavation analysis, ArSol allows, for example, to consult all the information from cartographic data to establish plans automatically according to the chronology included in the stratigraphic database or to map the artefacts distribution.

ArSol is designed as a recording and data management research tool during excavation as well as an exploratory analysis data system during post excavation work. Finally the system makes possible rapid changes from intra-site to inter-site scales.

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The use of network analysis and the semantic web in archaeology: Current practice and future trends

(short paper)

ISAKSEN, Leif – MARTINEZ, K. – EARL, Graeme

Keywords: Network Analysis, Semantic Web, Roman ports, Western Mediterranean

This paper is a critical survey of two increasingly-applied fields of IT in order to establish in what manner they are being adopted and new avenues of potential, particularly with regard to multi-source projects. It is part of the initial groundwork for a Doctoral study exploring the relationship between Roman port sites in the Western Mediterranean and is intended to provoke discussion as well as identify key trends. The paper will look at

the theoretical bases underlying a number of projects that have used these approaches in recent years.

Networks are schematic renditions of connectivity between entities and there is a large body of mathematical theory which permits the description of nodes and links within the network as a whole. This provides a powerful mechanism by which to understand the importance of specific objects or locations with their broader context, as well a number of ways to describe the complete set. The paper will look at the different approaches taken in Evans et al. 2007 and Sindbaek 2007.

Semantic Web technologies are a major growth area in IT research. Their association with internet-based resources means that their principle adopter in cultural heritage has so far been the museum community but their utility in integrating heterogeneous data also make them ideal for research based on multiple excavations and it is in this context that they will be discussed. Particular focus will be given to Cripps et al. 2004.

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Digitization of archaeology – Is it worth while?

(short paper)

HOLMEN, Jon – ORE, Christian-Emil

Keywords: digital documentation, survey, Norway

The last 15 years the Unit for Digital Documentation at the University of Oslo has carried out a series of large scale digitizing and software development projects for archaeological museums. The objectives have been to improve access to and management of information about finds, excavations and archaeological surveys in Norway.

The list of projects comprises event based databases for topographical archives (presented at CAA and EAA in 1999), relational databases and XML-encoding of archaeological find catalogues and grey literature (presented at CAA 1996, CAA 2003 and CAA 2004), site and monuments registry for Norway, large image databases for finds, sites and a number of GIS based excavation projects. The databases are all CIDOC CRM (ISO21127) compatible.

The final projects were completed by the end of 2006 and all the different systems have been in use for at least one year and up to ten years. Have the intended users benefited and have the massive efforts been worth while? To answer these questions we have done a survey among a group of Norwegian archaeologists both in the museums and in the

national distributed archaeological authority in Norway. We asked them in what way these various databases and applications have influenced the way they work and if they think archaeology itself has benefited from this.

The preliminary results from a pilot of the main survey indicate that the tools are in use to a much greater degree than we expected, and the archaeologists are quite satisfied with them. One can also note that a simple web service with rock solid data like the site and monument registry for Western Norway published on the web 10 years ago can be of just as much importance as the highly sophisticated newer databases. The pilot also indicates essential obstacles of organisational nature lack of training, interconnection with external data resources and access rights. They must be solved to increase the value of the tools. The paper will present the result results of the full survey.

Unit for digital documentation, University of Oslo



**TOWARDS A TOTAL ARCHAEOLOGICAL
RECORD: HIGH PRECISION SURVEY AND
INTEGRATED ARCHAEOLOGICAL RECORDING**

APRIL 4-5, FRIDAY – SATURDAY

TOWARDS A TOTAL ARCHAEOLOGICAL RECORD: HIGH PRECISION SURVEY AND INTEGRATED ARCHAEOLOGICAL RECORDING

Chair: CAVERS, Graeme

Over the past ten years, advances in technologies for high-precision survey have pushed the boundaries of what is possible in terms of archaeological recording, while simultaneously bringing these technologies into the range of archaeological project budgets. Increasingly, there is an emphasis on the need for a 'total record', and high precision, high-data volume techniques such as 3D laser scanning are specified as a recording methodology on more and more projects. Furthermore, the software and hardware for the production of fully integrated archaeological databases on-site is increasingly widespread. However, despite this move towards detailed digital recording, specifications of high-precision surveys are still poorly defined and highly variable across the profession, and while advances have been made in standardising practice in laser scanning and other techniques, the research design behind many high-precision surveys is vague. While analysis of methodology is important, it is equally essential to be critical of the purpose of archaeological recording techniques. This session aims to explore both the philosophy and the methodology of high precision survey in archaeological recording, considering the following key issues:

Methodologies:

Methodologies for linking archaeological information and 'objective' datasets such as pointclouds, Extracting interpreted records from 'objective' datasets, Survey, excavation, interpretation and GIS- the integration of 'objective' records and the compilation of interrogable digital archives, Practicalities: The integration of laser scan survey and GIS- practical issues, Issues arising from the introduction of integrated on-site recording: the view from rescue archaeology, Problems of translating and integrating data formats, Philosophy: The responsibility to aim for the most complete record possible, The paradigm shift from paper to integrated database, The impact on the archaeological process: interpretation versus the 'total record'

Papers are invited that present case studies making use of high-precision recording techniques, discussions of the methodologies of high-precision recording for archaeology and practical issues arising from their implementation, as well as wider discussions of the philosophy behind the endeavour for a 'total archaeological record'

**Towards a total archaeological record:
Terrestrial laser scanning and archaeological recording at
Keiss, Caithness, Scotland**

(short paper)

CAVERS, Graeme

Keywords: onsite digital recording, terrestrial laser scanning, GPS, total station

Developments in terrestrial laser scanning technology over the last decade have allowed high precision survey techniques to become much more commonplace in archaeological fieldwork than has ever previously been the case. These new techniques have led to a radical shift in what is possible in terms of detailed recording, and archaeological records are now much more easily integrated with 3-dimensional models of physical remains. The progression in technology is not free from difficulties, however, and the full integration of archaeological data raises theoretical as well as practical issues that must be addressed as part of a new paradigm in archaeological recording standards.

This paper explores some of these issues, based on recent archaeological work in Caithness, northern Scotland, involving terrain modelling, narrative topographic survey and excavation recording. The methodology of constructing a detailed geodatabase is scrutinised, as are the challenges surrounding the integration of multiple data sources including laser scanned point clouds, GPS and total station data, and traditional records. This illustration provides the basis for an examination of the aims and standards of archaeological recording that should now be expected, as well as for a critique of taking an integrated approach to digital recording in field archaeology.

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**Digging deeper: Moving beyond the surface paradigm in
stratigraphic recording**

(short paper)

CARVER, Geoff

Keywords: stratigraphy, documentation, visualisation

Since strata have traditionally been conceived in terms of being chronological units, archaeologists have usually tended to document surfaces – Harris’s “interfaces,” derived from Hutton’s “unconformities” – as layer boundaries on profile drawings or as Single

Context Plans. This was justified, in part, on the basis of widely-held assumptions that the surface of any given stratum indicated its interior: assumptions that are not supported by geoarchaeological “reality.” Recent contextual studies now place more emphasis on recording evidence of site formation processes and the distribution of artifacts and other items *within* individual strata, despite the fact that field recording techniques (reflecting both recording technology and excavation methods) have changed little over the past 150 years or so.

This paper presents the results of an experiment in recording archaeological strata not as surfaces but as volumes, and considers means for dealing with problems of visualisation and analysis when working with models of complex stratigraphy.

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Terrestrial laser scanning is an expensive technology with some serious limitations. Does balloon-based digital photogrammetry offer a low cost alternative in recording excavations?

(long paper)

CORNS, A. – SHAW, R.

Keywords: Laser scanning, digital photogrammetry, helium balloon, orthoimage, DEM, low-cost, aerial photography, excavation

At the CAA conference in Berlin in 2007 the Discovery Programme presented a paper on the application of terrestrial laser scanning to the recording process of an archaeological excavation. Although successfully implemented over a full excavation season, we identified a number of weaknesses in the end product which we wanted to resolve. Of particular concern was the poor quality of the derived orthoimages - our basic visual archaeological record, which resulted from the low resolution of the integrated camera. This problem was most apparent in situations where features were defined by subtle changes in texture and colour, a common scenario in archaeology.

The search for a solution led us to consider the potential of using a low-cost PC based photogrammetric system. In these systems images are taken using inexpensive non-metric cameras and processed in the software to generate DEM's and orthoimages from overlapping image pairs. For excavation recording we needed to capture our images looking down on the site from above and the solution to this was found by using a helium kite/balloon as a low level aerial platform from which to mount our camera.

This paper describes the practicalities encountered in operating such a system and uses comparative data from our excavation to examine the pros and cons of the laser scanning

and digital photogrammetry. How do they compare in positional accuracy and resolution? How do the data-capture and processing times compare? What are the equipment costs and training requirements?

Our research ultimately addresses the question as to how these technologies relate to each other. Are they competing or complimentary approaches to the recording process?

Villa Adriana in Tivoli: Four years of digital surveys and research growth

(short paper)

VERDIANI, Giorgio – TIOLI, Francesco

Keywords: archaeological survey, digital recording, Villa Adriana, Tivoli, Italy

Starting from 2004 the survey laboratory of the “Dipartimento di Progettazione dell’Architettura di Firenze” has planned and acted a series of digital survey activities in one of the beautiful archaeological monuments in Italy, the Emperor Adriano’s Villa in Tivoli, the “Villa Adriana” site. In this paper, we are going to present the works done in these years, the results obtained and the path that our research is following, combining scholarly studies with student theses, Ph.D. dissertations and research projects. All is based on the digital survey as the first step to investigate the archaeological monument and to create its accurate digital representation. In this way all the data post processing, all the analysis and all the graphical developments will be made having as a reference one of the most accurate surveys ever made on those monuments, and can be made far from the monument. This massive data gathering allows replicating in a digital space all the details and all the geometrical characteristics of the real object, producing a descriptive model as never seen before. All the research and all the work done in these years are now getting reshaped in a more clear workflow, where step by step our massive data gathering becomes geometrical analysis, historical investigations, landscape studies, the basis to plan a new project for the museum design, the basis to verify hypothesis and a starting point for a new and more accurate survey of architectural details and archaeological finds. All is based on the digital survey operated using Laserscan from Leica, Faro, Nextengine, Minolta, but all those surveys are linked to a solid topographical network, which has been structured year by year allowing to correlate all the single surveys to a single digital model. At this time the survey (complete or partial) of the “Grandi Terme”, “Cento Camerelle”, “Grande Vestibolo”, “Piccole Terme”, “Palestra” and “Serapeo” are available and define the geometrical shapes of those monuments in the exact moment of their survey, in this way the surveys of the Villa become a strong point of reference to compare in time any changes in the shape of those monuments and to find better solutions for the restorations needed. The main workflow applied to this survey process as well the one applied to the data processing can be considered innovative for the use in the archaeological environment,

because it combines a complete system of digital tools to achieve research results without limiting the process to simple specific aims.

Facoltà di Architettura di Firenze, Dipartimento di Progettazione dell'Architettura

Short range photogrammetry and remote sensing application in the Celtiberian city of Segeda

(short paper)

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Keywords: Segeda, 3D laser, thermal imaging and short range photogrammetry

The extent, specific characteristics, and heterogeneity of the Celtiberian city of Segeda call for a broad-ranging exploration of the methods that can be applied to the identification and recording of Segeda's underground and exposed features. In order to achieve this, recordings were taken in the summer of 2007 throughout the site with the use of a 3D laser sensor, a photogrammetric short range camera, and a Thermacam thermal sensor. The goal is to corroborate whether the thermal anomalies recorded through spectral angle mapping are in fact indicative of physical structures.

The article discusses each of the sets of recordings and provides an overview of the methodology involved in the digital manipulation of the multi-source data which allowed us to confirm and/or reject the signals produced in previous surveys by the emission and reflective spectrum.

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Fusion of 3D data at Tiwanaku: An approach to spatial data integration

(short paper)

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Keywords: data integration, fusion, visualization, 3D

Between 2005 and 2007, a wide range of digital geospatial data were collected to document the pre-Columbian site of Tiwanaku, an actively excavated UNESCO World Heritage site on the Bolivian Altiplano. This paper summarizes the efforts of integrating geospatial data collected at Tiwanaku into a unified site model. Methods of data collection at this site include ground-based geophysics, terrestrial laser scanning, digital aerial photogrammetry, and total station surveys. In addition, existing sources of spatial information were collated and digitized. These data originate in various native formats, coordinate systems, and scales, and were collected during multiple epochs across several disciplines. Through geospatial data fusion, these data were co-referenced to a common coordinate system and converted to a universal file type for manipulation within a single software package. This integrated geospatial model functions as a single spatial database in which information gathered at Tiwanaku across the last century has been combined in a compatible and accessible manner. The importance of unifying these disparate data sources into an integrated three-dimensional environment is underscored by the increased information potential of a comprehensive site model. Furthermore, this method of data integration allows for future geospatial data collected at Tiwanaku to be readily assimilated into the model.

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Multi-scalar GIS at Merv, Turkmenistan: bringing it all together

(short paper)

BARTON, Justin – WORDSWORTH, Paul

Keywords: Laser scanning (high-definition survey), GIS, Islamic heritage

Since the designation of Merv, Turkmenistan as a UNESCO World Heritage Site in 1999, multiple archaeological projects have aimed to disentangle the complex heritage of this unique urban landscape. The cities of Merv demonstrate elements of a wide-range of cultures that subsumed Central Asia over the two millennia of their occupation, meanwhile displaying remarkable preservation. The main focus of recent studies, and indeed the target of this study, is the early Islamic city of Sultan Kala, occupied between the 8th century and Mongol siege in 1221AD. Currently the types of investigation underway include the excavation and documentation of several sample trenches, charting of the visible urban landscape through GIS, and high-definition 3D documentation (laser scanning) of the extant architecture within the archaeological park. The project now aims to integrate this data and previous work to form a complete and comprehensive record.

One of the major reasons we feel it is important to compile such a 'total record' is in the context of maintaining archival unity. As research standards become increasingly stringent in order to streamline the archiving and mass storage of data (in line with modern high-level commercial practice) archaeologists must demonstrate a high level of standardisation and structure to data management. Secondly, integrating a variety of data sets in a compatible environment affords a higher level of analytical interrogation. In Merv, this allows for isolated monuments (documented via high-definition survey) to become part of a wider landscape study (GIS), whilst facilitating detailed conservation studies and monitoring of erosion of the earthen remains. Ultimately, the Ancient Merv Project aims to educate and inform on a local, national, and international level, making the user interface an important part of the digital archaeological record. The immersive environment of 3D GIS has been proposed as an ideal platform.

However, there are several technical obstacles: data handling, processing, storage and management; making the system both useful *and* usable; and tackling the design differences between the ways data is captured (from pen-and-paper context records to point-cloud assimilation). At the forefront of Ancient Merv Project's research is providing information (accessible and useful) to both academic and non-specialist audiences, in term promoting discourse through dissemination. For Turkmenistan, a major challenge continues to be access to digital resources (such as the internet, which is virtually non-existent within the country), presenting a critical philosophical debate about data accessibility.

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High resolution airborne LiDAR for the recording of archaeological monuments

(short paper)

CORNS, A. – SHAW, R.

Keywords: LiDAR, High Resolution, 3D Modelling, Helicopter, DTM, Visualisation

Airborne LiDAR (Light detection and ranging) has been used effectively in the recording of landscapes and their associated archaeological features. The ability of LiDAR to penetrate through vegetation and record structures beneath the foliage is of great use to the archaeological surveyor. However, the resolution (70cm) and accuracy ($\pm 15\text{cm}$ in height, $\pm 30\text{cm}$ in plan) of the resultant surface models is limited by the sensor technology and the use of an aeroplane as the aerial platform. Subtle archaeological features are often missing or poorly defined. The introduction of the FLI-MAP 400 system: a helicopter based LiDAR system has for the first time allowed the aerial collection of height data at a resolution (10cm) and accuracy ($\pm 5\text{cm}$ in height, $\pm 8\text{cm}$ in plan) comparable with traditional ground based survey methods. This paper describes the application of this technology in the recording of archaeological monuments and their associated landscape context. Three sites in Ireland: Newtown Jerpoint deserted medieval settlement; Dún Ailinne pre-Christian hillfort and the Tara archaeological complex were surveyed. The subsequent data was processed to enable the production of two point cloud data models:

- digital surface model (DSM) representing the first laser return measurement
- digital terrain model (DTM) or 'bare earth' model displaying the landscape devoid of building and vegetation cover

A secondary stage of point data processing removes LiDAR 'noise' and enables the intelligent decimation of the model, necessary for the successful management of the extremely large data files. Utilising a combination of GIS, image processing and modelling software a 3D model of each of site was created forming a spatial framework for the detailed analysis and interpretation of the archaeological features. Finally this paper illustrates the different digital visualisation approaches used to view the final archaeological interpretations and 3D survey data.

Digital epigraphy and autopsy at the Tomb of Menna (TT69), Egypt

(short paper)

BRUHN, Kai-Christian

Keywords: high-resolution digital photography, digital documentation,
3D-referencing of images, Egypt

The Tomb of Menna Project (TT 69) is a sponsored project of Georgia State University (GSU), the American Research Center in Egypt (ARCE), the Egyptian Antiquities Conservation (EAC) Project with funding from USAID, working in collaboration with the University of Liège, the University of Ghent and the Centre de recherche et de restauration de musées de France (C2RMF) and the Supreme Council of Antiquities Egypt (SCA). The project aims to fully document and consolidate one of the finest painted, non-royal Egyptian tombs open to the public today, joining traditional methods of visual analysis with new digital and archaeometric methods (cf. <http://mennaproject.com/menna.html>). This collaborative approach required a recording of the tomb's architecture and its wall's decoration serving the different needs of the involved disciplines adapting restrictions in budget as well as in the working environment. The applied methods covered a full survey combined with high-resolution digital photography resulting in a virtual 1:1 copy of the tomb's architecture and decoration. The data acquired within three weeks fully comply with the requirements of the project (conservation, interpretation, publication) and were processed with a set of open source and proprietary software. The paper will present the technical details of the documentation process including survey, distortion and 3D-referencing of the images as well as the stitching of the photographs to a geometrically projected mosaic of the decoration. It will discuss other approaches on documenting Egyptian art digitally with a focus on how the "human factor" can be included into a computer based workflow. It will argue that a key feature of traditional documentation, the autopsy, needs to be considered very carefully when attempting a 'total archaeological record'.

digital-documentations.com, Heidelberg

Virtual 3D model of the antique temple construction in Sirwah (Republic of Yemen) for archaeological object documentation by terrestrial laser scanning and digital photogrammetry

(short paper)

KERSTEN, Thomas – LINDSTAEDT, Maren – MECHELKE, Klaus –
GÖTTING, Marcel – HEIDEN, René

Keywords: Laser scanning, digital photogrammetry, 3D GIS, texture mapping, interactive visualization

The geometrical 3D data acquisition of complex objects is usually carried out by a combination of photogrammetric multiple image procedures and geodetic measurements methods. However, today terrestrial laser scanners are increasingly available on the market and they are used as an efficient alternative to or in combination with geodetic and photogrammetric methods. By their fascinating characteristic to measure a very large number of 3D points within a short time period without point signalisation laser scanners offer a high potential for applications in architecture, cultural heritage and archaeology.

In a project co-operation with the Sana'a Branch of the Orient Department of the German Archaeological Institute (DAI) the antique temple construction in Sirwah (Republic of Yemen) was recorded by terrestrial laser scanning and digital architectural photogrammetry in February 2007. The data acquisition was carried out with the 3D laser scanning system Trimble GS101 and with the digital SLR camera Fuji FinePix S2 pro. A virtual 3D model of the antique temple construction in Sirwah was generated by triangulation of the 3D point cloud (3D mesh) with the program Raindrop Geomagic. Hence, the modelled data was textured and visualized with appropriate software (Geomagic V9, QT Sculptor, aSpect 3D). Furthermore, different aspects of 3D modelling and texture mapping are pointed out and analyzed. Additionally it was investigated to what extent the modelled data can be reduced by appropriate filtering techniques, in order to derive a geometrically and visually correct result of the virtual 3D model. For the quality control of the modelled data (3D triangulation with texture mapping) the oriented photogrammetric image data was used. The generated virtual model of the temple construction shall serve for the archaeologists as the basis for a future 3D GIS including interactive visualization. A time management of the individual work procedures was set up for the processing of the entire project, in order to be able to derive statements about economical aspects of the project. Furthermore, conclusions and recommendations will be given for further projects on 3D data acquisition for modelling and visualization of historical buildings with this procedure and with this technology, respectively.

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Kouris Valley Survey Project (Cyprus): Modeling methodologies, GIS and database on the bases of the local rules

(short paper)

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Keywords: GIS, remote sensing, quantitative methods, Database

KVSP involves different institutions, such as the Universities of Florence and Chieti, the laboratory of CAAM-Chieti, in collaboration with the local Institutions. The aim of the project is the intensive survey of the valley, in order to reconstruct the mechanisms of settling, the use of the local road network, the ancient landscape assessment and its changes and evolution from the Bronze Age to the classical period. However, the rules of the local Department of Antiquities do not allow to take away from the fields finds or samples to study them properly in the museum, except for very important finds. In this way it becomes extremely important to quantify the finds as well as to study or analyse them directly in the fields, making slower the process of the field survey. For this reason, before starting the project, it has been necessary to adapt our database, introducing new tables specifically created for the analysis of each find in real time directly *in situ*. Therefore, during the survey, together with the usual '**Field Recording Form**' (**I level of investigation**), each member of the team (walking by parallel lines), has to fill a '**Line Recording Form**' (**II level of investigation**), containing short information on the typology of the finds, and for the pottery also fabric, color of inner and external surfaces, dimensions, thickness, type of fragment and form of the vessel. Moreover, already at this stage, and still *in situ*, the main finds are then more widely documented with drawings, photos, microscope scanning of the fabric, and filling a new specific form for each find, that is the '**Relevant find recording form**' (**III level of investigation**), updating the GIS in real time. In case a site or scatter is found during the survey, a more intensive sampling strategy is used with a consequential new level of the database: the '**Site Recording Form**' (**IV level of investigation**). In this way, although the survey seems to be apparently slower than usual, recording the data in real time, the post processing phase of the research is shorter and the GIS improves simultaneously with the survey. The database is organized in separate tables, which are obviously strictly linked to each other. However, these choices have determined a more careful choice of the technical equipments also looking at their possible large electrical autonomy and technical versatility. Already during the first season, in 2007, the survey provided interesting results, coming from the typological and archaeometric study of the pottery as well as from the remote sensing of the HD satellite images, and from the preliminary geoprospections of specific sites, constituting simultaneously a multilayer GIS and giving the possibility of wider geostatistic analysis and interpretation of the data.

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GIS technology and CMS application in archaeology site management and research

(short paper)

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Keywords: Archaeological Field survey, Mobile GIS, Web GIS, CMS, site management

At 2007 CAA conference, we published a paper about the research work of Archeology GIS system by Mobile GIS, Web GIS and CMS, with the title is [GIS Technology and CMS Application in Archeology Field Investigation, Data Analysis and Information Display : Example of investigation]. This year, we have already built up this system, it can integrate processes of field survey, special data creation and analysis, information management and sharing.

The Archaeology GIS system includes three databases: site database, GIS vector and raster reference database, and Archaeological talent database. And The system contains below three parts:

1. Site in time and space Application of CMS, to build a powerful website which contains, edits and publishes diverse information and research on archeology. This system platform is provided to the Council for Cultural Affairs Taiwan(CCA) for sites management. There are lots of original forms for site management to be integrated into the site database. It also provides a space to discuss and share archeological methods, ideas, study and research. The Gmap and Gmarker function allows researchers to edit a site's spatial information on google map real time. It also can input and export site files (GIS format) through spatial database to site survey/supervisal work.
2. Archaeology survey system succeeds in combining the indispensable tools for field investigation, including Mobile device (TabletPC), high accuracy Differential GPS(DGPS), digital camera, and other recording devices. We refer to site field survey and supervisal work forms, then design electric forms for these works. Integrating these devices and electric forms to the Mobile GIS can help CCA's staff and archaeologists to record site information into electric forms correctly and efficiently. And these data will be saved by SHP files(GIS format).
3. Archaeology Web GIS through the rigorous plan and design of the metadata, the spatial databases are compiled the Web GIS retrieval system, combined with the abundant database materials, is constructed to display the intact archeology investigation results. The web GIS can display site place and the relationship with environment. It also can publish site locations and information to GoogleEarth. At the next research phase, we will refer these site data and develop a method to predict unknown site locations.

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The stone of the elephant, from the survey to the modelling

(short paper)

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Keywords: Sardinia, Italy, Digital survey, Laserscan, Modelling.

In the northern part of Sardinia, the main Italian island, near Castelsardo, there is a unique volcanic stoneⁱ: the natural forces worked on it giving to the stone a strange elephant shape; the ancient humans worked on it carving sepulchres for their deaths; in the contemporary age, after centuries when the monument was lost and forgotten, the works for a new road brought to light the stone. This monument is a mix of natural and architectonic events and it's a very interesting case study for any real surveyor because it has a shape almost impossible to survey with traditional measuring solutions. At the same time its strange and original shape gives no guarantees about the health status of this monument: if a small part should get lost it will not be easy to verify the real damage. Moreover the stone is now placed along a road and it's freely accessible night and day without any kind of surveillance; what will happen in case of a car crash or in case of some tourist with a hammer and bad intentions? A complete survey of the shape of the stone was neededⁱⁱ, so our survey laboratory decided to go there to produce a meaningful case study, facing the unsurveyable stone with contemporary laserscan technology and with our research experience. The work required only two days to be completed, producing an accurate laserscan survey integrated by a topographical networkⁱⁱⁱ. Here we present the first results of this work, where we define the real shape of this ancient monument in a specific moment, producing a useful archive which defines the definitive shape of the elephant stone at the beginning of the 21st century. starting from now any transformation can be clearly verified as well any complete study can be developed starting from a very accurate three dimension model.

Originally a volcanic stone rolled down the hill, bigger than all the others which populate that area.ⁱⁱ Until our survey operation on this monument, the existing surveys focused only on the horizontal and transversal sections of the carved tombs, no documentation about the whole shape was provided before our intervention.ⁱⁱⁱ The Survey team who operates in this mission was coordinated by prof. Giorgio Verdiani, the laserscan operators were Sergio Di Tondo, Federico Piras, Giovanni Guccini. The topographical survey was operated by Francesco Tioli. The digital modelling project was developed together with prof. Filippo Susca.

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The GIS background of archaeological fieldwalkings in less known areas

(short paper)

CZAJLIK, Zoltán¹ – HOLL, Balázs²

Even in countries where archaeological surveys have been quite extensive, it often happens that research in mountainous or isolated areas is lagging behind the study of areas more affected by large-scale investments and construction works. GIS plays a significant role in designing projects studying such areas, since it enables the most efficient use of available resources and the faster investigation of these zones.

This paper will present the most important GIS-related aspects of a project aimed at the study of prehistoric iron metallurgy in northeast Hungary, carried out in 2000-2002.

The creation of an appropriate topographic and hydrological reconstruction played an important role both in the implementation of the project design and the interpretation of the archaeological data. The high-resolution elevation model of the Szendrő Basin was complemented by a hydrological reconstruction created with a simulation program. We carried out floodplain analysis of the various rivers in the area and determined the maximum water level through the analysis of the location of known sites. Through the calculation of the depth of the riverbeds and the velocity of the water-flow we managed to delineate the areas suitable for human occupation and determine the possible locations of ancient fords and roads. During our survey we were able to verify prehistoric and early Roman Period occupation in all dry areas, often with the help of the presence of large amounts of iron slag.

The Szendrő Basin and its wider environment still show an archaic settlement pattern, consequently even before our research the medieval origin of most settlements could be assumed. Furthermore at Szalonna and Jósvalfő we were able to demonstrate that the hills observable of the elevation model formed the core of the prehistoric occupation of the given settlement. Based on these we can determine in other villages as well (e.g. in Szín) those areas where prehistoric occupation can be expected. It is obvious based on the hydrological data that occupation continuity in areas suitable for settlement is connected to the karstic character of the higher zones. As a consequence of the latter, areas with water sources, suitable for permanent human occupation could only be formed in the larger valleys. Even there it was important to withdraw as little area as possible from agricultural production, which is delimited even today towards the valleys because of the karstic character of the area.

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Primary experiences of using mobile GIS application in field survey, and integration into an archaeological GIS in Zala County, Hungary

(short paper)

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Keywords: Archaeological GIS, Mobile GIS, Data integration

The elaboration of a geographic information system ranging over a wide geographical unit has recently begun at our institution. This application is actually an information system processing archaeological sites based on topographic field surveys. Its goal is the up-to-date elaboration of every archaeological site in Zala County. Data recorded during field surveys constitute the basis for the system. In addition it contains sites discovered by other means (air photograph, excavation, old map) and can be completed by new information about the sites. The result is prompt and up-to-date data supply for archaeological impact studies, for the preparation of excavations preceding building projects as well as for scientific surveys.

Lately we use mobile GIS instruments in field survey. By these means data arranged and downloaded from the desktop earlier surveys can be checked and modified on the spot. Data in existing archaeological application are completed and corrected by geographically accurate data. The points of a newly discovered site (archaeological artefact, feature, edge of site) are recorded and descriptive as well map data are connected to the points and recorded in the survey-database.

The presentation also describes a site level GIS that contains all available data of an excavated site (coordinates, description of features, photo, drawings), the description and depiction of finds (register, photo and drawing of artefacts) as well as the results of scientific analysis. This system assists archaeological analysis. The advantage is that all data of the features can be accessed on one interface. Queries are visualised on result maps (periods,

types of features, finds). The systematic elaboration of sites enables comprehensive analytic investigations of different archaeological periods.

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Archaeological survey and GIS in Csongrád County (SE Hungary)

(short paper)

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Keywords: archaeological survey, GPS, GIS

The systematic archaeological survey of the territory of Hungary has been an official scientific project for more than 50 years. Its co-ordination is one of the main tasks of the Archaeological Institute of the Hungarian Academy of Sciences, founded in 1958, and so far 10 volumes of this have been published. In Csongrád County, the project has been carried out by the students and lecturers of the University of Szeged. By the late 1990s, it became necessary to organize the huge data set that had been accumulated and create a GIS database. The integration of the results of the increasingly intensive rescue work since 2003 posed further challenges. By the end of 2007, the database of the Hungarian CH Office contained 6905 sites from Csongrád County (5899 identified and 1006 unidentified), which makes it the largest such county (regional) database in Hungary. Last year a new software was developed in order to facilitate faster and more efficient orientation in the database, to improve the joint visualization of excavation data and the site gazetteer, to integrate the various types of data, and to map the sites of the database of the Hungarian CH Office. In the paper the authors will present the archaeological and software issues of the new development, the way it evolved, its present state and the future possibilities of its use and further development.

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Creation and application of archeological geoinformational system of Margiana

(short paper)

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Keywords: Merv oasis, geoinformational systems, Spatial Analyst, reconstruction of the dynamics of resettlement and irrigation system.

The work on fixing all the archaeological sites and creating an archaeological map of Merv oasis began in the 80s of the last century. The first phase of work had been completed by 1998, when the first volume of the Report was published [The archeological map of the Murghab Delta. Preliminary Reports 1990-95 / ed. by A. Gubaev, G. Koshelenko and M. Tosi. Roma, 1998]. The Report introduced about 1000 sites from all the periods: from the Early Bronze to the Late Middle Ages. The list of sites included the site's exact location (determined with the help of GPS system), size, shape, timestamp derived from the collection of ascensional material. Further work on this project comprised: 1) expanding the zone of studies; 2) clarification of all the insufficiently ascertained features of sites included in the "general list"; 3) the creation of problem-oriented GIS for archaeological sites of Merv oasis; 4) reconstruction of the dynamics of resettlement and irrigation system.

In the course of the work on the project an electronic database of archeological sites of Merv oasis of three historical periods (Hellenistic, Parthian and Sasanids) was created. GIS geo-basis was established consisting of topographic map mosaics, as well as aerial photograph mosaics, partially covering the southern part of the oasis.

A total of 221 archeological sites of Merv oasis were mapped. As part of the GIS mapping two layers (shape-files) of sites were created: of area (polygonal), and pinpoint types, to create further opportunities in the spatial analysis of different types of tasks. Furthermore, all the archaeological material on some of these sites was included in the database. The principle of the sites selection for filling the database, in addition to topographical and geographical also with archaeological material was defined by the objectives of the project: the ultimate refinement of the methodology of creating the base that would combine two categories of information. To do so, „master” sites of different types were selected. The database comprised: the body, constituted of the archaeological description of the site, its historical interpretation, a complete bibliography, as well as graphic material (archaeological plans of the site, location of the excavation, plans and sectional drawings of the excavations, reproduction of the most typical finds). The data of research results on the basis of GIS-technologies were compared to the source book data (in particular, Claudius Ptolemy).

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**APPLICATION OF ACCEPTED STANDARDS IN
DATA MANAGEMENT**

APRIL 4, FRIDAY

APPLICATION OF ACCEPTED STANDARDS IN DATA MANAGEMENT

Chair: LANGE, Guus

Computer applications in archaeological pottery: A review and new perspectives

(short paper)

MARTÍNEZ-CARRILLO, Ana

Keywords: Archaeological pottery, review, methodology

In the previous years many publications about computer applications in the field of drawing, classification and analysis of archaeological pottery have been presented in different congresses by different researches.

This paper will review and analyze the most relevant works published up to now. It will focus on computer applications which oriented towards the graphical visualization and analysis of data relevant to archaeological pottery.

The intention is to order and systematize the previously mentioned pottery data and to review those publications relevant to archaeological computerized systems. This review and analysis will introduce the methodology that it is used in the CATA project (Archaeological Wheel Pottery of Andalusia in its acronyms in Spanish). The procedures used in the CATA project for the representation, archiving, analysis and retrieval of data concerning pottery vessels and their fragments.

The main aim of the CATA project is to provide a scientific tool for the analysis of pottery findings in the geographical area of oriental Andalusia. These findings will be introduced into a database with documental and graphical capabilities for visualizing pottery fragments and vessels. The objective is to create a general tool which can be applied to any kind of ceramics found in any geographical location.

The innovative part is the use of the above mentioned methodology as applied to the archaeological research of pottery.

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Digital archiving at the Archaeology Data Service: A quest for OAIS compliance

(short paper)

MITCHAM, Jenny

Keywords: Digital archiving, Archaeology, practical case study,
Open Archival Information System (OAIS)

The importance of secure digital archiving of archaeological data can not be underestimated. This is particularly the case where the archaeological data in question can not be recreated because a site has been lost through the very process of excavation. Since it was first set up in 1996, the Archaeology Data Service (ADS) has been archiving and preserving archaeological data for the benefit of current and future researchers. However, in the wider world of digital preservation a number of new initiatives have emerged that we needed to investigate in order to be sure that we are doing the job to the best of our abilities. One of these initiatives is the Open Archival Information System (OAIS). This is a framework and reference model that all archives can use to ensure that the right basic activities and data flows are occurring as part of their preservation work. It also gives us a language and set of terminologies that different archives can use to communicate to each other. At the ADS, we have spent some time looking at the OAIS model and mapping our activities to it to establish whether we can call ourselves OAIS compliant or not. This presentation will describe some of the things that an archive needs to do in order to meet with the OAIS model and how our staff and day-to-day activities map to it.

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From paper to online database: Access and long-term preservation of archaeological information

(short paper)

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Keywords: database, digital archive, online access, preservation

The Archaeological Repertory of Romania (RAR) was created by the „Vasile Pârvan” Institute of Archaeology in Bucharest between 1949 and 1956. The Repertory is an important collection of paper cards, arranged topographically, recording any mention of archaeological discoveries in the literature back to the 19th century.

CIMEC The Institute for Cultural Memory in Bucharest offered to digitise the archive in 2001 and make it available to researchers on the Internet, with the funding and encouragement through the European project ARENA, under the Culture 2000 Programme. The equipment, software, technical assistance and scanning was provided by CIMEC with financial assistance from the Ministry of Culture and Religious Affairs.

We performed the digitisation of half of the archive between 2001 and 2006 and published the database online in 2007 (<http://www.cimec.ro/scripts/ARH/RARIndex/sel.asp?Lang=EN&>). We created a searchable digital resource with a user friendly interface, in Romanian and English, for searching, browsing, zooming and printing. The project site provides a search index on location, period and site type (for 8,887 entries from 4,708 localities), and each digitised card (2,565 cards in total) can be seen online. A future portal will allow searching both the digitised archive and the current National Archaeological Record Database as well as the localisation of the sites on the digital map of Romania (<http://map.cimec.ro>).

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Cross-border data sharing: A case study in interoperability and Web services

(short paper)

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Keywords: heritage data, online datasets, cross-search, web service

Releasing heritage information online is to be encouraged but it is important that any project contemplating this should also look into the issues of access to their data. There are vast amounts of heritage data available online in a format which has very little use for researchers who would like to reuse or interrogate the datasets. XML is one way to provide a solution to this and Web Services furthermore allows users to create their own aggregated searches across a number of online datasets. This paper discusses an attempt to develop a deep portal which accesses the Swedish Sites and Monuments Record (FMIS) and the ARK system developed by L - P : Archaeology through web services. A simple Web Service was written for the ARK system which was set up to serve data from any ARK dataset. The portal accesses the FMIS and ARK web service and re-maps the XML output to Midas standard formatted XML and combines them into one resultset. This allows the portal to facilitate a cross-search of the two datasets and return the data as one combined Midas formatted XML file. The paper presents the successful parts of the approach as well as the potential pitfalls. It illustrates the ease of developing a webservice and discusses the use of ARK as a tool for outputting data from various sources in many different schemata.

On whose authority? Interpretation, narrative, and fragmentation in digital publishing

(short paper)

RABINOWITZ, Adam¹ – SEDIKOVA, Larissa²

Keywords: digital publishing; authority; interpretation; dissemination; Chersonesos

This paper uses case-studies to explore the tension between authority, interpretation, and data dissemination in current archaeological publication. Digital technologies have irrevocably changed the way we conduct archaeological research. The tools we use in the field generate an exponentially larger quantity of primary data, much of it only in digital form. At the same time, web-based interfaces make it possible to present these data easily and contextually to a vast audience. These developments are reflected in discipline-wide discussions about field methods and in the proliferation of archaeological data and gray literature on the web. Some projects now post data and pre-publication work in real time, so that the scholarly community can have access to important material that would otherwise wait years for final publication. This is in keeping with a broader movement toward wikis, user-generated content, and the sharing of draft-stage written work among knowledge communities. These trends are further spurred by the growth of rescue and contract archaeology, in which the prompt presentation of data is often more important than the generation of an authoritative scholarly monograph. Yet academic expectations still focus on synthetic interpretation by recognized authorities, and publishing houses prioritize narrative even to the exclusion of the data. And in many parts of the world, scholars base their reputations on the creation of the most compelling, authoritative, and incontrovertible picture of a certain past -- which can actively discourage the publication of the primary evidence. As a result, there is an increasing divide between data and narrative, and while the latter is evaluated by the traditional system of print publication, few strategies for the peer review of the former have emerged. Moreover, the archaeological community is divided in its view of the authoritative voice, whether that of excavation director or specialist. Some feel that a more distributed system of interpretation is desirable, while others insist on the primacy of one or two thinkers in the organization and explanation of the data. How, then, should we reintegrate data and narrative, and what systems will evaluate the authority of the result? How do we define an authoritative voice while still leaving room for the reuse and reinterpretation of primary data? To what extent can users understand data without authoritative interpretation? This paper examines these problems in the context of selected digital publications, and discusses their role in our decisions about the publication of excavations at Chersonesos (Crimea, Ukraine).

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Setting a standard for the exchange of archaeological data in the Netherlands

(short paper)

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Keywords: archaeological heritage management, archaeological fieldwork, data exchange, data standards, XML

Over the past ten years, the introduction and growth of a commercial market for archaeology has enormously increased the amount of archaeological fieldwork done in the Netherlands. This is combined with an increased use of digital techniques to record, store and analyse excavation and survey data. The result has been a proliferation of data formats: the various companies doing archaeological fieldwork all have developed their own databases and GIS/CAD-systems for daily use. Because of this, a national (and obligatory) generic standard for archaeological data storage was introduced in 2007 that allows data collectors freedom in designing their own database structures, while maintaining minimum quality norms for the way in which archaeological data are registered and stored. However, this standard does not yet solve the problems of data exchange between archaeological companies, heritage managers and non-archaeological parties. In practice, getting to use someone else's data implies mapping the fields and codes used to one's own system. This is a time-consuming exercise, which has to be repeated each time a different data set is imported. Even then, data that cannot be adequately translated may be lost in the process. To remedy this problem, a working, XML-based national exchange format was already developed for soil data by SIKB (the Dutch organisation responsible for the development and implementation of quality standards in soil management and archaeological fieldwork). SIKB therefore decided to extend this initiative and investigate the possibilities of such a standard for archaeological data as well. In this paper, we will sketch the potential of exchange standards for three main categories of data: borehole data, finds that are submitted for storage in repositories, and the national sites and monuments records (Archis). It is concluded that the development of exchange formats is relatively easy from a technical point of view, and will solve a lot of the issues mentioned above, but it will need a nationally accepted organisational structure that ensures the implementation and management of the standards.

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ACIS: A collaborative hypermedia geospatial community information system of Afghan monuments and sites

(short paper)

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JANSEN, Michael¹ – JARKE, Matthias²

Keywords: Metadata, Interoperability, Web 2.0, Social Software, GIS

In the past several years, the World Wide Web has experienced a new era, in which diverse user communities are greatly involved in the production of digital content. Such Community information systems have been highlighted with the emerging term “Social Software” and Web 2.0. They are characterized by the massive use of multimedia of different types and they allow free association of terms to be added to content descriptors regardless of taxonomy rules deriving from specific thesauri or metadata vocabularies. However, the semantics of the multimedia contents in community communication and collaboration is hard to capture and complex to compute. The potential of these techniques for the heritage preservation sector has been explored in ACIS (Afghan Monuments and Sites Community Information System). ACIS has been deployed for a GIS project for the management of cultural heritage in Afghanistan. It is designed to assist collaborative heritage management for communities of practise in the field of cultural heritage preservation. It is being used to support the efforts of a geographically dispersed international expert community active for the preservation of the World Heritage Site in the Bamiyan valley by making use of geospatial data on historic monuments and enriched with diverse multimedia content. ACIS addresses users from three sectors: the Government and administration sector such as the Ministry of Information, Culture and Tourism, of Afghanistan, Research sector such as students and lecturers of different majors, and Preservation sector such as engineers and scientists in the cultural heritage conservation field. The concept of a community of practice could provide diverse user communities communication channels for an intra-generational and intergenerational, as well as intra- and interdisciplinary cooperation. It is composed of a Map Server based on ORACLE 10i Spatial Database containing specific site information on historic sites combined with diverse multimedia items (maps, photographs, videos). A Lightweight Application Server (LAS) developed at the Chair of Informatics provides a web-based Service Oriented Architecture for various MPEG-7 services such as a high-level annotation tool for arbitrary images or videos as well as server side media adaptation for different end user devices on the client side in order to ensure full support for mobile environments. The use of MPEG-7 combined with MPEG-21 standards for personalized content adaptation will ensure context as well as semantic interoperability between metadata domains in the future. The use of diverse mapping services results in structured XML documents which comprise the various structured content description formats such as Dublin Core or CIDOC-CRM enriched by community derived “free” content annotation.

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What you give is what you get: Multitype querying for pottery

(short paper)

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Keywords: query by example, pottery retrieval, axis of rotation, rotational symmetry, tagging

Having information about findings stored digitally surely is an essential prerequisite for most archaeologists, since such information can be accessed quickly and hundreds of thousands of objects can be managed easily. However, we believe that there is more to computer support for archaeological research than database records or Excel sheets. Simply imagine an archaeologist somewhere in the outback, just having excavated something that he believes must be closely related to another region far away. In order to verify his assumption, he takes his mobile scanner to capture the object's 3d geometry, then sends this data to an internet based search engine to ask for similar objects found in the beforementioned region. Within seconds he will retrieve the results that his equipment is able to present him in 3d. Seriously, part of this vision is far from being real. Nevertheless, recent research in the fields of computer graphics and multimedia retrieval has built the fundamentals for such applications.

Our approach to such an application is the part where 3d objects may be provided as the input for a search engine for archaeological findings to retrieve similar objects. We chose pottery as the main subject for our system, since this is both meaningful for scientific conclusions and rather easy to analyze automatically. We set up a database, storing objects in terms of descriptors. Such a descriptor is a set of properties describing an object from a certain point of view, e.g. its geometric shape, ornaments at its surface, or physical properties. The way how these objects are represented digitally has the major advantage that it can be extended to other points of views that archaeologists might find interesting.

Searching pottery is being facilitated as follows. First, the user may enter some properties of the required vessel into a web form, which then are used by the search engine to match objects against. The result will be a ranked list that shows the user how well each object fits his demands. Second, the user may provide the 3d model of a reference object, optionally accompanied by descriptive terms, to gather similar pots. This query-by-example method automatically extracts shape features to be matched against the objects stored in the database. The results of these comparisons will be used to create a ranked list, that is finally presented to the user. As is common in most retrieval systems, objects to be stored or matched must be normalized beforehand, which we do by automatically aligning pottery to their axis of rotation by inspecting the strength of symmetries within the object.

The overall goal of our approach is both to support different types of queries – be this plain text, 3d reference models, or other media like images – and to offer strong search

results by exploiting different points of views (descriptors) onto the objects stored in the database.

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BIOARCHAEOLOGY AND TECHNOLOGY

APRIL 5, SATURDAY

BIOARCHAEOLOGY AND TECHNOLOGY

Chair: BARTOSIEWICZ, László

This session will explore the use of technology for the recording, analysis and interpretation of all aspects of bioarchaeological remains. Medical imaging of skeletal and mummified human remains has increased significantly as an analytical tool in bioarchaeology. Digital microscopy is enabling high-quality image analysis of all types of bioarchaeological remains including plants, animal and human bone, hair/fur and soft tissue. Virtual reality is used for analysis, interpretation and public communication.

This session welcomes papers related to all aspects of the use of digital technology for the recording, analysis, interpretation and presentation of all types of bioarchaeological remains.

Eliminating typology and its myths in bioarchaeology: Computer methods for achieving a true Darwinian science

(short paper)

ROVNER, Irwin

Keywords: bioarchaeology, computer-aided morphological typology

Conventional morphological typology, in spite of its long history in Bioarchaeology, is an obsolete, error-prone and unreliable methodology. It is a survival of anti-evolution 17th Century “Natural Philosophy” which assumed that species were immutable, divinely created in perfect repetitive form and design. Accordingly, individuals in a species conformed to a fixed and unvarying morphological type. In the 19th century Charles Darwin persuaded the scientific community of the reality of evolution based on the universal presence of individual morphological variation, not perfect design. Nevertheless, the obsolete morphological type concept continues to dominate analysis and identification of bioarchaeological remains.

The “morphotype” is inherently flawed, based primarily on: (1.) subjective observer perception seeking an arbitrary, idealized construct by reducing or ignoring Darwinian variation; or, (2.) an arbitrarily selected “type standard” individual whose morphology cannot ever be exactly duplicated in a Darwinian world. Measurements are restricted to length, width and thickness arbitrarily oriented on an X-Y(-Z) coordinate grid. This does not measure the real object itself, especially if it is irregular, but measures the “snug box” the object fits into.

Decades of development of computer-based morphometric programs now provide rapid and accurate measurement of complex morphological features (including size, shape, texture, tomography and fractals) of any shaped object (and groups of individual objects). The result is an opportunity to abandon subjective typology in favor of accurate, objective,

quantitative suites of measurements, i.e. a “Science”. Moreover, such a methodology does not obscure Darwinian variation but readily exposes it to critical scrutiny and analysis. Thus, it allows scientific study of the real biological world rather than an arbitrarily constructed fiction.

Initial morphometric analysis of selected bioarchaeological proxy systems, mostly botanical, has already demonstrated enormous superiority to conventional typology. For example many assumptions used in analysis of seed populations are suspect, if not simply wrong. Seed morphology is not narrowly varied and the distribution plots of size and shape are not “normal” (parametric). Mean (and modal) values are inconsistent between replicate populations and size is an unreliable indicator of wild versus domestic --an alternative method based on comparison of measured variation is offered. Typological analysis of plant microfossils in archaeology is particularly dubious. Types are often contrived lacking proposed taxonomic value resulting in the promulgation of inaccurate, as well as outright dishonest and fraudulent results in critical areas of archaeobotanical research.

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TOOLACE 1.0, a Microsoft Access based multidisciplinary application in bone tool researches

(short paper)

CSIPPÁN, Péter

Keywords: faunal analysis, bone tools, database

The programme Microsoft Access is a well-known database software around the world. With the help of this easy and flexible programme, it is easy to develop customized databases.

In 2005 René Kysely, archaeozoologist at the Archaeological Institute of the Czech Academy of Sciences in Prague, introduced an Access database for faunal analysis in the the Aquincum Museum, Budapest. This application gave us the basic idea for developing our own database with a special user interface to design an inventory and analyze modified animal bones.

The program TOOLACE 1.0 enables a systematic description of bone tools (both zoological and archaeological) and has two aims:

Initially, its typological content was based on the system of Jörg Schibler (1981) developed in Basel. So we built a program on the basis of an internationally known standard. At the same time a brand new visual inventory was made which integrates the zoological and technological data.

The basic idea and much advice originally come from Alice M. Choyke, who was the coordinator in the development of this system. Because the TOOLACE does not use a special basic software, everybody can access and/or expand the database around the world.

On the other hand, the use of this application is advantageous in broad-base analysis, since Schibler's original illustrated typology is included in the programme, therefore the program can be profitably used by non-specialists for collecting data. Therefore it is a useful tool in both researching and teaching a special group of biological materials with high cultural content. At the end of the analyses we get a database which combines the variables on technology and style with the indispensable zoological parameters.

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A new method for human evolutionary systematics based on virtual 3D analysis of first molars

(short paper)

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MALLEGNI, Francesco³ – PERSIANI, Franco² – GRUPPIONI, Giorgio¹

Keywords: teeth; reverse engineering; virtual anthropology; 3D orientation systems; morphometry

The taxonomic attribution of teeth in palaeoanthropology is difficult and often yields uncertain results. The traditional approach to dental morphometric analyses usually focuses on the recording of several measures of the tooth with calipers. However, since these measures do not adequately represent the complex morphology of the tooth, 2D images and 3D virtual models of the dental morphology have been used. For both, the possibility of correctly comparing homologous teeth depends on the adoption of a common orientation system. The lack of such a system makes it difficult to compare the results of different studies, rendering them of doubtful validity. Here we describe a new method for the taxonomic attribution of first molars. It consists in the definition of a standard system to orientate virtual models of the teeth, and a method of virtual morphometric analysis which is not invalidated by dental wear. The proposed orientation system, which meets a geometric criterion, is based on 3 points identified on the cervical line. The morphometric analysis of teeth oriented in this manner is based on virtual sections of the dental crown (for the first 4 mm) beginning from the cervical line. This method, tested by principal components analysis, correctly distinguished teeth belonging to different taxa and allowed us to classify two specimens of uncertain attribution. In addition to being based on an objective criterion of comparison, the method maintains its power of taxonomic discrimination even when the crown height is reduced to 3 mm by wear. In a broader perspective, with a larger sample of fossil hominid teeth, it will be possible to quantify the dental morphometric variability of

each species and to classify teeth of doubtful attribution. At the same time, this pilot study provides guidelines to extend the new methodology to the other types of teeth.

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Evaluating humeral bilateral asymmetry by means of a virtual 3D approach

(short paper)

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Keywords: Asymmetry, Humerus, Reverse Engineering, Morphometry

Bilateral asymmetry of the human postcranial skeleton, particularly of the long bones, is partly due to imbalanced biomechanical loading and the consequent bony remodelling of the contralateral homologous skeletal segments. These exogenous factors related to the mechanics of loading and movement are not the only ones involved in cases of bilateral asymmetry of the human skeleton. There are also endogenous factors, such as genetic influences. Most studies on postcranial bilateral asymmetry have dealt with upper limb bones since the effects are more evident in them than in other skeletal regions because of their independence of locomotor function.

The traditional approach to the quantification of morphological and morphometric differences between contralateral skeletal segments is to perform measurements directly on the bones. However, these measurements are often limited to the length of the bone and diaphyseal diameters and circumferences. Hence, they do not allow assessment of the areas of muscle insertions, where the greatest modifications of the cortical surface occur due to the mechanical loading regime. Moreover, the resulting data are subject to errors, due to the limits of precision of the instrument used (calipers, osteometric board, metric measuring wheel, etc.) and to the observer, which can compromise the reliability of the results.

The present note describes a new methodology for a more accurate evaluation of bilateral asymmetry of the humerus. It consists in the comparison of 3D digital models of

the two contralateral humeri in a virtual environment. The 3D geometric models, obtained with a NextEngine laser scanner and recorded with proprietary ScanStudio Core software, were orientated in PolyWorks 10.0. In the same software, proximal and distal epiphysis of the oriented humerus were cut at the 20% and 80% of the humerus maximum length in order to compare individually the three obtained parts (proximal epiphysis, distal epiphysis and diaphysis). The inspection analysis, performed in the IMInspect module of PolyWorks, allows us to identify the areas where the two humeri differ morphologically and morphometrically and to quantify the differences with high precision.

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**FEEDING THE BEAST:
INTEGRATION AND
ANALYSIS OF NEW DATA TYPES INTO GIS**

APRIL 5, SATURDAY

FEEDING THE BEAST: INTEGRATION AND ANALYSIS OF NEW DATA TYPES INTO GIS

Chair: FIZ, Ignacio – ORENCO, Hector A.

This session aims to explore one of the most powerful features of GIS, yet one often ignored: data integration. It has been rightly suggested that the analysis' result is as good as the quality and diversity of the data employed.

The integration of different data types is accomplished thanks to the spatial nature of the data. That is particularly evident when dealing with maps, ortophotographs, or site plans – that is two-dimensional scaled types of data. Through processes, such as ortorectification and georeferenciation, it has also been possible to adapt non-scaled data types. With the diffusion of firstly total stations and later differential GPS and photogrammetric processes, 3D data has also become an important component of many GIS geodatabases. Nevertheless, it should be kept in mind that other data types have also important geographical components.

Although new approaches to data integration into GIS are welcome, the main focus of the session is directed towards the development and implementation into GIS of commonly ignored data types such as old photographs, pictorial representations, texts, ethnographical accounts, environmental data, etc. The potential of those spatial representations to the study of past spaces cannot be ignored any longer: it is our thesis that the development of new integrative approaches has the potential to render GIS a much powerful tool, especially for those of us working with past landscapes, which have been so dramatically changed over the past century.

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Synergy and interaction: The value of using historical sources in archeological landscape studies

(long paper)

DE SILVA, Michele

Keywords: GIS, Data Integration, Landscape Archaeology, Historical Cartography

The paper is focused on the precious informative content obtainable by the analysis of historical cartography and ancient documents, in particular it highlights problems and potentialities related to the integration of historical sources in a GIS environment. The historical approach to the study of landscape allows us to recognize the role of natural events and human intervention in the transformation processes that constitute the matrix of the

present territorial setting. The historical sources represent a range of key elements for the understanding of the various changes which dynamically have shaped and characterized the landscape of the past. This issue led to regional studies in which the continuity and changes can be better understood by mean of spatial comparison. In this perspective our landscape archeology studies have taken advantage of the use of different types of historical sources (namely geometric cadastres, geodetic and pre-geodetic cartographies, geographical descriptions, thematic maps, agrarian technical reports etc.) collected in the Tuscan historical archives. Different procedures have been adopted to input these data into GIS. Clearly one of the major problems regards the possibility of georeferencing historical cartography especially when documents have not geometrical characteristics. Moreover crucial information can also be added through the contextualization of descriptive archive documents. However this is a way to obtain the great value of an analysis based on comparison of different sources related to different historical phases; the analyses can be powerfully performed within an integrated approach. In fact the integration of different sources in a GIS environment allows us the emerging of latent features and information otherwise not clearly identifiable through single visualizations. Data integration led to the synergy of the interaction between historical sources and other type of data. The paper is focused on exploring this approach presenting some case studies.

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GIS and epigraphy: A new approach to the study of the sepulchral inscriptions. The Altino case

(short paper)

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Keywords: GIS, Altino (Italy) Epigraphy, Latin Inscriptions

The paper will present an ongoing project of the University Ca'Foscari of Venice (Department of Antiquity and Near East Sciences) aiming to combine computer science and epigraphy for an innovative approach to the study of Latin inscriptions from the Roman necropolises of the city of *Altinum* , ancient Venice.

The goal of the Altinian epigraphic GIS is to organize the data coming from archaeological excavations conducted between the 70s and 80s of the last century in the cemetery area along *Via Annia*, still largely documented in paper without an organizing system.

The GIS allows in depth analysis of the epigraphs from a textual, typological and content point of view and it has proven to be particularly efficient in the extrapolation of data like gender, social class, occupation, public positions, familiar and social context of the holder of the sepulchre, as well in increasing the spatial contextualization of each sepulchre, a

datum, usually neglected, that has proven to be key support for the interpretation of the ancient inscriptions. The location of a gravestone will in fact enable us to increase the information about the so-called „anthropology of the death” (related to gender, social status, property qualification as well as the monument typology adopted) and discover the strategies of self-representation of the upper and lower classes, the routines of the ritual, the modality of the funeral apportionment, the length and the forms of the association or exclusion from the *loci sepulturae* .

Moreover from the spatial analysis of the extension of the different lots in the sepulchral areas and of their positioning inside the necropolis we can obtain information related to the property asset of the different defuncts, the choices underlying the organization of the necropolis area, permitting us to define which parts were used first and their development over time, as well as how certain factors affected the choice of the sepulchral lot, factors such as its location inside the sepulchral area, extension, visibility, monumentality, and the social status of the owner.

The project will further develop with the insertion of the unscripted finds in the GIS that will help in the global reconstruction of the necropolis, allowing us to focus attention on the organization and disposition of the monuments and the sepulchral enclosures, and of the epigraphs of non-funerary nature that will allow a better understanding of the suburban areas of the municipium.

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Archaeological spaces and their exploration in GIS: A case study of intra-site cemetery analysis

(short paper)

SMEJDA, Ladislav

Keywords: GIS, fact space, data synthesis, model building

This paper presents an innovative method of data analysis in GIS. Firstly, the theoretical concept of archaeological *fact space* will be introduced, which regards both the spatial and formal attributes of the archaeological record as mutually interchangeable axes of analysis. Secondly, this approach will be demonstrated in a case study that deals with mortuary data, recorded five decades ago at the site of Holesov, Kromeriz district, the Czech Republic. This cemetery consists of 10 Bell Beaker and 420 Early Bronze Age graves and gives an overall impression of continuous development over a considerable period of time. It is the relative chronology of the site that will be examined in detail, alongside selected aspects of its gender structure. The data brought into play for this purpose include, for example, the chemical

composition of metal artifacts and the positions of individual graves in a multi-dimensional matrix of their archaeological description. The particular methods applied here are based on raster filtering, spatial trend analysis and graphic representation experiments, which treat conventional 2D graphs as if they were GIS maps. The main aim of these exercises is to highlight very positive aspects of contemporary computer software applications which encourage people to pursue new avenues of conceptualizing their research ideas. This can be done, for example, by experimenting with diverse data representations and by building abstract models which describe problems in a more productive way. Even data that have been thoroughly published long before and discussed many times can produce new knowledge, when examined from a fresh and striking perspective.

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Integrating artistic representations into a GIS-managed environment

(short paper)

ORENGO, Hector A.¹ – FIZ, Ignacio²

Keywords: data, integration, GIS, landscape

The quality and diversity of the data implemented into the GIS is essential in order to obtain the best analytical results. Therefore, integration and analysis of new data types into GIS becomes vital to improve archaeological GIS-based analysis. In this case an attempt will be made to incorporate some types of traditionally conceived nongeoreferenced data—specifically artistic representations. Artistic imagery is often ignored due to the lack of any mathematically defined relation between internal elements of such representations and their external referents. Nonetheless, artistic representations of archaeological sites, being historical documents, have been largely utilized by historical archaeologists, specifically when working on a long-term landscape analysis.

They can provide a unique record of nowadays disappeared archaeological elements or might offer an insight on pre-industrial landscapes, arguably similar to those which are object to archaeological study.

These data types are not metrically objective representations of the physical environment as maps or orthophotos could be but consist of subjective interpretations, reflecting the artist's landscape perception. A sophisticated integration of historical artistic works within a GIS framework is here argued to be decisive if we are to interpret the archaeological subject of those works based upon the artist's embodiment within the landscape.

A methodology to integrate historical, artistically produced images will be explored and tested on the modern city of Tarragona within its environment. Data introduction into GIS is based upon the concept of the "projection origin". In the case of artistic renderings, this would be the artist himself. By generating cumulative viewsheds from landscape control points also appearing in the picture it would be possible to locate this "projection origin".

The combination of 3D landscape modelling techniques along with a set of GIS-integrated paintings, drawings and engravings will provide the means to draw conclusions on long-term landscape change, but also on the changing perceptions of the individuals who inhabited it.

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A semantic based approach to GIS: The PO-BASyN project

(long paper)

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Keywords: GIS, settlement dynamics, Bronze Age, Knowledge Representation, qualitative reasoning

GIS offer a consistent set of search, retrieval and analysis tools dealing with spatial information which are mainly based upon relational database query techniques and quantitative math-based elaborations. Recent advances in the field of knowledge representation and the growth of web technologies and applications represent a fertile ground for enhancing these capabilities, offering a new perspective for GIS applications in archaeology.

By means of the exploitation of Data Integration and Semantic Web technologies, it is possible, for example, to support several innovative GIS functionalities, which are related with the semantic access, navigation and querying of heterogeneous multilayered data and information. In the same manner, it is possible to envisage some new analytical and explanatory capabilities which are more connected with knowledge representation techniques applied to describe in a deeper way the entities that are situated in the GIS

environment and to exploit these descriptions with techniques that go beyond the typical quantitative geographic mathbased algorithms.

The focus of this paper is, on one hand, to present a specific technological proposal on how to enable data integration by means of an ontology-based approach (in the light of the present W3C recommendations). On the other hand the paper aims at defining a way to go beyond the data integration level, using an ontological knowledge representation to perform qualitative logic-based reasoning. This approach can be combined with the traditional quantitative analysis, significantly improving the capabilities of the GIS based system.

The proposed case study is the POBASyN (Po Valley and Bronze Age Settlement Dynamics) project, aiming at representing, integrating and managing the archaeological knowledge available for this scenario. The availability of a huge dataset with information on sites and finds needs a process of systematic classification and harmonization; this situation, on the other hand, represents also a unique opportunity to test the analytical expressiveness of the proposed solution. This particular case study offers a rich and qualitatively relevant corpus of heterogeneous data, deriving from excavations, surveys and museum collections, including structured (database related) and semistructured data, documents, images, georeferred data, and cartographies. Different classification models and different analytical and environmental data with heterogeneous semantics are also comprised in the dataset. The innovative analytical capabilities of the system will be a key element in supporting the analysis of settlement dynamics, in particular for the identification of significant settlement clusters and patterns.

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Complex social-landscape's data in GIS: A cognitive-processual methodology

(short paper)

BONZANO, Simone

Keywords: GIS, Social-Archaeology, Landscape Archaeology, Highlands Archaeology,
Near-Eastern Archaeology

To help the research of the southeastern Anatolian highlands social complex landscape, a GIS methodology was outlined to describe its own local territorial systems (LTS), which are micro-regional functional networks sharing the same geographical and cultural milieu considered as main social agents.

Their analysis has for several problematic issues: handling big clusters of data, working both on the geography and on the human/territory's dialectics and interpolating together quantitative and qualitative results.

This methodology analyses the archaeological palimpsest using an interdisciplinary approach interpolating archaeological, geographical, historical and socio-anthropological informations through a cognitive-processual theoretical lens.

It was called MARKER because it marks those LTS geographically. As interdisciplinary tools the MARKERS use a shared typological "language", resulting in a given database relation table, based on data's relative "quantification" and "qualification".

To handle data the GIS used is GRASS GIS 6.2 with a SQLite DBMS managed locally and through Mozilla Firefox to have a powerful but simple, reliable, open source methodology. The GIS was chosen because of its own powerful processing modules for raster (r.mapcalc mainly) and vectors (v.digit) as well as the SQLite integration.

This presentation presents the preliminary applications of the MARKER methodology on the region around the Van Lake, southeastern Turkey. The results of the tests done, which are presented in this paper, clarify the analytical potential to describe the social assets of the local territorial system as landscape social agents. Similarly to the methodology, the interpolation of interdisciplinary data permits to go over the given limits of the non-homogeneous distribution in space and time of the archaeological evidence.

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Concept for an ontology based WebGIS information system for HiMAT

(short paper)

HIEBEL, Gerald – HANKE, Klaus

Keywords: Web based spatial information systems; GIS; Databases; Ontology;
Cultural Heritage Management; Work in Progress (Project)

In March 2007 the multidisciplinary research program HiMAT started at the University of Innsbruck to investigate the History of Mining Activities in Tyrol and adjacent areas. A diversity of disciplines with a major focus on archaeology is involved in the project to answer archaeological, cultural, environmental and social questions related to historic and prehistoric mining activities in these areas.

To enable integration, communication, retrieval and presentation of data within the project HiMAT and to the public it is essential to build a web based spatial information system. The main challenge of such a system is how to deal with the diversity of intellectual concepts, research methods and heterogeneous data coming from the participating

disciplines (Archaeology, Linguistics, Surveying and Geoinformation, European Ethnology, History, Mineralogy, Prehistory, Botany, Archeozoology, Dendrochronology, Petrology).

As conceptual background for knowledge representation of these disciplines an object oriented semantic model is the best choice. The formal ontology of the CIDOC CRM provides the necessary semantics for this task.

The proposed architecture of the system consists of a document management system used to store all kinds of relevant digital data. The documents stored will be associated with metadata based on CIDOC CRM standards. Topographic names with their coordinates are part of these metadata and with the help of a WebGIS -documents are annotated with topographic metadata. The same WebGIS interface will be used to retrieve documents from the document management system. Metadata and spatial data are stored in a database providing the link between WebGIS and document management system. The same database provides the access to spatial Data for Desktop GIS users. Essential for an integrated database is the creation and application of terminology lists.

Up till now a document management system and a prototype for a WebGIS are implemented. We are still in the evaluation process which database could provide the necessary data structures (spatial and semantic) and interfaces. Especially the interfaces to and from the database will be a crucial factor for the success of the architecture.

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FREE GIS AND ARCHAEOLOGY

APRIL 5, SATURDAY

FREE GIS AND ARCHAEOLOGY

Chair: DIEZ-CASTILLO, Agustin

In recent years, see CAA 2007, free GIS is becoming more and more popular among archaeologists. Open source and open standards should be the way to go, but the debate about the use of free software is a debate largely postponed in general, but very specially in public Universities and should be confronted without delay. There are very good examples of the use of free GIS, with the same guarantees that commercial systems of extra orbited costs out of the reach of students. In addition to ideological considerations, free gis should be use because it is a better choice. The use of free GIS allows us to benefit from the work of others, at the same time that our contributions benefit others. Without doubt GRASS (<http://grass.itc.it/>) gvSIG (<http://www.gvsig.gva.es/>), (<http://www.qgis.org/>), uDig (<http://udig.refractor.net/>), are tools with capabilities similar to commercial software. The idea is to have different examples about how those Geographical Information Systems deal with archaeological problems offering to participants a current update of how much Free Gis have been developed in recent years. The growing availability of web data services through protocols like WMS or WFS are the perfect companion to free gis allowing archaeologist to manage free spatial and accurate data.

Exploiting the cultural assets by open source WebGIS technologies. The case of the Roman aqueducts

(short paper)

BORDONI, Luciana¹ – COLAGROSSI, Attilio²

Keywords: Open source technologies, GIS and Web-Gis software development, Roman Aqueducts.

The past decade has seen numerous applications of computer technologies to cultural assets. A variety of different issues has been dealt with, such as of figurative works, reconstruction of frescoes, virtual 3D reproduction and so on. All of these applications, finalized to exploit the cultural asset, have dealt with works limited in size and well defined in their placement in space. The case of the Roman Aqueducts – a cultural asset scattered in space and not concentrated in a given place or well-defined location – is another matter entirely. Since the technologies discussed above appear difficult to apply to the case of exploiting the aqueducts, we have concentrated on other computer technologies that appear to respond better to this need. Towards these ends, Web-Gis technologies have been considered, and this work presents an application of these technologies to the Roman Aqueducts built between the third century BC and the third century AD. In particular, the development of a Web-Gis application in open source technology that allows the 3D vectorial representation

(using DEM) of the traced routes of the Aqueducts (eleven Roman Aqueducts within a radius of about 30 Km from the centre of Rome, including the still-functioning *Aqua Virgo*), to be exploited on Internet, employing a normal web browser. Historical and technical data as well as Aqueducts photographs are also integrated in the application. The Web-Gis application has been realized by using ALOV Map/TMJava, developed as a joint project by ALOV Software and the Archaeological Computing Laboratory of the University of Sidney. ALOV Map/ TMJava has been entirely implemented using Java. It allows for publishing vectorial and raster maps on the web. ALOV Map/TMJava is executed on the client side: the vectorial maps are loaded by the applet on the pc client, making more efficient the interaction with the data. It is also compatible with most commercial and open source DBMS.

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You got what you've paid for? Free GIS in Cultural Heritage Management

(short paper)

BRONK-ZABOROWSKA, Katarzyna

Keywords: free GIS, SMR, Polish case study, open source, web GIS

“Free software is a matter of liberty, not price. To understand the concept, you should think of ‘free’ as in ‘free speech’, not as in ‘free beer’”. (Richard Stallman: <http://www.gnu.org/philosophy/free-sw.html>)

Freeware and open source software offer a great advantage over commercial programs – the costs involved in obtaining them are usually low or none. The latter, by providing the source code, also appeals to the potential users with the promise of safety and everlasting youth. It may seem that free software is a perfect solution for Cultural Heritage Management, as their institutions are nearly proverbially struggling for money; the practice however shows that even small, local offices prefer to pay for the software, instead of choosing their free equivalent. One of the main reasons behind it is popular conviction that commercial products offer better support and are designed to be user-friendly, while free software, especially open source one, demands from the user the level of expertise available only to computer engineers. Is it only a myth? How to balance the advantages of various types of free software with the increased responsibility they put on the user? Can a layman apply and tailor to particular needs non-commercial software with success? Is there a solution which combines user-friendly layout and open format, thus assuring future recovery of

the data? I would like to discuss the pros and cons of free software, using as an example developing Polish Sites and Monuments Record.

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Open source GIS in practical use — experiments and experiences from Hungary

(short paper)

LARSSON, Nicklas

Keywords: free GIS, total station, software development, GRASS

While working for a Hungarian county museum with a strained financial frame, alternatives had to be found to commercial GIS software. In this presentation the approaches which we have taken in using open source software in the archaeological work on and off site will be introduced.

We have been fortunate to be able to work with a total station at our excavations, whereby everything we wanted to measure could be measured. There is, however, no free software to handle this kind of data intelligently. By necessity I had to develop an application that does just this. It is very much based on the concept of Intrasis (<http://www.intrasis.com/>). While being at a very early developing stage only the most fundamental functions are implemented, but it has proven its use in several small and medium size excavations. The measured data, which is coded with information on type of object (e.g. a feature or soil sample) and geometry (e.g. polygon or point), is parsed by the application and everything is stored in the open source relational database PostgreSQL (<http://www.postgresql.org/>) with the free extension PostGIS (<http://postgis.refractions.net/>) that adds support for geographic objects. Internally, the application uses the GEOS (Geometry Engine - Open Source, <http://geos.refractions.net/>) for geometric functions. The spacial data can then be exported to a wide range of vector file formats, including ESRI shape and MapInfo files, with OGR (<http://www.gdal.org/ogr/>) for further processing in open source applications such as GRASS (<http://grass.itc.it/>) or OpenJUMP (<http://openjump.org/>). Although a steep learning curve, GRASS has proved to be a very flexible and advanced application to meet most of our needs and has become an important and indispensable tool for various objectives.

The in-house software and its open source building stones, as well as the features of GRASS that we mostly use, will be presented and some reflections on some of their up- and downsides will be put forward.

Hungarian Cultural Heritage Service

Free and open source webGIS solutions for the POBASyN project

(long paper)

MANTEGARI, Glauco – DE SALVO, Marco

Keywords: Free/Open Source software, webGIS, Bronze Age, WMS

The paper describes the use of Free and Open Source webGIS technologies in the context of the POBASyN project which aims at studying the Bronze Age settlement dynamics in the Po river valley (northern Italy).

The storage, search and retrieval of spatial information by means of efficient tools and techniques are central elements for our research and GIS applications play a key role in all the aspects involved in georeferenced data management, analysis and sharing.

Within the project, GIS is employed in different ways, ranging from desktop applications for local data acquisition and analysis to clientserver solutions for collaborative work and data sharing. The project focused particularly on the development of the AISBA (Archaeological Information System for the Bronze Age in northern Italy) webGIS (<http://www.archeoserver.it/aisba>) which is conceived as a continuously updated system containing the most important available information about the examined archaeological domain.

The development of the AISBA webGIS arose several issues related to georeferenced data integration and access on the Web. In fact, the study of the Bronze Age in northern Italy involves many institutions and scholars and thus it can be difficult to integrate different data sources, possibly having different granularities, within the framework of a shared platform. On the other hand, this aspect directly influences the efficiency and user friendliness of the access to information, which, in addition, has to be sufficiently accurate to make the system effectively useful for scientific purposes.

To face these issues the AISBA webGIS was conceived, since the beginning, as an open and evolutive architecture developed using Free and Open Source technologies. We believe that these technologies are mature enough to compete with commercial and proprietary solutions and let us experiment different solutions without the high costs of traditional software licenses. Moreover, some peculiar characteristics of Free and Open Source GIS seem to fit particularly well our needs, as for example, their flexibility, modularity and support to standards.

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Can FOSS4G (Free and Open Source Software for Geospatial Data) and INSPIRE help out archaeology?

(short paper)

DIEZ CASTILLO, A.

Keywords: free GIS, FOSS4G, INSPIRE

In recent years there are more and more attempts to introduce both free and open source software in the archaeological community but it seems that there is still more resistance than acceptance. There are very good examples of the use of free GIS (i.e. the Medland Project <http://www.asu.edu/clas/shesc/projects/medland/>) with the same guarantees as not so cheap commercial versions. In some cases, very low budgets and the like, FOSS4G is the only choice; in others, like the Medland Project, it is just the best choice. To date there is little doubt that software like GRASS 6.3 (<http://grass.itc.it/>), with the complement of QGIS (<http://www.qgis.org/>) or gvSIG 1.1.1 (<http://www.gvsig.gva.es/>) with the addition of SEXTANTE (<http://www.sextantegis.com/>) are tools with similar capabilities to commercial software. Moreover, the use of free GIS allows archaeologists to benefit from the work of others, at the same time as our contributions benefit others. INSPIRE (<http://www.ec-gis.org/inspire/>) along with recent developments in SDI technology provide the perfect framework for the use of web data services through protocols like WMS or WFS which are the perfect companion to FOSS4G allowing European archaeologists to manage free and accurate spatial data.

Even when our main option is still GRASS + QGIS, recent developments of gvSIG + SEXTANTE have simplified enormously the management of spatial, not only for being a robust WFS, WCS and WMS client, but for the ability of georeferencing old documentation, the spatial database (Postgres, PostGis, Oracle) connectivity, and the very easy and intuitive digitalization tools. FOSS4G should be the way to go, but unfortunately we archaeologists are not big players in the debate about the use of free software and open standards. This situation needs to be reconducted as far as archaeologists will be preferent users of the new technologies in the near future.

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**STATISTICS AND MATHEMATICAL
MODELLING IN ARCHAEOLOGY**

APRIL 3, THURSDAY

STATISTICS AND MATHEMATICAL MODELLING IN ARCHAEOLOGY

Chair: HERZOG, Irmela

Retrieving the past from stones: An application of non- parametric statistics to the study of Jomon Stone assemblages in prehistoric Japan

(short paper)

ADI, Bongo¹ – VALDES, Milgaros²

Studies of the Jomon period through the analysis of stone artifacts still remain an under-explored area in contemporary Japanese archaeology. In order to fill this gap, this study attempts to explore the socio-cultural, ecological and livelihood patterns of the Jomon society through the analysis of the nature of assemblages of stone artifacts employed by Jomon hunter-gatherers in prehistoric Japan using a database of stone artifacts excavated from different archaeological sites in Japan. This database was constructed based on the availability of archeological reports from excavation sites. From the available 478 archeological reports out of 560 Jomon archeological sites 400 different types of stone tools were generated. These stones were further reclassified into 65 different categories of stone tools. Only stone tools were analyzed. We employed rigorous statistical techniques in order to discover distinctive patterns and dimensions hidden within the data of stone tool assemblages. Two different statistical techniques were employed for this purpose: Analysis of Variance (ANOVA) was used as a descriptive method for understanding the level of variation (difference) among different stone tool assemblages. ANOVA results show that while there are significant within-group variations (within assemblage variations), the amount of variation in the constellation of stone artifacts across different groups is insignificant. This implies that we can sustain the hypothesis of significant homogeneity across different Japanese regions during the Jomon period.

To investigate this hypothesis further, various clustering methods were employed to explore the pattern classification across the different stone tool assemblages. Non-hierarchical cluster analysis (without assuming a priori groupings of assemblages) with a bootstrap test for optimal grouping shows the significance of 7–10 groups out of the distinctive 25 data groups. The same result is confirmed using k-means cluster analysis with the a priori definition groups. Using these statistically validated grouping criteria, this research explores various conjectures that could explain the clusters as found in the data. The dual significance of this research lies in the use of stone tool assemblages to understudy the Jomon period and the application of computationally intensive, non-parametric statistics to reveal inherent patterns in the data. The latter contributes to the

growing body of archaeological literature that employs novel statistical techniques to extract archaeological information from data.

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A statistical algorithm for use in provenancing silicate artefacts based on chemical analysis data.

Examples of application using XRF and INAA

(short paper)

CRANDELL, Otis

Keywords: provenancing, statistics, geochemistry, silicates

In prehistory, trade routes were used to transport people and goods. Of the commonly found materials at archaeological sites, the most useful to determine these trade routes is siliceous stone. In geologic studies, determination of the major, minor and trace elements in lithic samples is a popular method of sourcing artefacts. If one determines the proportions of the constituent elements in a lithic artefact, the results can be compared to known proportions in suspected quarrying sites to aid in determination of the source of the artefact. The difficulty in analysing chert or quartzite is the extremely low quantities of diagnostic trace elements and the fact that these materials are generally heterogeneous. Different areas of an artefact or geological sample will contain different proportions of different elements. These factors make sourcing studies very difficult and time consuming. The intent of this study was to create a mathematical-statistical algorithm that could automatically process chemical analysis data of geological materials and artefacts and then predict the sources of silicate artefacts. Data from XRF (X-Ray Fluorescence) and INAA (Instrumental Neutron Activation) analysis of chert and quartzite was used to successfully test the algorithms using the SPSS software.

Several statistical methods were tried. Some produced better results than others.

- Simple cluster analysis and linear discriminant analysis (LDA) appeared to be unable to differentiate between sources or predict with a reliable amount of accuracy the source of an artefact except when there were only a few sources available.
- It was found that the accuracy and statistical significance increase when the raw data is combined with data derived from factor analysis - generally the first four or five principal components (PCs).
- It was found that Cluster Analysis of the entire dataset based on the first 5 or 6 principal components produced better than random results but still not very well grouped.
- When the cluster group values were added to the database (with the raw data and PCs) and analysed using LDA, that the results were better than using only the raw data.

This paper will present the algorithms used in this study along with observations on their relative strengths and weaknesses.

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Experimental approaches to glyptic art by the use of Artificial Neural Nets. Investigation on the Ur III iconological context

(short paper)

DI LUDOVICO, Alessandro

Keywords: glyptic art, Self-Organizing Maps, Fuzzy Contractive Maps, iconology, Mesopotamia

Mesopotamian glyptic is a subject which can be studied from a number of viewpoints and by many different concrete approaches. The contemporary interaction of the scholar both with the problems of the production of ancient artifacts and those of contemporary logics and cybernetics may allow him to uncover features and relationships which had been completely ignored before. In this contribution the author, who in recent years used Self-Organizing Maps models for similar researches, investigates the iconological relationships “hidden” in a corpus of scenes depicted on late third millennium Mesopotamian cylinder seals. The main tools used are some non-linear mathematical models developed by Artificial Neural Nets specialists, that is Fuzzy Contractive Maps algorithms quantifying distances and connections through the examined specimens. The investigation is based on inner evidence and starts with a training and learning process by the Net. The final Contractive Maps analysis leads to the development of a general picture of the semantic relationships among the representations under study and gives the researcher the chance to exert intense self-criticism concerning the way he looks at ancient artifacts and the criteria he uses to segment and classify them. The main aim of this experimental study (which is, of course, part of a research project still in progress) is to highlight the semantic features which function as clues of the syntax and the mental order the glyptic representations were founded on.

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Algorithmic reconstruction of broken fragments

(short paper)

ELIUK, Steven – BOULANGER, P.

Keywords: computer-aided pottery reconstruction, laser scanning,
Pearson Correlation Coefficient

The reconstruction of broken fragments is an extremely difficult task, even for the experienced archaeologist using the latest toolsets. The difficulty is apparent mainly due to the high probability of missing pieces, likelihood of erosion, and probability of including fragments from many different models. The paper describes some of the most successful techniques for reconstruction and presents a new technique for reassembly. The technique relies on a simple ordered process of laser scanning, segmentation into interesting curves, alignment of curves, curvature comparison, and pairwise comparison. The significance of the process is the ease of making high quality curvature comparisons by means of the Pearson Correlation Coefficient which requires only a limited amount of time in the alignment stage. The alignment stage is normally where a significant amount of time is spent attempting to align two fragments ideally. The presented process eases the time consuming reconstruction process that is found in many areas of archaeology.

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The potentials and limits of different quantitative approaches to mortuary analysis: a case study from the Late Neolithic Carpathian Basin

(long paper)

SIKLÓSI, Zsuzsanna

Keywords: mortuary analysis, stasistics, frequency occurrence, cross tabulation, seriation,
cluster analysis, correspondence analysis

Archaeologists often consider mathematical, quantitative or natural scientific methods as magic tools without knowing and understanding their potentials and limits. Such methods are usually considered to be objective and analytical, whereas statistics is actually subjective in several elements. It is obvious that the application of statistical methods can facilitate the survey of high amounts of archaeological data, but at the same time several theoretical and methodological problems arise. It is even more true when we use them for mortuary

analysis. The choice of the most appropriate statistical method depends, among others, on the researcher's epistemological background, the size and type of the "sample", and what kind of questions we would like to be answered.

In this paper, I would like to show what kind of problems arise by the application of quantitative methods from the planning of a survey up to the interpretation of the results through the study of a Late Neolithic cemetery, Aszód–Papi földek:

- problems of sampling,
- coding of data,
- selection of suitable quantitative methods,
- advantages and disadvantages of different quantitative methods,
- problems of the interpretation.

Aszód–Papi földek is a part of a cemetery containing 225 graves, which I studied from a social archaeological point of view. For that, it was necessary to answer such questions as

- demographical representativeness,
- the inner chronology of the cemetery,
- attributes connected to the age and gender of the deceased,
- connection among the elements of burial ritual.

For that, I used several quantitative methods, like:

- frequency of occurrence
- cross tabulation
- seriation
- cluster analysis
- correspondence analysis.

This paper aims at providing a short summary of theoretical and methodological problems of quantitative methods through a case study.



SPATIAL ANALYSIS IN PAST BUILT SPACES

APRIL 5, SATURDAY

SPATIAL ANALYSIS IN PAST BUILT SPACES

Chair: PALIOU, Eleftheria – KAMERMANS, Hans

Computer-based spatial analysis has been widely applied to the investigation of historic and prehistoric space, both domestic and ritual. Typically, however, the focus has been on larger spatial scales ('landscapes') rather than urban spaces and buildings. More recently, a range of formal spatial analytical methods have begun to be developed for the formal investigation of human engagement, experience and socialisation within the built environment, which emanate from the fields of architecture, urban studies and geography. The various methodologies that have been suggested for the study of past urban spaces, and specifically in an archaeological research context, differ significantly in the exact modelling method used, the scale and the specific aspects of human engagement with built space they seek to investigate. Besides space syntax approaches (axial maps, isovists, visibility graphs), GIS-based approaches such as viewshed and GIS-T network analysis have been proposed, as well as methodologies that seek to exploit the analytical capabilities inherent in 3D modelling software (visibility analysis in 3D spaces, agent-based approaches). These methodologies have already been applied to a variety of archaeological contexts as diverse as Iron Age Kerkenes Dag, the Minoan Bronze Age, Medieval Towns, Roman Pompeii and Byzantine and Victorian churches.

This session invites archaeological and inter-disciplinary papers on a variety of spatial analysis methods for the investigation of experience and social meaning of historic and prehistoric urban spaces. Participants are encouraged to give emphasis to the usefulness of these methodologies in the understanding of past built environments, and also to address issues of the theoretical positioning of such analyses within wider archaeological discourses. Relationships between urban space, agency and social practice may provide one focus for this.

Visibility analysis at Protopalatial Malia

(short paper)

HACIGÜZELLER, Piraye

Keywords: Minoan Civilisation, Visibility Analyses, Malia, Aegean Bronze Age

Malia is located on the central northern coast of Crete (Greece) and is one of the principal settlements of Minoan civilisation. It acquired an urban character at the beginning of the Protopalatial period (ca. 1900/1800-1700 BC) with the organisation of street networks and public squares accompanied by the expansion of the settlement through the construction of new house clusters on previously unoccupied parts of the site. Examination of the urbanisation process in Malia is of prime importance for Minoan studies as the site is the only Protopalatial settlement with a largely uncovered urban system. The aim of the

study is to create a three-dimensional model of the settlement together with its terrain to conduct visibility analyses and highlight possible everyday experiences encountered at the built space that relate to visibility. The study employs a GIS-based methodology where each volume within the built-space (man made or natural), larger than average human size, is modelled in three dimensions as a non-textured, abstract object embedded in a Triangulated Irregular Network (TIN) surface, representing the terrain. ArcView 9.2 (© ESRI) is used as the main tool for the analysis. The TIN representation of the terrain is created by digitising the topographical map of the site. Buildings on the site are added to the terrain model using point and line feature classes as “mass points” and “breaklines,” which are surface feature types provided by ArcView. The model provides a multi-scale approach into the visibility analysis within the built-environment as inquiries are conducted both at landscape and inter-building spatial scales. While the model is also promising for the intra-building applications, there are limitations connected to the inquiries at this scale, which are discussed in the paper.

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Space, functions and human behavioural strategies: The “analisi funzionale tattica” as tool for the understanding and explanation of ancient and medieval fortifications

(long paper)

MONTI, Alberto

Keywords: space, functions, exaptation, behavioural strategies

Among both qualitatively and quantitatively most widespread archaeological-monumental evidences within ancient human landscapes, we can doubtless count fortifications. In a field of more general functionalist studies applied to structured landscapes, we are developing what we define *analisi funzionale tattica*: an approach moving from our knowledge of how, within pre-firearms military tactics, could a defender choose and “co-opt” some of the natural landscape features in order to profit them in defence and how, whereby and to what degree should he then structurally integrate that to get effective fortified systems. This allows us to state an *effectiveness level* for the whole fortification defence, then taken on as a reference value to analyze and explain the detailed running of defence for every single structural item and concerning every assault way to fortification. The main result will be a factorization of any fortified context into both its natural and artificial elements, and thus an explanation of functions for each and every one.

GIS, actually ESRI ArcGIS 9.2 Spatial Analyst and 3D Analyst modules are the tool for this kind of analysis implementation. After detailed natural morphology and known defence

structures 3d processing, we proceed by applying to the model map algebra procedures and GRID reclassification formulas, expressly developed in order to evaluate each single space portion behaviour according to its resistance to different assault techniques. Thus we achieve realizing in a contour GRID map a good estimate of the mental image a fortification expert could create evaluating presented defence items. Hence this kind of analysis simulates a targeted cultural cognition of defensive points embodying their inner and outer connexions.

This process can be employed both for an explanatory purpose – when applied to a structurally and topologically known fortification – and for diagnostic and predicting purpose – when wishing to make plausible hypotheses about an unknown typology and entity of the defenses, and even for quantifying the fortification builders skills in profiting the most from what the surrounding environment provided to them.

The presentation is made of 4 parts;

1. environmental skills: man intentionally co-opts landscape in order to perform and enhance his activities
2. pre-modern fortifications: theoretical principles and cases of natural features co-optation and strengthening through dedicated artificial structures;
3. functional tactical analysis implemented through 3d GIS: 3d models and algorithms to depict and measure defence efficacy;
4. a short case of study: the small Medola castle (Appennino modenese, Italy)

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“Chattering” in the baths: The urban Greek bathing establishment and social discourse in Classical Antiquity

(short paper)

GILL, Alyson A.

Keywords: virtual reconstruction; archaeology; architecture; spatial analysis

In his play *The Clouds* Aristophanes has Just Logic remark that the Greek public baths (*balaneia*), by virtue of their design and use of warmed water which stood in stark contrast to the cold water bathing in Greek gymnasia, were responsible for the lack of character among Athenian youth who frequented them. (Ar. *Nub.* 1050-54 “These things, these are what make the bath-house full of youngsters chattering all day, but the wrestling schools are empty!”) Literary testimonia of this sort suggest that the public baths were associated in antiquity with frivolity, or were at the very least in some way responsible for the moral degradation of young Athenian men. Despite these comments, or perhaps because of them, public baths were integrated into the fabric of Athenian life—evidence for which comes from the construction of baths outside each of the four gates into the Classical city

and their longevity. These baths, I will argue, served a critical discursive for the Athenians who frequented them, allowing them to hear news from travelers entering the city and to provide information to those visitors as well. In this paper I will plot each of the four baths on a map of Classical Athens, and then using 3D models of the *balaneia*, I will demonstrate how the space itself functioned to facilitate discourse. In making this case I will suggest that as the baths moved inside the city walls in the late Classical period, visibility between bathers was decreased. In providing less visibility, I will argue that the function of the later baths shifted and became increasingly utilitarian.

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Generation of a 3D model of Baalbek to analyse the historical development of the city using non-calibration, historical photos

(short paper)

ALAMOURI, A. – GRUENDIG, L.

Keywords: Camera, Calibration, Adjustment, Combining, 3D Model

Baalbek is an important World Urban Heritage site to the 5000 years of history in the city and the ancient building remains. The main objective of this research is creation of a 3D model of Baalbek on the one hand to provide an important document for the city and on the other hand to understand the historical development of Baalbek's building remains from Prehistory until 20th century. The generation of a 3D model depends on the photogrammetric analysis of Baalbek's historical images; (vertical, oblique and terrestrial photos). The problem of the graphic materials is the images' properties (such as: different cameras used and no primary data of the cameras' parameters, different image scales, different altitudes of the flight, the contrast of the gray values and the image noise are relative great, in addition the images were taken in different dates). Therefore, an effective and correlated approach will be developed to perform an optimal calibration of the different cameras used. In addition, an optimal orientation of Baalbek's photos requests the combination of the different classes of Baalbek's photographs. This combination was investigated insufficiently up to now; moreover, the faulty parts of the objects can be derived using the combination of the different data sources of Baalbek.

The cameras' calibration was enforced using the bundle block adjustment method and different strategies. The computation flow consists of four steps. First consistency and plausibility check of input data is performed. In the second step the functional model of the calculation is derived from the collinearity equations and changed in a way that it converges well. In the third and the last steps an optimal bundle adjustment including parameters for

modelling of the lens distortions is achieved. Through this method a coordinates' model was created and the errors of the image points were eliminated.

As results of this work the internal geometric configuration of the different cameras and the lens systems were described, furthermore the photos were oriented, so that the measurements of 3D points are possible. Identification of the achievable accuracy with the consideration of the quality of the input data, as well as the geodetic and geometric quality of the results were analysed. The attainable accuracy of the results allowed using them as database for the Geoinformation system of Baalbek's space and to create a 3D city model either LOD¹ (level of detail one) or LOD².

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Documenting Mackenzie Inuit architecture using 3D laser scanning

(short paper)

DAWSON, Peter C.¹ – LEVY, Richard M.² – ARNOLD, Charles³ –
OETELAAR, Gerald⁴ – LACROIX, Dominic⁵

Keywords: 3D modelling, laser scanning, Inuit architecture

Laser scanning is currently being used in various areas of the world to document ancient architecture (Ioannidis 2004; Ahmon 2004). Laser scanners record the proveniences of numerous points on an object's surface. The resulting three-dimensional images can be used to test various building scenarios, analyze activity areas in a three dimensional context, and digitally archive heritage resources threatened with destruction via erosion and industrial activities (Brizzi et al 2006; Brown 2001; Ioannidis 2004). Laser scanning may have applicability in the Mackenzie Delta region, where archaeological research has become increasingly focused on the interpretation of Mackenzie Inuit architecture, and the preservation of houses threatened by erosion (Friesen 2006; Arnold and Hart 1992). Early ethnohistoric and ethnoarchaeological sources treat Mackenzie houses as largely unvarying in their distinctive cruciform shape (Richardson 1828; Petitot 1876; Whittaker 1937). However, archaeological research conducted in the region over the past 25 years has revealed a great range of architectural variability. Recent work suggests that dwellings with two and three sleeping platforms replaced the earlier Thule pattern of houses with single alcoves (Friesen 2006). Furthermore, the prevalence of two and three alcove house types appears to vary geographically, from east to west (Friesen 2006). The destruction of houses due to coastal erosion, particularly those situated along the outer coast of the Beaufort Sea, has hindered the study of the precise nature of this architectural variability

(see Arnold 1988). In this paper, we report on our use of 3D laser scanning to document a Mackenzie Inuit dwelling from the Pond Site (NiTs-2), located in the outer Mackenzie Delta. Specifically, we evaluate the challenges and benefits of using laser scanning in remote arctic environments, and outline potential ways that 3D computer reconstruction might shed light on the study and preservation of Mackenzie Inuit architecture.

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Using 3D finite element analysis techniques for testing the structural stability of Thule whalebone houses

(short paper)

LEVY, Richard M.¹ – DAWSON, Peter C.²

Keywords: 3D modelling, 3D finite element analysis, architectural stability, Thule Inuit archaeology

Structural analysis techniques can be used for testing the validity of archaeological reconstructions based on limited archaeological data. In this research, we considered a variety of construction alternatives for Thule Inuit whalebone houses and assessed their structural integrity using 3D finite element analysis. An important assumption in arctic house construction is that the houses be capable of withstanding the heavy weights of bone and cover materials, snow loads, and severe wind loads. Archaeological artefacts from the Deblicquy site (QiLe-1), Bathurst Island, Nunavut provided the elements for constructing computer models of alternative whalebone houses, which were tested for structural stability. The stresses and deflections in framed structures of these models were determined using 3D finite analysis. With Multiframe, a computer application used by engineers to design and test frame structures, the behaviour of various idealized forms of a Thule whalebone house were compared. In the ideal case, a house built entirely of closely spaced mandibles would have resulted in a form with great strength and stability. However, finite element analysis can indicate that introducing ceremonial elements into the design of these forms can change the strength of the architecture (Dawson and Levy 2006; Lee and Reinhardt 2003:114). In this case, the maxilla/crania building elements used as a ceremonial entrance reduced the overall structural integrity of the structure. We also examined the importance of ribs as a means of reducing racking and hoop stress

in the structure. Finally, we considered how the age of the actual whalebone elements impact the overall stability of these unique forms (Curry 2002; Erickson, et.al. 2002; Rayfield, E., et.al. 2001; Snively, E and A. Russell 2002). Whalebone changes in elasticity and strength as it ages. By considering the differences in material strength by age of these unique building elements, some light is shed on the variety of design solutions that were created to withstand the harsh living conditions of the arctic.

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Building castles on the cheap: A critical evaluation of low-cost 3D modelling

(short paper)

PAFORT, Catja

Keywords: 3D modelling, DEM, costs

Regardless of the level of realism of complex Virtual Reality models like 'Roma Instaurata', they represent a commitment in time and resources that few researchers can provide if they wish to use 3D modelling as one of many techniques alongside photography, mapping, and GIS, to name a few. The point of this paper is to examine the possibilities and limitations of models that can be produced by those with little or no modelling experience. To provide limitations, a budget of \$250 and 80hrs (= two working weeks) was set. The models produced under these constraints are not designed to be standalone projects with the same scope as professionally produced Virtual Reality constructions; they are supposed to complement and enhance existing research in archaeology and related disciplines. This paper deals with two main questions: what kinds of models are possible to produce under these constraints, and what is their academic validity. Examples are drawn from the three main groups of 3D models: structural models, which reproduce the construction of buildings or artefacts, representational models, which reproduce the appearance of buildings as well as their relationship to their immediate environment, and conceptual models, which concentrate on selected aspects of the modelled objects, eg. their shape, dimensions, and location within a landscape, without making a claim to being faithful reproductions. Landscapes present an even greater challenge to modellers than buildings, and the acquisition of reliable DEM data is usually connected with great cost or difficulty. Examining alternative methods of relief construction for use in viewshed and visual impact studies makes up the second

part of the paper, culminating in a comparison of digital constructions and photographs of Harlech Castle (North Wales, UK).

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**AUTHENTICITY AND ACCURACY OF VIRTUAL
RECONSTRUCTIONS – A CRITICAL APPROACH**

APRIL 5, SATURDAY

AUTHENTICITY AND ACCURACY OF VIRTUAL RECONSTRUCTIONS – A CRITICAL APPROACH

Chair: VASÁROS, Zsolt

In the last 2-3 decades numerous virtual reconstructions have been published in the field of archaeological representation and cultural heritage management. Softwares and modelling methods have become much more sophisticated, and user-friendly platforms have made the creation of 3D models fast and simple. Nevertheless, there is a significant fluctuation in their “quality” and precision. The aims are also varied, and we can encounter all kinds of uses between visual effects for movies and accurate, scientific models and photorealistic reconstructions. The developments of the past decades justify our questions raised regarding the issues of the authenticity and accuracy of such virtual reconstructions. In many cases these reconstructions are created as part of the analytic preparations for the reconstruction of monuments, and here the issue of authenticity is especially acute. One of the advantages of computer modelling can be the option of alternative reconstructions and their progressive analysis, which is, however, utilized only by very few projects.

The session invites papers discussing and critically analyzing the above issues. With regard to case studies we invite papers that present projects – and their scientific background and the means of the reconstruction – that go beyond mere aesthetic representation.

The digital model of the Villa of the Papyri: Issues of reconstruction

(short paper)

ZARMAKOUPI, Mantha

Keywords: 3D modelling, alternative reconstructions, Villa of the Papyri

The reconstruction of an ancient building is a research project that asks for decisions of subjective nature. The archaeological record is usually fragmented and researchers have to propose solutions on the ways in which structures are built or look in their reconstructions. In the case of the Villa of the Papyri, the problem of reconstruction is further complicated by the fact that the site still lies underground and its plan was created during the discovery of the villa in the eighteenth century. The record is not only fragmentary but also physically inaccessible. Attempts to reconstruct the site have been influenced by the Getty Villa, whose plan was based on the Villa of the Papyri but whose final appearance replicated other houses and villas on the bay of Naples. Ultimately, there can be no conclusive model of the Villa of the Papyri and the new digital model of the Villa presented in this paper does not claim to be one.

The recent excavations, conducted in the past twenty years, have confirmed Weber's plan and have contributed to our understanding of the Villa's position in the landscape as well as its access from the sea. In this paper I will present a digital model of the Villa of the Papyri that incorporates the new information and proposes a reconstruction of the Villa. Research on the architecture of Roman luxury villas has informed this reconstruction. I will analyze the decisions taken in reconstructing the Villa and tackle the ways in which the ambiguous issues were resolved. The purpose of this paper is to open a discussion on the ways in which we can approach the reconstruction of this ancient site.

UCL Institute of Archaeology

An Archaeology of the Mundane: Interpretation and reconstruction of the Grandi Magazzini di Settimio Severo at Portus, Italy

(short paper)

BEALE, Gareth C.

Keywords: 3D modelling, alternative reconstruction, Roman urban space, Italy

This presentation will discuss and seek to explain the methodologies employed in the interpretation and virtual reconstruction of the Grandi Magazzini di Settimio Severo, a large structure which forms part of the Roman harbour complex at Portus, Italy.

Portus was the principle harbour of Rome for more than three hundred years from its initial construction during the reign the Emperor Claudius in 42AD. Development was undertaken by the Emperor Trajan in the mid second century; it was during this phase of development that the Grandi Magazzini di Settimio Severo was built.

The primary goal of this project has been to explore the form and function of the Grandi Magazzini di Settimio Severo. It explores the implications of using these terms for architectural archaeology and explains how they might be of use in the analysis of Roman urban space. I also seek to explore and to propose a new approach to dealing with uncertainty within an archaeological data set.

In order to achieve this objective it was decided to integrate virtual reconstructions within the research process in a meaningful way. The reconstructions not only acted as illustrative tools, they also played a functional role in the interpretive process. During the discourse which accompanied the interpretive process, the models have formed a visual focus and catalyst for discussion. They were constantly updated and altered in accordance with changing conceptualisations and so they provided an adaptive and engaging focus. In fulfilling this role the virtual reconstruction has become a front line tool for archaeological analysis rather than a side show or visually engaging but vacuous and ill-considered end product.

The methodology proposed emphasises the difficulty of visually representing data which is loaded with cultural and ideological meaning and explores the extent to which this data can be used to create virtual pasts which are more than visual constructions of modern misconceptions of the past.

Through the use of 3D modelling, a series of virtual reconstructions have been developed. Each represents a differing interpretation of the appearance and function of the building. These have allowed data collected at the site to be consolidated and interpreted in a way which has not, until recently, been possible. It has also allowed the data to be interpreted from a unique perspective.

University of Southampton

Managing the uncertain in archaeological virtual environments for educational purpose. The Glauberg VE

(short paper)

BEUSING, Ruth

Keywords: 3D; Environmental Reconstructions; Modelling; GIS, Mobile Guide, Simulation; Teaching; Virtual Reality; Work in Progress (Project)

How can we develop virtual-scenes of archaeological sites and their environments to best provide both: high quality, interactive virtual surroundings and the correct procurement of archaeological research? The NetConnect project has dedicated its research inter alia to this task. The Glauberg VE is one of three project prototypes of NetConnect developing 3D environments of archaeological sites for web, desktop and mobile use.

Computer games and animated films have formed visual and auditory habits of public users on-site, in museums and in the internet. Many VE in archaeological contexts still blur the distinction between the actual knowledge of the archaeologists and the photo-realism those systems provide. Many Archaeologists emphasize to avoid the impression of completeness and to divide and highlight certain and uncertain information both in the same model. In preparation of the Glauberg VE different approaches to the presentation of uncertainties in VR models have been collected and evaluated. This paper will deal with a comparison of diverse approaches and present the first Glauberg VE solutions in this direction. Using these techniques the Glauberg VE tries to find different kinds of demonstration/visualization of uncertainties in interpretation. Metadata, visual effects and are utilized in the model to enable the user to find out more about variants in architecture, environmental patterns and different suggestions about social life. These will be mainly

achieved by Web based GIS technologies what will be used to navigate the archeological sites and to access interactively virtual reality reconstructions of the sites.

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Surfaces as a medium to project excavation generated plans onto 3D Space

(short paper)

HILL, David

Keywords: 3D modelling, GIS

3D is difficult, expensive and time consuming – is probably how many archaeologists that have attempted 3D would summarize their experiences with it. The benefits that 3D give lie largely in the domain of visualization, few attempts at solving analytical problems of data have successfully been made. Another problem is the production of 3D images that can be effectively shown in a printed format, such as a report or publication. 3D is a luxury item in archaeology – in that the primary uses of excavation budgets goes to data acquisition, recording, report and archive production and is consequently not seen as a central or indispensable element in the archaeological tool kit. Recent work undertaken by David Hill, from the Museum of Cultural History, University of Oslo in creating a digitized plan and GIS of the classical city of Metropolis, Izmir, western Turkey has looked at incorporating a 3D element into the normal recording strategies, and GIS of Metropolis. A GIS in plan is the main goal of the work, yet the possibilities for effective and exciting visualization are present in the material, that is a classical city with monumental architecture; defensive walls, amphitheatre and standing remains, and cannot be avoided. By using surface model and projecting the plan data on top of that an effective and resource efficient use of 3d has been achieved. Many attempts of architectural visualizations aim to recreate the building and remains and are undertaken by architects and add detail and elements to models that are subjective in nature. Another important aspect behind 3D reconstructions is that working in this way only uses observed and therefore objective views of the Metropolis' remains rather than subjective reconstructions that cannot be used for pure archival purposes. We are in a period when 3D scanning in the field is becoming cheaper and more available, but most of us do not yet have the possibilities or resources to employ them, and plan recording of structures and contexts are still the central elements of fieldwork and excavation that we use our time and resources on. In this paper I will present simple yet effective results in 3D that enhance plan recording through visualization.

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Augmented reality based user interfaces to assist fieldwork on excavation sites

(short paper)

KAYALAR, Ceren¹ – KAVLAK, Ahmet Emrah² – BALCISOY, Selim¹

Keywords: Mobile augmented reality, archaeological excavation site, user interface design

Archaeological site excavation is a destructive and irreversible process. According to archaeologists, there is a certain need to visualize and analyze the previously collected data and completed work. Over the past years, researchers have developed virtual and augmented reality (AR) applications for cultural heritage sites. The current applications are mainly focused on AR context, where 3D virtual objects are integrated into the real environment in real-time. They can be classified into two main categories: mobile tour guides and reconstructive tools of remains. Although there are examples of excavation analyzers in indoor augmented reality and 3D virtual reality contexts, there are no such applications which offer real-time on site digital assistance using outdoor augmented reality.

In our project, we present an outdoor augmented reality tool to assist fieldwork of archaeologists on excavation sites which provides a user friendly interface. Our prototype consists of an ultra mobile PC embedded with a camera and connected with orientation and positioning sensors. It serves as a navigation and annotation tool.

We provide a user scenario to explain the workflow: An archaeologist wants to work on a point of interest (POI) in the excavation site. He/she makes observations on the provided vectorial map and gets information of the POIs on graphical interface widgets. Upon selecting POI to investigate further using the stylus of the mobile PC, the POI's detailed information sheet appears. Besides this navigation property, our tool allows the archaeologists to model the remains of the port walls in real-time, where AR context is activated. By lifting the mobile PC to his/her gaze direction, camera input starts and AR interface offers the 2D model of POI. The user selects reference points of the wall on the video input by considering the corresponding points of the 2D model and completes the 3D modeling process. The archaeologist can later work on the remains by marking and annotating the different strata on the video input. Thus, a complete 3D model of POI is created on site with layer information.

We are currently testing our prototype at the Yenikapi excavation site in Istanbul. This area is considered as the most exciting and important archaeological discovery in the history of Istanbul where the archaeologists uncovered an ancient port of Constantinople with perfectly preserved ancient ships' skeletons. Since 2005, a team of archaeologists, geologists and authorities of Istanbul Archaeology Museum are working on the remains on the fourth-century port, *Portus Theodosiacus*.

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Standards, scientific reliability, uncertainty and 3D visualization for Cultural Heritage

(short paper)

HERMON, Sorin

Keywords: 3D modelling, EPOCH, standards, CIDOC-CRM, XML

The aim of the paper is twofold: to discuss methods and technologies designed to achieve intellectual transparency in 3D visualization outcomes and to define a working framework based on widely accepted standards. The paper will present the experiences matured within the frame of the EU-funded EPOCH Network of Excellence (www.epoch-net.org), in particular debates over technological and methodological standards for 3D Cultural Heritage objects (Collada, X3D and 3D scenegraphs), semantic interoperability of 3D outcomes (use of CIDOC-CRM and XML) and the evaluation of their scientific reliability. Consequently, the London Charter, an initiative that aims to define the basic principles for the use of 3d visualization methods in order to ensure intellectual integrity, reliability, transparency, and concerning documentation, standards, sustainability and access, will be presented.

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Standards, methods and criteria for testing the dimensional accuracy and completeness of computer-modeled archaeological reconstructions

(short paper)

JOHNSON, David

Keywords: high resolution orthographic renderings, dimensional accuracy

Before the introduction of computer modeling, archaeological drafting techniques were used exclusively in the documentation, reconstruction, and publication of dimensional data from excavations and surveys. When orthographic or perspective reconstructions were made, it was generally understood that these drawings would accurately and completely reflect the dimensional data in every prior publication. Because of the large scope of many reconstruction projects, it seems likely that some academic computer models have abridged, simplified, or excluded data collected and published in existing conventional drawings and surveys. But without high-resolution orthographic renderings similar to those published in

conventional architectural studies, it is often impossible to objectively confirm or disprove the dimensional accuracy and completeness of any particular computer reconstruction. This presentation will argue that it is essential to require disclosures concerning the accuracy and completeness of computer reconstructions relative to the dimensional data in existing publications. The publication of high resolution orthographic renderings will be discussed as a prerequisite for objective testing of the accuracy and completeness of reconstructions. A planned trial of testing methods and procedures will also be presented, together with high resolution reconstructions of the mastaba of Knumhotep at Dahshur developed in collaboration with the Metropolitan Museum of Art Egyptian Expedition

The Museum of Reconstructions, Digital Architect



**ARCHAEOLOGICAL RESULTS OF
REMOTE SENSING METHOD**

APRIL 5, SATURDAY

ARCHAEOLOGICAL RESULTS OF REMOTE SENSING METHODS

Chair: CZAJLIK, Zoltán

The increasingly well-known methods of remote sensing have become frequent topics of archaeological conferences. We know many excellent schools, important archives have been created, and aerial archaeological and magnetometric research have achieved important results during the past decades. The aim of the session is partly to review these archaeological results, and partly to present new results that are connected to less wide-spread methods (e.g. gravity measurement, satellite applications, LIDAR, etc.), to specific archaeological fields or periods, and have preferably been verified by excavations or other means.

Pointclouds and radar-waves: Applying new technologies in preventive excavations of Roman sites in Aquincum, Budapest

(short paper)

T. LÁNG, Orsolya

Keywords: excavation, new technologies, laser-scanning, documentation

The growing number of building investments on archaeologically protected territories, represents an ever increasing challenge for archaeologists throughout Hungary.

The situation is especially critical in Budapest, where building activities bring to light the ruins of Óbuda, Buda and Pest. The primary intention of investors, even if they are interested in archaeology, is to have the excavation carried out by the Museum as soon and as cheaply as possible. The demand is similar when public utilities are being constructed or in the case of public transport.

Relatively new technologies such as geophysical survey and laser-scanning have been used by the Budapest Historical Museum, mainly as complements to traditional documentation. A few case studies will be presented here to show how useful these technologies really are. Further, it will be shown that through these new technologies, we have been able to fulfill those expectations and conditions developed earlier (“New technologies and their application to Cultural Heritage preservation and enhancement” conference held in 2005, Budapest).

This type of very accurate and precise documentation that can be carried out in a few hours, is not only of help to the archaeological research, but may also yield new

information helping to explain excavation data from previous years which hitherto could not be understood.

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Use of imaging total station and photogrammetry in wall documentation, case: Suomenlinna Sea Fortress

(short paper)

KURRI, Ilari

Keywords: Photogrammetry, Imaging, Total Station, Survey

Suomenlinna Fortress is a 250-year-old military construction on the islands near Helsinki, Finland. It has been preserved quite intact because of its military use. The fortress was included in UNESCO's World Heritage List in 1991. Today, due the heavy tourism and weather conditions wall restoration and repairs are a continuous process on the site. Restoration means of course surveying and documentation. In this process efficiency is the key factor.

The purpose of this paper is to introduce the method of using Imaging Total Station Topcon GPT70005i together with Hi-res digital images to produce orthographic images. These images are then used to produce elevation pictures of walls in AutoCad.

First, a sufficient amount of points are measured from the wall. The total station also takes pictures of the points so no markers are needed on the wall. Then hi-res digital images are acquired and imported together with survey data to Photomodeller software. Then images are rectified on Photomodeller and exported to AutoCad and the actual Cad-drawings are produced. The method is very quick and rather cost-efficient and the actual accuracy is adequate.

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Cadastral of tell settlements in Hungary

(short paper)

ANDERS, Alexandra – CZAJLIK, Zoltán – CSÁNYI, Marietta – KALICZ, Nándor –
NAGY, Emese Gyöngyvér – RACZKY, Pál – TÁRNOKI, Judit

Keywords: database, remote sensing, aerial photography

This paper will present the results of a research project launched 10 years ago. Its main aim is the creation of a complete database of tell settlements in Hungary. Although Hungarian law provides increased protection for these elements of our cultural heritage, both as protected sites of archaeology and as natural environment, their geographical identification and cataloguing is not complete yet. The program was launched and supported by the Ministry of Environment, while later on Eötvös Loránd University continued its financial support. In its present state – which is not yet final – the cadastral contains the description of 45 Neolithic and 230 Bronze Age tells primarily based on the literature and museum archives. The next step was their exact topographic location. As of 2002 we started the review of the state of the tell settlements, perhaps before the last possible moment. Their continuous destruction has accelerated due to increased agricultural activities, natural catastrophes (floods) and large-scale construction works. The review is carried out through aerial photography. Later on this database could become part of the monitoring system of CH institutions and enable the monitoring of the changes of the tells, their environment and the wider landscape.

Beside the review of their state, the work has a scientific significance as well: it became possible to verify the existence of circular ditches around both Neolithic and Bronze Age tells, previously known only in a few cases (e.g. Jászdózsa-Kápolna-halom). The synchronous study of Bronze Age fortified settlements along the northern edges of the Great Hungarian Plain drew attention to an interesting phenomenon. In some cases (e.g. Emőd Nagyhalom) aerial photography did not verify the existence of a rampart, but their impressive circular ditches make them comparable to tell settlements. At the same time, some of the tells may also qualify as fortified sites (e.g. the plateau of Berettyóújfalu-Herpály-Földvár, which elevates from its surroundings and is protected by a ditch). Consequently, the two settlement types cannot be separated from each other in the Great Hungarian Plain and the neighbouring areas.

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The role of photomaps in archaeological survey

(short paper)

CZAJLIK, Zoltán – TIMÁR, Lőrinc

Keywords: aerial photography, photomap

Despite the fact that computer equipments and software designed to process even highly oblique photographs make it possible to develop aerial photo maps, there is only a marginal use of them. The cause of the problems is that the control points (which could be identified on maps) suitable for projection or conversion are usually missing from the detailed photos. It is also not clear for many users what has to be the first technological step: the interpretation or the conversion of the images.

According to our experience, the interpretation of the images has to be the first in most of the cases, because it ensures the maximum of the archaeological information. As a consequence, sometimes it is very difficult to synchronize the layers of the interpretation as they come from photos which have different geometry and contents. The priority of the archaeological filtering is very important when using image processing software. This method makes it possible to get the maximum from their layer technology and in addition there is a great chance to remove the modern structures from the interpretation. Even the phenomena of the same archaeological period can be grouped – sometimes a relative chronology can be developed, too.

The comparison of photo-maps and field survey data have had its results: there is no possibility to collect finds for dating at a great part of the phenomena identified in the photos, sometimes even the dating of larger objects (eg. trench systems) proved to be impossible without excavations. However, in some cases we have noticed (eg. in the surroundings of Bugyi) that the information drawn from the interpretation of aerial photomaps helped us to connect separated archaeological sites identified by field surveys – even through zones with no archaeological finds on the surface. This emphasizes the importance of the use of photo-maps in archaeological survey work. We could even think about the possibility of redefining the concept and meaning of “archaeological site”.

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Reconstruction of the geoarchaeological landscape of Zominthos (central Crete) using geophysical prospection, geomorphological investigations and GIS

(short paper)

SIART, Christoph – EITEL, Bernhard – HECHT, Stefan – SCHUKRAFT, Gerd

Keywords: geoarchaeology, palaeoenvironmental reconstruction, geophysical prospection, earth resistivity tomography (ERT), sediment archives, GIS, remote sensing

In the last few years, numerous reconstructions of ancient landscapes have been successfully conducted and thus increasingly attracted the interest of archaeologists and geoscientists, particularly in terms of transferability to other regions and so far unstudied areas. As presented in this paper, using a multi-component top down approach based on preliminary GIS and remote sensing investigations, subsequent geophysical prospection (e.g. refraction seismics and geoelectric resistivity measurements), sedimentological analysis of geoarchives (colluvial fillings of karst depressions) and topographic surveying (total station and GPS mapping) can significantly support investigating palaeoenvironments and offer new and promising prospects to future geoarchaeological work.

The main focus of the project is on the Ida Mountains (central Crete) which are characterised by several remains of the Aegean Bronze Age (Neopalatial Period about 1650 B.C.) on a karstified high plateau at 1200 m a.s.l. Since the recent climatic and geologic conditions are very unfavourable for human purposes, the upper limit of modern settlement activities is located at about 700 m a.s.l. Therefore, the crucial question is how and why Bronze Age people were able to live in such a remote and inhospitable region. In cooperation with the current archaeological excavations we investigate the environmental and anthropogenic parameters in order to reconstruct the palaeoenvironmental conditions and processes in the Mid and Late Holocene.

In the preliminary context of fieldwork, adequate investigation areas (karst depressions) were mapped and selected on a large scale by remote sensing and GIS applications. Subsequent local refraction seismics enabled us to detect the thickness of colluvial fillings, while electrical resistivity imaging was used to analyse the differentiation of loose sediments and subsurface archaeological remains. These profile sections helped us to determine the most promising sediment locations for selective percussion drilling on the microscale. Off-site study results prove that the dolines are filled up with loose material more than expected. The analysis of geoarchives was carried out by X-ray diffractometry, grain size investigations, detection of heavy mineral spectra, soil chemical studies etc. Simultaneously conducted on-site investigations with ERT show furthermore that the size of the nearby Bronze Age settlement is by far bigger than actually indicated by superficial findings.

The aim of the paper is to demonstrate the potential of applying a set of modern geoscientific methods for archaeological purposes with regard to developing an image of landscape evolution. Moreover, the interconnection of techniques will be discussed and

archaeologically relevant research results will be presented, e.g. resistivity tomograms, micromorphological analyses of sediment cores and GIS outcomes.

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Safeguard of archaeological heritage in Ethiopia: Satellite photogrammetry for the archaeological map of Melka Kunture Palaeolithic site

(short paper)

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Keywords: Palaeolithic, satellite photogrammetry, IKONOS, DGPS, GIS.

An archaeological map represents a useful instrument to preserve the cultural heritage of an area; in this way the territory of places up to now kept untouched can be safeguarded and a proper landscape development can be proposed for them. Melka Kunture (Ethiopia) is a Palaeolithic site spreading over about 100 km², dated between 1.7 and 0.2 Myr., with more than 80 Palaeolithic sites individualized in 40 years of excavation. With the aim of safeguarding these sites, an archaeological-topographic map at a scale of 1:10,000 has been created using two Standard Stereo IKONOS 1m Pansharpened satellite imageries; the data has been organized in a Geographic Information System (GIS). The availability of high spatial resolution scenes allows us to consider satellite photogrammetry as a valid alternative to aerial photogrammetry, maintaining satisfactory characteristics of spatial resolution and geometric accuracy adding multispectral information. Furthermore, especially in developing countries where aerial photos of adequate scale are rare, it permits remarkable cost savings. A DGPS survey has been performed in order to collect topographic and archaeological data useful for the preprocessing of the images and the creation of the archaeogeodatabase, respectively. Digital photogrammetric techniques allowed the external orientation of the scenes, so that images could be analyzed by the stereoscopic vision necessary for the restitution of the topographic features. From this, the Digital Surface Model and the orthoimages of the whole area have been created. Thanks to the multispectral character of the images, also the land use interpretation of the terrain has been performed, focusing particularly on the individuation of obsidian outcrops of which Melka is the provisioning source.

The information related to the obsidian exploitation, in addition to the archaeological and topographic data contained in the GIS, will permit to perform intersite analyses, necessary to propose a settlement model and to create a predictive model concerning the position of buried settlements. In this case, the future research activities will be oriented

to the excavation of unexplored remains in a way to find new sites continuing supporting the conservation and the protection process of this invaluable heritage. The archaeological map will be delivered to the Ethiopian Archaeological Service; this map will constitute an essential tool for monitoring and preserving the sites scattered over the area, and will permit to propose Melka Kunture as a future UNESCO World Heritage Centre.

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Detection of Neolithic settlements in Thessaly, Greece through multispectral and hyperspectral satellite imagery

(short paper)

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Keywords: Remote Sensing, Hyper-spectral imagery, Tells, Thessaly, Neolithic

Thessaly is a region of low relief in Greece where hundreds of Neolithic settlements/tells called *magoules* were established from the Early Neolithic until Bronze Age. Multisensor remote sensing was applied to the study area in order to evaluate its potential to detect Neolithic settlements.

Hundreds of sites were geo-referenced through systematic GPS surveying throughout the region. Data from 4 primary sensors were used, namely Landsat ETM, Aster, EO1 - Hyperion and Ikonos. After correcting geometrically and atmospherically all the images, the digital number pixel values were converted to reflectance values.

A range of image processing techniques such as colour composite, principal components analysis, de-correlation stretch and then visual interpretation, were originally applied to the hyperspectral imagery in order to detect the settlements and validate the results of GPS surveying. The next step was to collect spectral signatures of these tell sites, to correlate them within the same spectral range and finally to proceed with their statistic analysis. Classification of all the images using different hard and soft classifiers was followed. Various filters were applied to all images to explore the high spectral variability of the settlements patterns. In addition, multiple vegetation indices were applied to detect any possible surface soil anomalies that could be related to the location of the sites. Finally, the

thermal infrared imagery of Landsat and Aster was used to measure the thermal emissivity of tells.

To cope with the difficulties of pixel based methods, object-oriented classification techniques were applied to Ikonos imagery to classify the tells according to their shape and geometry.

Although there are specific difficulties encountered in the classification of archaeological features composed by a similar parent material with the surrounding landscape, the results of the research suggested a different response of each sensor to the detection of the Neolithic settlements, according to its spectral and spatial resolution. The complementary use of different imagery could lead to a more satisfying result, especially in predictive modeling.

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Multispectral satellite imagery and the detection of subsurface Roman field systems

(short paper)

ORENGO, Hector A. – PALET, Josep M.

Keywords: landscape, Roman, centuration, satellite, multispectral

Multiple factors should be considered when employing multiband satellite imagery to locate subsurface archaeological features. It has to be acknowledged that, despite the rapid increment of spatial and spectral resolution in commercial satellite imagery, it remains problematic to locate traditionally-conceived archaeological structures by these means. However, much can be achieved if the research focus is changed from a site-centred investigation to a wider, landscape perspective. In this sense, satellite multispectral image data has great potential in locating landscape macrostructures such as ancient roads or field systems. In this paper the ancient centuriated field system of Roman Tarraco's hinterland will be analysed. Landsat TM near infrared (1.55 – 1.75 μm) band response to subsurface macrostructures will be strengthened by its combination with pluviometric records. This band susceptibility to soil moisture content and the nature of the focused archaeological features will warrant detection improvements. Metrical and morphological analyses will

be combined in order to assess the Roman origin of those macrostructures located through this integrative methodology.

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Locating an unknown archaeological site in the valley of Filippi, East Macedonia, Greece

(short paper)

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Keywords: Aerial and Remote Sensing Archaeology, diachronic aerial photos, diachronic-seasonal QuickBird-2 Images, Best Period of Mark Detection, soil and crop marks, locating unknown settlement

During the last few years, at the Laboratory of Photogrammetry and Remote Sensing of the Department Rural and Surveying Engineers of the Aristotle University of Thessaloniki, there is an ongoing research of the wider area of North Greece (East Macedonia, 500km²), with the purpose of locating archaeological sites. The basic tools for the archaeological prospection are diachronic archived greyscale aerial photos and QuickBird-2 satellite images. At least in one occasion, the sections of excavation that took place in positions located during this research and pointed out by the research team, brought to light archaeological findings of special interest.

In this paper we present the findings of a geographic location, in this wider area of study, that cover an extended area and are probably of significant archaeological importance. The research begun with the processing and study of various scales archived aerial photos (1945-1:42000, 1965-1:7000, 1993-1:30000 and 1996-1:15000). In this dataset, few weak diachronic soil and crop marks, and their geometric patterns called for further research.

Thus, a QuickBird-2 Satellite image, whose date of reception is within the Best Period of Mark Detection, was studied. In this satellite image there were a number of marks of a specific (organised) formation, of total area coverage of 0.275km². The size and the formation of the marks refer to the existence of an ancient buried settlement.

The study, which continues with the gathering and processing of new data, and the surface research that will be conducted, are expected to lead to safe conclusions regarding the dating and the evaluation of the findings.

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Using the three-dimensional capabilities of GPR to reinterpret the Roman town of *Mariana* (Corsica)

(short paper)

VERDONCK, Lieven

Keywords: Ground-penetrating radar, magnetic survey, Roman period, Corsica, archaeological interpretation

In 2006 and 2007, a geophysical prospection was carried out at the Roman town of Mariana (North East Corsica), on two fields north of the excavated part of the town. The aim was to find out more about the extent of Mariana, to localise its centre and elucidate details of its layout. From the magnetic survey, conducted in 2006 with a fluxgate gradiometer, it could be concluded that the town extended over most of the prospection area. A possible industrial zone with iron slag and a presumed kiln complex were detected, and the orientation of most of the buildings suggested a close link with the excavated parts. No clear road traces could be detected, except for one east-west axis represented by an absence of building structures. The northern part of the survey area was characterised by a remarkable absence of magnetic features and was identified as the possible location of the forum. The 2007 ground-penetrating radar (GPR) survey over some of the clearest building structures detected in the magnetic survey allowed reinterpreting some of the results. Slices taken at different depths indicate that the ca. 30 m wide building originally had a regular plan with a courtyard surrounded by a portico. It may have been a big house or a public building, perhaps a bath complex or gymnasium. Shallower walls run through this original structure, probably belonging to a later (late Roman?) phase. Other walls appear east and west of the original building. This gives a possible explanation for the apparent absence of a road network in the magnetic survey. Whereas the magnetic prospection does not allow an easy distinction between shallow and deeper layers, in the GPR results it is possible to observe zones devoid of structures in the early phases of the town's history, which present themselves as possible locations for roads. The GPR survey also allowed a clearer analysis of the magnetically 'empty' area. A few linear anomalies, very weak in the magnetic survey, were found to be connected with GPR traces more to the south. This now seems to dismiss the hypothesis that this area represents the forum of Mariana. A 12 by 2 m test excavation confirmed the orientation and dimensions of two walls belonging to the building complex. The excavation data were helpful for the analysis of the radar wave velocity and for the calculation of the depth of the features detected in the GPR survey.

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**ALTERNATIVE ONTOLOGIES AND
APPROACHES TO DATA MANAGEMENT AND
DATA SHARING**

APRIL 5, SATURDAY

ALTERNATIVE ONTOLOGIES AND APPROACHES TO DATA MANAGEMENT AND DATA SHARING

Chair: FRISCHER, Bernard

When ontology and reality collide: The Archaeotools project, faceted classification and natural language processing in an archaeological context

(long paper)

JEFFREY, S.¹ – RICHARDS, J.¹ – CIRAVEGNA, F.² – WALLER, S.¹ –
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Keywords: Ontology, Faceted Classification, Natural Language Processing.

As a direct result of the successful proof of concept demonstrator for an archaeological faceted classification browsing system, “Archaeobrowser” (see CAA 2007 and <http://muninn.york.ac.uk/>) the Archaeological Data Service (ADS) and the Natural Language Processing Research Group at the University of Sheffield have embarked on a further project, named ‘Archaeotools’, which is funded by the UK’s e-Science Research Grants Scheme which itself is a collaboration between three major funding bodies, the AHRC, the EPSRC and the JISC.

The Archaeotools project represents the first UK implementation of a faceted classification system in an archaeological context, specifically to enhance the ADS’s Archsearch facility moving the search paradigm away from the strictures of a Google style “type and hope” approach towards a more intuitive and informative browser system, as well as using natural language processing to tackle the problem of unstructured, but highly valuable, archaeological data. However, the browser element of the project has faced two major challenges, firstly it relies on the existence and application of ontological structures and their associated thesauri and controlled word lists. Secondly, to take full advantage of the new system, data that is currently unstructured such as Grey Literature or historical literature needs to have structured metadata generated from it. This paper examines both these issues giving a practical perspective on the usage of natural language processing to populate pre-existing thesauri thus creating searchable and ‘resource discovery’ metadata and, more particularly, a real world example of the practical application of numerous independently curated thesauri and word lists to normalise large archaeological datasets. This paper will present to the broader archaeological community with the first concrete analysis of the scale and breadth of the mismatch between existing (legacy) datasets in the UK, such as monument inventories,

and idealised ontologies and thesauri, as well as indicating practical approaches to solving these mismatches. The paper will be of interest to all professionals in the cultural heritage sector who curate, or deliver archaeological thesauri or datasets.

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Heurist: Integrating bibliographic and research data in a Web 2.0 participatory framework

(short paper)

JOHNSON, Ian

Keywords: Web 2.0, data sharing, Heurist, data integration

Bibliographies traditionally record a narrow class of materials – primarily printed matter – conveniently instantiated as physical objects. In this paper I argue that the arbitrary distinction between bibliographic and other research data is a hangover from a simpler past, when there was a clear divide between published syntheses and the data from which they were derived. Today published material includes corpus materials such as site catalogues and identification keys, and raw or aggregated data from field surveys, excavations and laboratory analysis.

Artificial distinctions between these different levels of data hinders cross-referencing of information which should be linked eg. the linking of syntheses to original sources. Today's project databases generally fail to connect with the wider network world – they are often desktop-based, shared by copying, inaccessible outside a local network or provide human (html forms) rather than machine (XML) interfaces. We need to build on the real strength of online databases, standards and web services to build systems which flexibly support research and teaching using distributed web-accessible resources which can be edited, extended and remixed on the fly..

To illustrate the potential of a participatory Web 2.0 approach to archaeological information, I will discuss Heurist (HeuristScholar.org), a free academic social bookmarking service which provides rich information handling in a single integrated web service. Heurist handles an easily extensible set of more than 70 record types, ranging from bibliographic references and internet bookmarks, through encyclopaedia entries, seminars and grant programs, to C14 dates, archaeological sites and spatial databases, all uniquely referenceable within a single database service and cooperatively editable.

Heurist provides particularly rich facilities for attaching annotation to any record, irrespective of its type. This includes geographic data, photographs, multimedia files and wiki annotations. It provides a novel method of recording annotated, date-stamped, typed relationships between records, irrespective of type, allowing derived information to be

linked back to bibliographic sources (such as sites to the documents in which they are referenced) or field notes to the photographs, artefacts or trenches which they describe.

In this paper I will illustrate the way Heurist's flexibility has been used to build a variety of applications in which networks of related entities are built cooperatively online and visualized through formatted lists, maps, network graphs and timelines. These range from a departmental web site, through an archaeological bibliography and a research network visualization, to historical events visualization and contemporary community stories.

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Towards an accessible collection: What the standards won't tell you and why this matters for large scale archaeological projects

(long paper)

KILBRIDE, William – MCADAM, Ellen – RILEY, Kirsten – HAWKINS, Tracey

Keywords: virtual access to museums, investment-led archaeology, Glasgow Museums

This paper explores the relationship between physical and virtual access to museum collections, with particular reference to the very extensive collections owned by the City of Glasgow and curated by Glasgow Museums. Providing access to collections – and knowledge about collections – is a high priority for most museums, especially a large civic museums service. The wide range of the collections and the equally broad range of public interests means that this is no simple matter, especially when the overwhelming majority of the collection – around 98 percent – is in storage. Many museums have sought to address that problem in recent years with a particular focus on virtual access. To that end, standards and good practice for accessibility have emerged over the last decade and are increasingly supported by statute.

This paper will review these standards from the perspective of a current project within Glasgow Museums which will provide online access to the entire collection. It will be noted that the allure of digital accessibility is in large measure illusory unless access is planned into storage and archiving.

The paper will end by reflecting on what this means for the conference themes of large scale, investment-led archaeological research. Using the experience of Glasgow Museums as a example, consideration will be given to the sorts of services that will be required if the current boom in archaeological research is to have a lasting impact on research, learning and teaching.

Glasgow Museums

Not all content is ‘Born Archival’: Empirical acquisition, scientific reliability, and long-term digital preservation

(long paper)

MUDGE, Mark¹ – ASHLEY, Michael² – SCHROER, Carla¹

Keywords: digital Cultural Heritage, digital archiving, digital surrogates, authenticity

The tools and standards of best practice adopted by cultural heritage (CH) professionals will determine the sustainability of digital heritage, or lack of it. The paper explores a digital future for cultural heritage through key principles: adoption of digital surrogates, empirical provenance, perpetual digital conservation, and the democratization of technology.

This paper focuses on the barriers influencing widespread adoption of digital techniques in science and scholarship, and how these issues are mitigated through the practice of archival tolerance and self-documenting work practices. We draw on several successful examples from current projects, including collaborations with the University of California at Berkeley, the University of Southern California and Cultural Heritage Imaging. From field capture to archive to public sharing, we will demonstrate the impact of unifying core heritage documentation values and practices with the enormous power of the digital age through breakthrough techniques for digitally acquiring empirical information about our world, especially for cultural heritage.

We develop the key concept of ‘born-smart, born-archival’ digital representations and the roles the information acquisition process, empirical provenance records, and semantically-based knowledge management strategies play in generating ‘born-archival’ digital information. The paper also explores how empirical provenance can contribute to the authenticity and reliability of digital surrogates and, in combination with principals of perpetual digital conservation, can ensure that digital surrogates will be archived and available for future generations.

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Making the LEAP: Linking electronic archives and publications

(short paper)

RICHARDS, Julian¹ – WINTERS, Judith² – CHARNO, Michael^{1*}

Keywords: ICT, electronic publication, electronic archive

The growth of the Internet has been described as the most important event since the invention of the printing press. The Arts and Humanities, however, have been relatively slow to embrace electronic publication, and a range of exemplars is needed. Traditional publication of research projects often comprises a series of journal papers, a popular summary, an academic monograph, and sometimes an offline research archive, which is rarely accessible. There are growing numbers of online databases, but these are rarely linked directly to interpretative analyses. In addition, the Arts & Humanities community has no conceptual framework for evaluating online databases, which results in uneven and unsystematic reward for those that create them. Given that supporting data are invariably in electronic format, the advent of e-publication allows the combination of different forms of dissemination and the adoption of an integrated approach.

The potential of linking publications and archives has been discussed (Richards 2002) but as yet there are few exemplars (Clarke *et al* 2003, Millett *et al* 2000, Richards 2001; Theatron 2002). The aim of the LEAP project (<http://ads.ahds.ac.uk/project/leap/>) is to investigate novel ways in which electronic publication over the internet can provide broad access to research findings in the arts and humanities, and can also make underlying data available in such a way so that readers are enabled to 'drill down' seamlessly into online archives to test interpretations and develop their own conclusions. The LEAP project is using the existing infrastructure of the e-journal *Internet Archaeology* and of the ADS to provide four sustainable exemplars of multi-layered e-publications and e-archives. The four exemplars selected for the project were Medieval Whittlewood, The Troodos Archaeological and Environmental Survey Project, Silchester: House 1, and Ancient Merv (in progress). Users can experience these project outputs from either the publication or archive level, and navigate seamlessly between the two. This paper will review the four exemplars and address the technical aspects of their implementations.

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The combination of topographical, epigraphical and literary data on ancient Aventine in Rome with interactive maps

ANDREUSSI, Maddalena

Keywords: written sources, topography of Rome, CIDOC-CRM, AJAX, Semantic Web

At CAA 2007 in Berlin we described the concept of a tool to represent monuments, sites and places described by ancient sources as categorized in the “Fontes ad Topographiam Veteris Urbis Romae Pertinentes”. Ontologies and modern semantic tools make it possible to recreate internal relations linking together places with monuments (the natural starting point of each search). This evolves in links evaluation allowing us to discover connected information on names, creation, function, historic background and even events leading to a monument’s destruction. CIDOC-CRM ontology and the flexibility of the RDF language give us all the necessary technology to express complicate relations of this kind in order to build a complete history of monuments and places. The AJAX technology combined with the increasing quality of the web-based development tools available today (WEB2.0, Semantic Web) allows us to create powerful and user-friendly web applications. These are capable of managing the knowledge provided by the “Fontes” by using interactive maps and advanced semantic query interfaces. The project has now started its first year and involves the encoding of a yet-unpublished book on the Fontes. The book’s subject is the topography of the Aventin, the hill of Rome included by Augustus in the Regiones XII and XIII. We intend to illustrate our project’s application with some examples applied to a number of passages of ancient sources. Hopefully this will provide an interesting enhancement of our knowledge on the monuments of ancient Aventin.

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**CIDOC-CRM IN DATA MANAGEMENT AND
DATA SHARING**

APRIL 5, SATURDAY

CIDOC-CRM IN DATA MANAGEMENT AND DATA SHARING

Chair: STEAD, Stephen

Standardization or mapping? Some considerations on CIDOC-CRM extensions and alignments

(short paper)

D'ANDREA, Andrea

Keywords: CIDOC-CRM, Semantic Web

In the third generation of Web, Internet will become a universal medium for the exchange of data, information, and knowledge. A common framework will be guaranteed by the Semantic Web that will allow data to be shared and reused across applications and community repositories. To achieve this goal conceptual tools will be necessary to find, share and integrate information more easily. Ontologies are simpler means for structuring knowledge and for this reason they are seen as the key of Semantic Web.

Far as archaeological domain is concerned, only apparently we have many digital resources available on-line. Various formats, systems and structures make it difficult to access to different archaeological repositories. Standardization and sharing data are then the key works in archaeological computing agenda. In order to overcome this limit, mainly produced by the spread of computer applications often developed with proprietary format, recently we witnessed of implementation of thesauri, standards and metadata. The multiplication of these tools has increased the confusion: to guarantee the interoperability among various archives it is necessary to produce a mapping between different data structures.

Recently the diffusion of CIDOC-CRM ontology made this task easier. Many mappings to CORE CIDOC-CRM are already available for data encoded according to Dublin Core, EAD, AMICO, etc. Besides CIDOC-CRM is aligned to DOLCE, a foundational ontology and to other domain/application ontologies (X3D, MPEG7). Some national standards, for instance English monument inventory (MIDAS) or Italian archaeological forms (ICCD), are already mapped on CIDOC-CRM.

In this perspective CIDOC-CRM will become the core of a process joining different archaeological and not archaeological domains in a one multi-cultural and multi-linguistic environment.

This contribution will refer to these different mapping procedures pointing out benefits and risks as far as the process of determining correspondences between concepts and properties concerned.

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Data sharing between different databases by using an ISO 21127 related data format

(short paper)

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Keywords: CIDOC, data management, data sharing

Each archaeological project uses its own data source to store the relevant information. Different excavations with related content and findings store these findings in a different manner and shape, therefore reusing and sharing are quite difficult. However the biggest utilization would arise by using and combining the information of more than one source. A lot of manpower is required to reshape the data and reenter it into other databases. During this process the risk of mistakes (such as typing errors) is high. Afterwards changes in the original database do not affect the copy. Therefore approaches for an automatic, fast and easy data exchange are crucial.

The approach of this paper is to use general interfaces which define a general data format to exchange information between databases. For this purpose the ISO 21127 standard implemented by CIDOC (<http://cidoc.mediahost.org/>) is used. With some adaptations this standard is suitable for the intention of data exchange between different archaeological projects.

Based on the fact that each IT-system uses its own lists for describing the properties of the objects it is necessary to handle this issue by identifying different coding tables.

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A STAR is born: Some emerging semantic technologies for archaeological resources

(long paper)

MAY, Keith

Keywords: CIDOC-CRM, ontological modelling

Following work on data modelling of the various archaeological systems at English Heritage's Centre for Archaeology (CfA), a decision was made to create an ontological model that better reflected the inter-relationships across and between the existing information held in those systems. The aim was to inform any future systems development by better explicitly reflecting why people were recording the data that they did, and most importantly to highlight how the different types of data held in often isolated systems, carried important relationships to other data that needed to be made more readily available in any newly designed interoperable system.

Some initial results of this modelling, using the CIDOC-CRM, were presented at CAA2004 in Prato (ref: Cripps & May forthcoming). Since then work has progressed on refining the modelling and diagram of the CfA's archaeological processes and to create a number of extensions of the CIDOC-CRM to incorporate the details of CfA's archaeological information domain.

This paper will present the latest archaeological ontological modelling at English Heritage, and discuss the attempts to enable implementation of the modelling by mapping the ontological work to data fields from the CfA's legacy systems; existing databases; and plans for future systems integration.

Much of this latest work to be presented has been carried out in collaboration with Glamorgan University's Faculty of Advanced Technology, under the remit of the AHRC funded STAR project (Semantic Technologies for Archaeological Resources), and includes the development of the archaeological CIDOC-CRM extensions in RDF format, along with the investigation of the emerging SKOS W3C standard for development of online semantic terminology and knowledge organisation tools.

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A CIDOC-CRM model for Egyptian Middle Kingdom pottery: Archaeological theory and ontological practice

(short paper)

PERLINGIERI, Cinzia

Keywords: CIDOC-CRM, Egyptian pottery

This paper presents the conceptual elaboration of a CIDOC-CRM data scheme for ancient Egyptian pottery, based on a case study from the archaeological site of Mersa/Wadi Gawasis, Red Sea, Egypt.

Access to information, interoperability and standard structures are of fundamental importance to guarantee the actual usability and utility of archaeological data. The archaeological community still remains largely out of the international discussion on the “new archaeological methodologies” and the use of documentation standards has not yet entered the “archaeological practice” due to the high barriers to their implementation. Studies on ancient Egyptian pottery are valuable and massive, but still stored, and dispersed, in a myriad of different kinds of archives that make any kind of comparative analysis, both quantitative and qualitative, impossible.

The “Mersa Gawasis Pottery Classification System” is a morphology-based system which refers, for the description of the fabrics, to the so-called “Vienna System”, like many other researches in this field. That fabric classification system, divided into ware groups, sub-groups and variants, has been used to start a domain standardized thesaurus of technical terms for the description of the pottery morphology.

The analysis of ancient Egyptian pottery as a study domain and its conceptualisation as a formal ontology for the development of a practical semantic information system, is based specifically on these domain information requirements. The extracted semantic metadata, and the definition of their physical, spatial, and temporal relationships, or semantic associations, altogether describe the pottery objects and their archaeological context.

The case study demonstrates how the successful mapping of an ontology to the CIDOC-CRM, such as the Mersa Gawasis Pottery Classification System, makes it possible to share domain-specific data with the greater archaeological community and beyond.

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