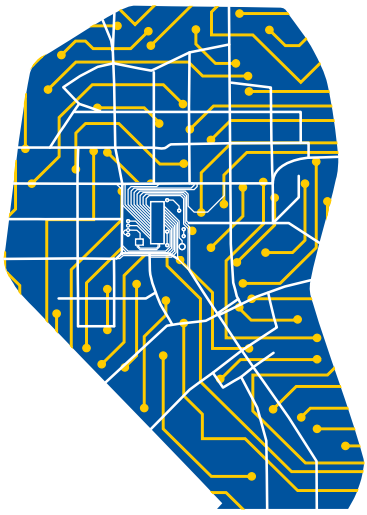
CHECK OBJECT INTEGRITY

Book of Abstracts



CAA
2019

KRAKÓW

Institute of Archaeology of Jagiellonian University
Polish National CAA Chapter

JAGIELLONIAN UNIVERSITY
IN KRAKÓW

Conference held under the honorary patronage of the Mayor of the City of Krakow Jacek Majchrowski

Kraków

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47th Computer Applications and Quantitative Methods in Archaeology

Annual Conference

CHECK OBJECT INTEGRITY

Book of Abstracts

Institute of Archaeology of Jagiellonian University

Polish National CAA Chapter

JAGIELLONIAN UNIVERSITY
IN KRAKÓW

KRAKÓW 2019

Honorary Committee:

prof. dr hab. **Jan Święch** *Dean of the Faculty of History of Jagiellonian University in Kraków*

prof. dr hab. **Paweł Valde-Nowak** *Head of the Institute of Archaeology of Jagiellonian University in Kraków*

prof. dr hab. **Ewdoksia Papuci-Władyka** *Head of the Department of Classical Archaeology*

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WI-FI - ACCESS

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User: maximumwifi@uj.edu.pl
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WITAMY!

Dear CAA Members
and Annual Conference Attendees,

It is with great pleasure to welcome the participants of the Annual CAA Conference "Check Object Integrity", hosted by Kraków and Jagiellonian University. This event is closely connected with the scientific interests developing at our university, especially in the recent advancements in the field of computer technology. For years, we have been championing efforts to improve the quality of archaeological research with the support of computer applications and quantitative methods. The CAA meetings create an excellent platform to exchange ideas and experiences in this area. I would like to express my gratitude to all participants of the conference and its organizers for maintaining the tradition of these meetings and to ensure that they are being kept at the highest scientific level. I am convinced that Kraków with all its heritage of centuries-old cultural development, history and intellectual achievements, will provide a conference with appropriate atmosphere for the scientific discourse. I wish you all a successful meeting and a pleasant stay at Jagiellonian University.

Prof. **Paweł Valde-Nowak**
Head of the Institute of Archaeology of
Jagiellonian University in Kraków

Dear Colleagues,

It is a great pleasure to welcome you all here in Kraków, at Jagiellonian University to the 47th series of Computer Application and Quantitative Methods in Archaeology conferences. Our city, unlike others, is a great combination of history and tradition with modernity. On one hand, there is the 1000-year history of Kraków with the second oldest university in Central Europe, and on the other hand there are modern research and development centres, intercollegiate synchrotron and tens of thousands of students.

We are delighted that the conference has been organised by our team from the Institute of Archaeology, which is the oldest Polish archaeological research institution. The Institute has been conducting research around the world e.g. from Southern and Northern Americas through Europe and the Middle East, to the Altai Mountains.

It is already the 47th meeting of the CAA community. Throughout this time, since the 1st CAA meeting, archaeologist have been exchanging their experiences of the usage of computers and statistical methods. The CAA conferences have become one of the most crucial events within the archaeological community interested in the development of scientific methods of acquiring and analysing the research of our discipline.

The conference has been prepared for you by the Organizing Committee and a group of volunteers from our Institute. On their behalf, I would like to wish you a wonderful conference but also to have a good time in vernal Kraków.

Łukasz Miszk
Head of Organizing Committee

CITY CENTER MAP

CONFERENCE VENUE
Auditorium Maximum (ul. Krupnicza 33)

ICEBREAKER PARTY
Collegium Maius (ul. Jagiellońska 15)

WORKSHOPS
Collegium Minus (ul. Gołębia 11)
Collegium Witkowski (ul. Gołębia 13)

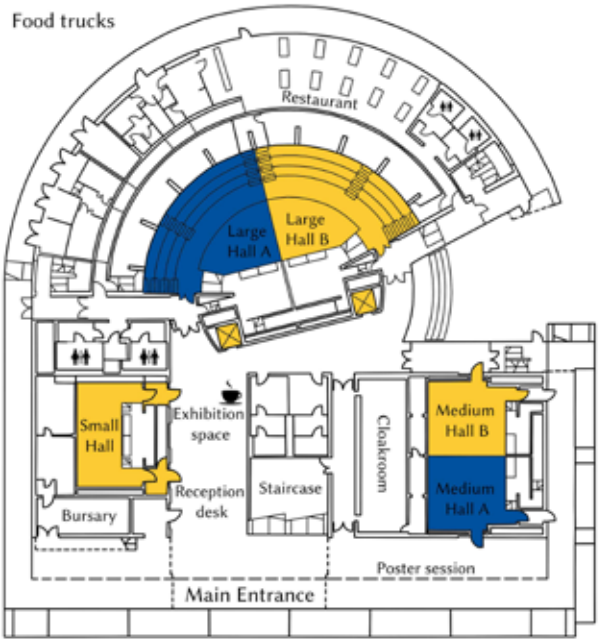
CONFERENCE DINNER
Manggha Museum (ul. Marii Konopnickiej 26)

VENUE

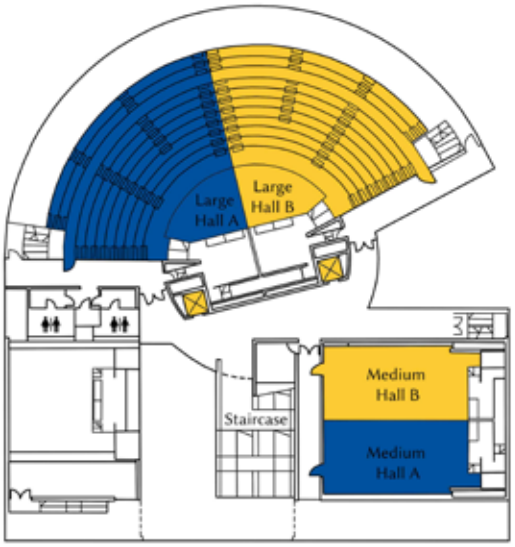
AUDITORIUM MAXIMUM

(address: ul. Krupnicza 33)

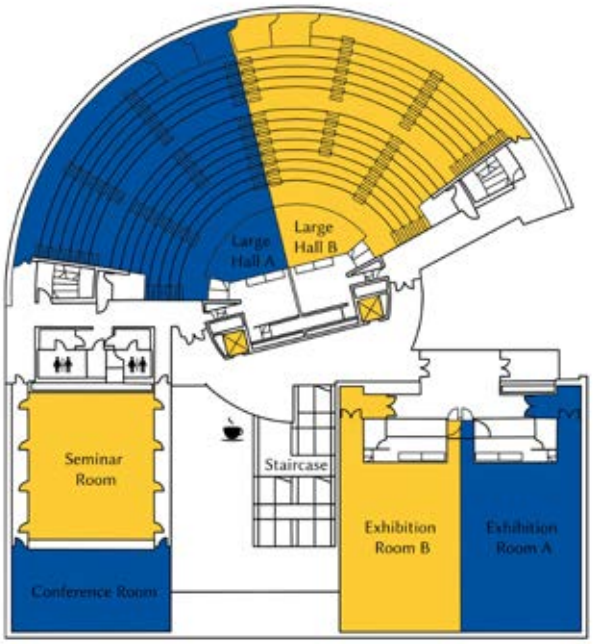
The conference takes place in a modern building of Jagiellonian University located on Krupnicza Street within a walking distance to the Main Square. Opened in 2005, Auditorium Maximum contains various rooms adapted for conference and teaching purposes, including a large amphitheatre hall. Spacious hallways and the lounge are the areas where coffee breaks and poster sessions will take place, providing a nice background for talks and discussions. Having lunch break at the restaurant located on ground floor will be an excellent opportunity for those who prefer to stay in the conference building.



Level 0



Level 1



Level 2

SOCIAL EVENTS

ICEBREAKER PARTY

(Tuesday, April 23th, 17:00-21:00; address: ul. Jagiellońska 15)

On Tuesday, after the workshops, we would like to invite you to the Icebreaker Party which will be held in Collegium Maius, the oldest university building in Kraków, built in 14th and rebuilt in the following century. It is located at the corner of ulica Jagiellońska (Jagiellon Street) and ulica Świętej Anny (St. Anne Street) just a minute walk from the Main Square. Today Collegium Maius serves as a museum of our university and we have prepared a free guided tour for those who would wish to experience the life of a student from Nicolaus Copernicus times. The party will be set on its arcade courtyard and also in the scenic garden.

The access to the event is possible only with yellow dot on the badge.

CONFERENCE DINNER AT THE MANGGHA MUSEUM

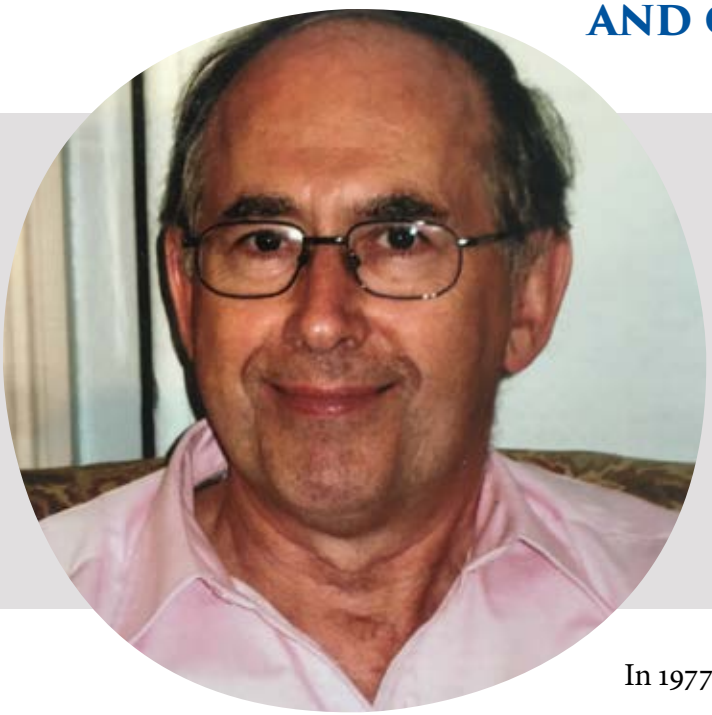
(Thursday, April 25th, 20:00-23:00 ; address: ul. Marii Konopnickiej 26)

On Thursday, we will have a reception at the Manggha Museum of Japanese Art and Technology or in short, the Manggha. Created on the initiative of Polish film director Andrzej Wajda and opened in 1994 as the Manggha Centre of Japanese Art and Technology. The Museum collection consist of artwork donated by the writer and collector of art, Feliks Jasieński to the National Museum in Krakow in 1920. It houses a collection of Far Eastern Art in addition to serving as a host for various cultural events. Manggha is located near the Vistula River, opposite Wawel Castle, which creates a unique and scenic view. The impressive form of the building, reminding the river's meander, was created by the famous Japanese architect Arata Isozaki, in collaboration with Krakow architects. The reception will combine a dinner with a plethora of dishes served buffet-style with a party, with dancefloor and DJ.

The access to the event is possible only with blue dot on the badge.

KEYNOTE

REFLECTIONS ON METHOD AND THEORY AT THE INTERFACE BETWEEN ARCHAEOLOGY AND COMPUTER APPLICATIONS



JOHN
BINTLIFF

In 1977 I took up my first lectureship, in Archaeological Sciences at Bradford University, when the university was encouraging staff to buy their first desktop computer. Since then digital archaeology has been a constant companion in my fieldwork and library research, and although I am not a computer archaeologist, I have always worked closely with those who are. This presentation will focus on the unavoidable, usually fruitful, but often difficult relationship between the approaches favoured by the digital community and the realities of archaeological data and interpretation. The examples given stem from my own experiences from the 1970s to the presentday, and include Sampling strategies, Landscape GIS, Ceramic Study, Big Data, Network Analysis and Virtual Reality.

SCHEDULE

Tuesday

08.00 - 16.00 › **Registration**
10.00 - 16.00 › **Workshops**
17.00 - 21.00 › **Icebreaker Party**

Wednesday

07.30 - 17.00 › **Registration**
09.00 - 10.00 › **Welcome Adresses & Keynote**
10.20 - 18.20 › **Sessions**

Thursday

07.30 - 17.00 › **Registration**
08.40 - 15.00 › **Sessions**
15.00 - 16.00 › **Poster session**
16.00 - 18.00 › **Annual General Meeting**
20.00 - 23.00 › **Conference Dinner**

Friday

07.30 - 17.00 › **Registration**
08.40 - 18.40 › **Sessions**

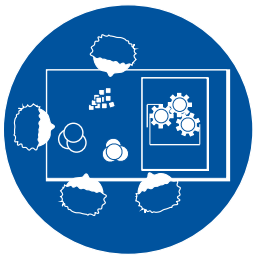
Saturday

09.50 - 18.00 › **Excursions**

TUESDAY, 23 APRIL 2019

WORKSHOPS

(Collegium Minus & Collegium Witkowski, 10:00-16:00)



Conference Workshops will be organised by the Faculty of History of Jagiellonian University. They will take place in two adjacent buildings Collegium Minus (ul. Gołębia 11) and Collegium Witkowskiego (Gołębia 13). These buildings are located in the old city centre in the heart of our university.

The Collegium Minus is one of the oldest buildings of the university, standing next to the Collegium Maius. This building is a burgher house, bought by the university in 1449. Fragments of the former building have survived in the cellars – the Gothic Lecture Hall until today. Today, it houses the Institute of Archaeology.

The Collegium Witkowski was erected in 1908-11. The building is a combination of Gothic-revival, Romanesque-revival and Art Nouveau styles. It was named after August Witkowski - a physicist who worked on physical properties and laws concerning gases especially in low temperatures. In 1910-1911 he was a rector of the university. Originally the building used by the physics department, it now serves the Institute of History.

Philip Verhagen, Steve Stead

WORKSHOP 1: IMPROVING PRESENTATION SKILLS

Gisli Palsson

WORKSHOP 2: FROM SHAPES TO SEQUELS: THE VALUE OF INTEGRATING POSTGIS WITH QGIS

Tomasz Łojewski

WORKSHOP 3: REFLECTANCE TRANSFORMATION IMAGING

Clemens Schmid, Martin Hinz, Carolin Tietze

WORKSHOP 4: CAA SCRIPTING LANGUAGES HACKATHON I – CAN YOU CODE THIS?

WORKSHOPS

Gabriele Gattiglia, Michael Remmy, Holly Wright

WORKSHOP 5: ARCHAIDE. A NEURAL NETWORK FOR AUTOMATED RECOGNITION OF ARCHAEOLOGICAL POTTERY

Eleonora Gandolfi

~~WORKSHOP 6: THE BLOCKCHAIN: MEET THIS "UNKNOWN FRIEND"~~

Stefani Crabtree, Enrico Crema, Iza Romanowska, Colin Wren

WORKSHOP 7: AGENT-BASED MODELLING FOR ARCHAEOLOGISTS

Angus Mol, Aris Politopoulos

WORKSHOP 8: INTERACTIVE HISTORYTELLING WITH TWINE

Serdar Aydin, Zeynep Özge Özdemir

WORKSHOP 9: KILL THE MUSEUM BY DESIGN: A DESIGN APPROACH FOR CREATION AND SHARING OF INFORMATION AND NARRATIVES

Karin Lund

WORKSHOP 10: INTRASIS WORKSHOP

ICEBREAKER PARTY

(Collegium Maius, 17:00-21:00; address: Jagiellońska 15)

WEDNESDAY, 24 APRIL 2019

	Medium A	Medium B	Exhibition A
09:00 - 10:00	**WELCOME ADDRESSES AND KEYNOTE** *Large Hall*		
10:00 - 10:20	**COFFEE BREAK**		
10:20 - 12:40	S02: Progress in WebGIS and DB solutions for Archaeology ***Matsumoto, Uleberg, Hochschild, Märker, Willmes***	S22: Digital Infrastructures for Archaeology: Past, Present and Future directions ***Richards, Wright, Niccolucci***	S27: Chasing heritage thieves: digital methods and approaches to contrasting trafficking and looting of cultural property ***Traviglia & Giovanelli***
12:40 - 14:00	**LUNCH BREAK**		
14:00 - 15:40	S02: Progress in WebGIS and DB solutions for Archaeology ***Matsumoto, Uleberg, Hochschild, Märker, Willmes***	S22: Digital Infrastructures for Archaeology: Past, Present and Future directions ***Richards, Wright, Niccolucci***	S24: New methods for stratigraphic modeling ***Andreaki & Barceló***
15:40 - 16:00	**COFFEE BREAK**		
16:00 - 18:20	O29: Our little minions, part 2: small tools with major impact ***Visser, Thiery, Mennenga***	S22: Digital Infrastructures for Archaeology: Past, Present and Future directions ***Richards, Wright, Niccolucci***	S24: New methods for stratigraphic modeling ***Andreaki & Barceló***

SESSIONS

Exhibition B	Large Hall A	Seminar	Small Hall
WELCOME ADDRESSES AND KEYNOTE *Large Hall*			
COFFEE BREAK			
S05: R as an archaeological tool: current state and directions (vol. II) ***Tietze, Schmidt, Grunert***	S26: Archaeological network research: formal network representation of archaeological theories ***Gheorghiade & Brughmans***	S28: Computational classification in archaeology ***Nakoinz & Hinz***	S41: From Micro to Macro: computer-based approaches for the analysis of big data in the study of artefacts and societies ***Lorenzon & Kaliszewska***
LUNCH BREAK			
S14: Modelling Data Quality in archaeological Linked Open Data ***Bruhn, Mees, Thiery***	S26: Archaeological network research: formal network representation of archaeological theories ***Gheorghiade & Brughmans***	S28: Computational classification in archaeology ***Nakoinz & Hinz***	S01: Student and Early-Career researcher session ***Miles***
COFFEE BREAK			
S46: Spatial Analysis of 3D Archaeological Information: Method and Theory ***Nobles & Raether***	S31: In pursuit of social space. Detecting activity areas in Palaeolithic contexts ***Moreau, Spagnolo, Morera, Wiśniewski, Nieto-Márquez***	R03: Roundtable Scientific Scripting Languages in Archaeology - Limits and Opportunities of Open Research ***Hinz, Schmid, Schmidt***	S01: Student and Early-Career researcher session ***Miles***

THURSDAY, 25 APRIL 2019

	Medium A	Medium B	Exhibition A
08:40 - 10:40	R39: The European Research Council (ERC): funding excellent research in the field of Archaeological Science *Priki*	O23: Taking your GIS onto the field. 'How'-s and 'Why'-s of future survey *Buławka, Campana, Chyla*	R36: User Experience Design in Archaeology and Cultural Heritage *Dolcetti, Perry, Opitz*
10:40 - 11:00	**COFFEE BREAK**		
11:00 - 12:40	S42: New technologies in woodland archaeology: problems and limitations *Niedziółka, Konczewski, Jakubczak*	O23: Taking your GIS onto the field. 'How'-s and 'Why'-s of future survey *Buławka, Campana, Chyla*	R36: User Experience Design in Archaeology and Cultural Heritage *Dolcetti, Perry, Opitz*
	LUNCH BREAK		
14:00 - 15:00		O23: Taking your GIS onto the field. 'How'-s and 'Why'-s of future survey *Buławka, Campana, Chyla*	
15:00 - 16:00	**POSTER SESSION & COFFEE** *Level 0 - next to Main Entrance*		
16:00 - 18:00	**ANNUAL GENERAL MEETING (AGM)** *Large Hall*		

SESSIONS

Exhibition B	Large Hall A	Seminar	Small Hall
R08: Teaching Digital Archaeology *Sonnemann, Kiarszys, Traviglia*	S34: Archaeological Data for Modern Problems. Modern Methods for Archaeological Questions *Crabtree & Romanowska*	O20: Recent Developments in Digital Numismatics – Breaking down barriers *Gruber, Tolle, Wigg-Wolf*	S01: Student and Early-Career researcher session *Miles*
COFFEE BREAK			
R08: Teaching Digital Archaeology *Sonnemann, Kiarszys, Traviglia*	S34: Archaeological Data for Modern Problems. Modern Methods for Archaeological Questions *Crabtree & Romanowska*		S01: Student and Early-Career researcher session *Miles*
LUNCH BREAK			
R09: Thinking out of the classroom: sharing knowledge and resources... *Verhagen, Lang, Kondo, Stead*	S34: Archaeological Data for Modern Problems. Modern Methods for Archaeological Questions *Crabtree & Romanowska*	O35: Extreme Data Processing in Archaeology *Cuy, Ducke, Foertsch, Block-Berlitz*	S01: Student and Early-Career researcher session *Miles*
POSTER SESSION & COFFEE *Level 0 - next to Main Entrance*			
ANNUAL GENERAL MEETING (AGM) *Large Hall*			

FRIDAY, 26 APRIL 2019

	Medium A	Medium B	Exhibition A
08:40 - 10:40	S33: Digital Landscapes in Archaeology: From field recording to the reconstruction of human use of space *Herrera Malatesta, Hinojosa-Balino, Hernández Cordero*	S13: Ethics in Digital Archaeology: Concerns, Implementations, and Successes *Dennis*	S21: Challenges and opportunities of machine learning in archaeological research *Brandsen, Kramer, Verschoof-van der Vaart*
10:40 - 11:00	COFFEE BREAK		
11:00 - 12:40	S33: Digital Landscapes in Archaeology: From field recording to the reconstruction of human use of space *Herrera Malatesta, Hinojosa-Balino, Hernández Cordero*	S04: Digital archaeology of modern conflict landscapes *Kiarszys & Kostyrko*	S21: Challenges and opportunities of machine learning in archaeological research *Brandsen, Kramer, Verschoof-van der Vaart*
12:40 - 14:00	LUNCH BREAK		
14:00 - 15:40	S18: Immersive Digital Media in Archaeology: Memory, Place and Performance *Beale, Richards, Smith*	S04: Digital archaeology of modern conflict landscapes *Kiarszys & Kostyrko*	S11: Pre-modern cities and complexity *Paliou, Artopoulos, Romanowska, Crawford, Kalayci*
15:40 - 16:00	COFFEE BREAK		
16:00 - 18:40	S18: Immersive Digital Media in Archaeology: Memory, Place and Performance *Beale, Richards, Smith*	S25: "Real-time" archaeological data. Hyperreality, temporality and materiality of digital archaeological objects *Stobiecka*	S11: Pre-modern cities and complexity *Paliou, Artopoulos, Romanowska, Crawford, Kalayci*

SESSIONS

Exhibition B	Large Hall A	Seminar	Small Hall
S06: Recent advances in spatial statistics for archaeology *Roe & Carrer*	O37: 3D Publishing and Sustainability: Taking Steps Forward *Sullivan, Richards-Rissetto*	S15: Issues of scale in archaeological computational modelling *Davies & Wren*	S01: Student and Early-Career researcher session *Miles*
COFFEE BREAK			
S06: Recent advances in spatial statistics for archaeology *Roe & Carrer*	S17: Empowering Archaeology of the Senses through digital approaches *Landeschi, Richards-Rissetto*	S32: Multiscalar and Multivariate Approaches to Digital Documentation of Archaeological Sites *Ippolito & Rissolo*	S01: Student and Early-Career researcher session *Miles*
LUNCH BREAK			
S45: Virtual Reality and 3D modeling: Where are we now? *Zarmakoupi*	S17: Empowering Archaeology of the Senses through digital approaches *Landeschi, Richards-Rissetto*	O07: Teaching 2.0: Show me how you teach! *Tietze & Hageneuer*	S44: Analysing Shape in the Digital Age: Current Considerations in Archaeological Application of Geometric Morphometrics *Hoggard, Stark, Roth, Janin*
COFFEE BREAK			
R19: Our knowledge is all over the place! *Reilly, Stead, Pouncett*	S40: Argumentation and the Archaeological Record *Gonzalez-Perez, Martin-Rodilla, Pereira-Fariña*	O07: Teaching 2.0: Show me how you teach! *Tietze & Hageneuer*	R16: Where does global meet local? Finding common ground for multiscalar analysis of settlement and land use dynamics *Verhagen & Nuninger*

SATURDAY, 27 APRIL 2018

TOUR 1: WIELICZKA SALT MINE TOUR

The remarkable and breathtaking site the Wieliczka salt mine has been listed on the UNESCO World Heritage List since 1978. The unique "underground town" consists of 300 kilometers of tunnels, shafts, chambers, chapels and lakes. Nine levels of mine's development reaches 327 meters under the surface.

By visiting the mine you can be among the famous visitors such as Nicolaus Copernicus, Johann Wolfgang von Goethe, Alexander von Humboldt and John Paul II who visited the mine and discovered this amazing place. During the tour you will have a chance to learn about history and the development of salt-mining from prehistoric times. English speaking guide will present the local legends and miners' daily life. You will explore the underground lakes, chapels and the monumental St. Kinga's Chapel. The Wieliczka Salt Mine is a must-see place in Poland.

Meeting /Drop off point: Auditorium Maximum, ul. Krupnicza 33
Pick up time: Saturday 27th April 2019 9:50 am
Duration: ca. 4 hours

During the tour you will be assisted by English speaking tour leader. The Salt Mine tour will be carried out by an experienced guide. At the entrance you will be given headsets and receivers since the guide will use the voice transmitter.

Salt Mine regulations:
Please keep in mind that you will have to climb 380 steps down.
The photo fee: 10 PLN.
The temperature in the mine is constant (about 14°C/58°F) please take warm clothes

EXCURSIONS

TOUR 2: THE MEMORIAL AND MUSEUM AUSCHWITZ-BIRKENAU TOUR

KL Auschwitz is the largest former German Nazi concentration and extermination camp. Over 1.1 million women, men and children lost their lives there. Auschwitz-Birkenau has been a symbol of Holocaust since it became the deadliest extermination centre of European Jews. The victims were transported from all over of the Nazi occupied Europe. The complex has been preserved as a memorial museum and has remained as a living monument of genocide and as a warning for next generations, according to quote by George Santayama: "Those who cannot remember the past are condemned to repeat it."

The visit is divided into two parts. Firstly you will pass the gate with the infamous inscription above your heads: Arbeit Macht Frei in Auschwitz I: the concentration camp. You will learn about the everyday life of prisoners. You will see the multitude of confiscated belongings of the Nazi victims. In the extermination camp of Auschwitz II: Birkenau you will experience the horror of the Jews unconsciously led to death.

Meeting /Drop off point: Auditorium Maximum, ul. Krupnicza 33
Pick up Time: Saturday, 27th April 2019 9:50 am
Duration: ca. 8 hours

During the tour you will be assisted by English speaking Tour Leader. The tour will be carried out by a museum guide. At the entrance you will be given the headsets and receivers since the guide will use the voice transmitter. The tour is divided into two parts. In Auschwitz I (Concentration Camp) the tour takes around 2 hours, then the short break is provided. Next you will move to Auschwitz II Birkenau (Concentration and Extermination Camp) by a bus (5 minutes ride) where the visit lasts usually about 1 hour.

Museum Regulations:
At the entrance of the Museum there is a security control (similar to those at airports). You will be asked to empty your pockets and put every metal object onto a basket.
The weapons (knives, scissors), alcoholic beverages, food are not allowed in the museum. Smoking is allowed only in designated areas. Taking photos is allowed (without flash inside buildings).
IMPORTANT: You can carry inside only a small bag.
The allowed dimensions: 30×20×10 (A4 format)

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Standard session 01:
Student and Early-Career researcher session

***James Miles**, Archaeovision*

Small Hall, 14.00 – 17.40, 24 April 2019
9.40 – 15.00, 25 April 2019
8.40 – 12.40, 26 April 2019

Following the steering committee meeting for CAA-2018, it was decided to create a session for all student and early-career researchers (up to three years post degree) who wish to present at CAA for the first time, aimed predominately for those who may not wish to present in alternate specialised thematic sessions. This session will only be open to students and early-career researchers, with all student papers being automatically considered for our annual Nick Ryan Bursary. Only those presenting in this session will be nominated for this prestige award and will allow for the best student paper to be identified, with the recipient receiving 1000 euros towards the costs of attending CAA-2020. The session will be actively publicised, and it is hoped that it will be well attended, acting as a way for students and early-career researchers to engage with the CAA community for the first time. All members of the reviewing panel for the Nick Ryan Bursary will be present and will be on hand to provide useful feedback around presentation style and the content discussed. The session will include all themes and topics. The aim of this session will be to introduce new members to the CAA community and to create a focussed session that allows CAA members to view all Nick Ryan Bursary nominated papers. In turn this will create a greater review process, with each paper being assessed against the others presented in the session.

24TH APRIL

14.00 – 14.20
No Longer Standing: Digital Applications for the Relocation of the Perrenoud Homestead,
Madisen Hvidberg, Peter Dawson

14.20 – 14.40
Re-visiting of Shivta. Aerial and land surveys on the Byzantine site in the Negev,
Maciej Wacławik, Konrad Górski

14.40 – 15.00
Intersecting Landscapes: A Multi-Model Approach to Understanding Dynamic Spatial Power Relations in an Agricultural Context,
Stefan Woehlke

15.00 – 15.20
Computational Erosion Modeling of San Miguel Island: Preserving Archaeological Sites,
Yesenia Garcia, Isaac I.T Ullah

15.20 – 15.40
General Discussion

COFFEE BREAK

16.00 – 16.20
'Brochs' - built for visibility?
Anna Katharina Loy

16.20 – 16.40
Applying space syntax to insula V ii in Ostia: A comparative assessment of four space syntax methods,
Alexander C.Q. Jansen

16.40 – 17.00
From text to data: a NLP approach to digital archaeology,
Elisa Paperini, Nevio Dubbini, Gabriele Gattiglia

17.00 -17.20
Surveying the Okak Inuit Winter Village using Exploratory Photogrammetry,
James Samuel Williamson, Francois P. Levasseur, Peter Whitridge

17.20 – 17.40
Applying an Agent-Based Sailing Model to the Iron Age English Channel,
Karl Smith

25TH APRIL

9.40 – 10.00
Ideology in Architecture: Analysing the Visibility of Household Shrines in Pompeii,
Max Timothy, Boyd Peers

10.00 – 10.20
'MEETING THE MINOANS' – an Assesment of Visitors' Experience on a Bronze Age Archaeological Site in Crete,
Thérèse Claeys

10.20 – 10.40
Unlocking Roman Houses. Space Syntax Analysis in the nova urbs of Italica (Baetica),
Sarah Al Jarad

COFFEE BREAK

11.00 – 11.20
Issues of preservation of archaeological material in the process of creation of accessible data sets,
Stepan Stepanenko

11.20 – 11.40
Using XRF spectrometry and Statistical Analysis to determine the provenance of Ancient Egyptian Faience,
Michelle F Whitford, Damian Gore, Timothy D Murphy, Michael Alderson, Paul Pigram, Michael J Withford

11.40 – 12.00
Maps as Bodies, Bodies as Maps in 3D GIS,
J. Alyssa White, John Pouncett, Rick Schulting

12.00 – 12.20
Comparison of ground control points surveying techniques for photogrammetric documentation of archaeological excavations,
Joachim Pawliński, Adam Wala, Edyta Puniach, Paweł Ćwiąkała

12.20 - 12.40
A GIS-based approach for understanding landscape-scale mobility using stone artefacts,
Matthew Barrett

LUNCH BREAK

14.00 – 14.20
An Automated Approach to Segmentation and Refitting of Fragmented Faunal Remains Using Differential Geometric Methods,
Katrina Yezzi-Woodley, Jeff Calder, Peter Olver, Martha Tappen, Reed Coil, Anthony Yezzi, Cheri Shakiban, Pedro Angulo-Umaña, Riley O'Neill, Bo Hessburg, Jacob Elafandi

14.20 - 14.40
Dorset Harpoon Head 3D Morphometric Variability in the Eastern Canadian Arctic and Subarctic,
Francois P. Levasseur

14.40 – 15.00
Recycled Blessings? Investigating a Votive Animal Mummy using Non-Destructive Neutron and X-ray Imaging,
Carla Adele Raymond, Joseph J Bevitt, Yann Tristant, Ronika K Power, Anthony William Lanati, Christopher Davey, John Magnussen, Simon Martin Clark

26TH APRIL

8.40 – 9.00
Comparison of the quality of models created from different photogrammetric data and used to present cultural heritage in virtual reality,
Jakub Łobodecki, Kamil Choromański, Jakub Kaczorowski, Aleksandra Podbielska

9.00 – 9.20
Exploring Early Neolithic materialized identity networks,
Petr Pajdla

9.20 – 9.40
Graves of war crimes in areas of Poznań. Identification using remote sensing methods,
Kuba Łada-Siwiec

9.40 – 10.00
Using Digital Photography to Identify Chemical Relationships between Objects,
Heather R. Christie

10.20 – 10.40
Data analysis on series of medieval wooden plates and bowls from northern Poland,
Katarzyna Barucha

10.20 – 10.40
General Discussion

COFFEE BREAK

11.00 – 11.20
Photogrammetric documentation of architectural details in condition of archaeological field research: a case study,
Justyna Elżbieta Ruchała, Edyta Puniach

11.20 – 11.40
Depopulation and devastation. Linking GIS data for estimating changes in archaeological landscape of Kharaib el-Desht (Kuwait),
Paweł Lech, Marek Truszkowski, Piotr Zakrzewski

11.40 – 12.00
Why The Implementation Of Modern Technologies In Museums To Popularise Archaeology Still Fails To Reach Out To Millennials,
Benjamin Hanussek

12.00 – 12.20
The shoreline remains; A landscape study of Fire cracked stone heaps,
Amanda Saga Jeppsson

12.20 – 12.40
Structure from Motion as a documentation technique. A critical approach to 3D modeling of discs at Plain of Jars 52, Laos,
Zuzanna Kowalczyk, Joanna Koczur

No Longer Standing: Digital Applications for the Relocation of the Perrenoud Homestead

Madisen Hvidberg, Peter Dawson

The disassembly of structurally unsound heritage buildings for the purposes of safety and development is a well-established practice. Oftentimes this removal comes with the intent of moving, reassembling, or rebuilding the structure in the future. Located in southern Alberta, Canada the Perrenoud Homestead is one such site; taken apart and placed in storage in the summer of 2017 to be rebuilt sometime in the future. It is composed of two residences and is a heritage site valued for its significance to the establishment of early ranching operations in Western Canada. During its disassembly, the Perrenoud Homestead was digitally documented using terrestrial LiDAR scanning and drone-based photogrammetry. The utilization of these methods is important in innovating not only access to this heritage resource while the physical structure of the homestead is absent from the site, but in providing a roadmap for future steps in this project. In this paper, I discuss the Perrenoud Homestead project, focusing on the use of these digital methods to aid the heritage building relocation process.

Re-visiting of Shivta. Aerial and land surveys on the Byzantine site in the Negev

Maciej Wacławik, Konrad Górski

In the beginning of the Byzantine period (fifth to seventh century AD) the period of prosperity started in the region of the Negev Desert (Israel). Small settlements established in the previous times on the trade routes as stops for caravans flourished into cities with magnificent architecture. After few centuries of development, they disappeared in the sands of time and were discovered in XIXth century. One of best preserved of them is Shivta – ancient Sobata. With the use of new technology and contemporary methodology it was revisited again as a part of Byzantine Settlement of the Negev (BSN) project. Combination of both aerial pictures taken by drone with data collected during land survey, joined in GIS database, allowed to verify previous theories about town development. In light of new evidence it looks like so-called Central Church should be considered rather as a civic-administrative building. Similar, the theory about functioning in town three monasteries should rather be rejected, and in place of two of them normal, ecclesiastical buildings were working. Close to northern range of the town, attached to previously recognised hostel, second structure of this type has been detected. Also the theory about peaceful cohabitation between Christians and Muslims should be rejected, because there is no evidence to assign the attributes of mosque to the structure that is currently considered as one of it.

Intersecting Landscapes: A Multi-Model Approach to Understanding Dynamic Spatial Power Relations in an Agricultural Context

Stefan Woehlke

The agricultural systems in the Southern United States changed dramatically during the 19th century. This is the result of many factors including the end of legal slavery, increased mechanization of agriculture, development of chemical fertilizers, and shifting legal structures. These changes impacted people differently depending on where they were located within a web of complex social relations. Race, class, and gender are among the dominant social forces that structured the lived experiences of people during this period. The study uses a combination of modeling approaches along with an intersectional framework that emerged from Black feminist theorists to develop a nuanced understanding of how the landscape both structured and was structured by social relations. The analysis is centered on the property of the Montpelier Foundation, where President James Madison and his family lived for three generations. This paper will present the results of visibility and cost surface analyses conducted for multiple dates from the early 19th century through the early 20th century. Shifts in spatial and visual relationships occurred throughout this period and had differential impacts on individuals depending upon their racial, economic, or gender status.

Computational Erosion Modeling of San Miguel Island: Preserving Archaeological Sites

Yesenia Garcia, Isaac I.T Ullah

Archaeological sites are non-renewable resources, increasingly pertinent to historical ecological studies for sustainability and conservation management. Preserving these resources is therefore a critical endeavor. One issue facing this work, however, is the amount of effort that needs to be expended to find, analyze, and prioritize the mitigation of current and future erosional damage to important archaeological resources. An interdisciplinary approach that combines empirical measurement and simulation modeling offers a way forward on this difficult problem. I present here an initial case study of this methodology, which looks to quantify and rank potential future erosion damage to important sites on San Miguel Island, off the coast of Santa Barbara, California. I will use landscape simulation tools in GRASS GIS to simulate hillslope and channel erosion under a variety of climate and land-use scenarios. These experiments will be calibrated using daily historical climate records and historical aerial photographs of the Island that cover the period from 1893 to 2018. Much of the previous erosion mitigation research effort on the Northern Channel Islands has focused on coastal sites and coastal erosion processes such as storm-surge and waves. This new work will enable mitigation plans to also be developed for inland sites, which are of equal importance to coastal ones. In this way, we can better address

and mitigate the loss of cultural heritage across all parts of the Northern Channel Islands and attempt to equally preserve all cultural resources. The workflow should be broadly portable to other parts of the world.

'Brochs' - built for visibility?

Anna Katharina Loy

In this paper the usual approach to viewsheds and the so called brochs, monumental stone buildings of the mainly Atlantic Scottish Iron Age, is turned around. The aim is to get a notion of how the monuments could have been perceived from within their surrounding landscapes. Different scenarios of the utilisation of the monuments, which as of now is heavily disputed on, will be discussed. For this purpose two regional studies - one in a classic Atlantic area, one in the lowlands - are implemented using R and GRASS. A deliberate decision was made to include quite different landscapes: Caithness as a coastal region with relatively soft relief and the wider Forth Valley as a typical region at the edge to the Highlands.

Applying space syntax to insula V ii in Ostia: A comparative assessment of four space syntax methods.

Alexander C.Q. Jansen

Over the past decades, space syntax has already proven to be of added value for archaeological research. However, several factors may scare off archaeologists from using these tools and unlocking their potential. Those who are not versed in space syntax theory have to become familiar with a complex and broad theoretical framework. Additionally, numerous methodological problems can be encountered. Furthermore, the few handbooks that exist are aimed specifically towards architects and urban planners. In order to provide a groundwork which is suitable for archaeologists, this paper assesses and compares four space syntax methods: access analysis, isovist analysis, visibility graph analysis, and agent analysis. Several innovative ways to apply these methods for studying change in the layout of buildings are also discussed. These methods are applied on two construction phases of a city block in Ostia, known as insula V ii, to study changes in accessibility, privacy, ownership, and functions. The four methods are each used individually to analyse the well-documented ground floor plan of the Severan phase (c. 200 AD) and final phase (c. 400-500 AD) of this block. This paper discusses both the individual buildings and the insula as a whole. For the purpose of studying change, this paper recommends the use of access analysis as it is a time effective method that allows for a broad range of interpretations. Each method is shown to be of added value, but their effectiveness depends on the dataset and research questions

From text to data: a NLP approach to digital archaeology.

Elisa Paperini, Nevio Dubbini, Gabriele Gattiglia

Extracting data from archaeological texts (from grey literature to journal papers) represents one of the archaeology's most leading challenges. In recent years, Natural Language Processing (NLP) has been also adopted in the archaeological domain, but we are still far away from achieving robust results. This work is part of a more complex project related to extraction, visualisation and analysis of text data, carried out by MAPPA Lab, a digital archaeology lab of the University of Pisa, together with Italian NLP Laboratory of the Institute for Computational Linguistics "A. Zampolli" (http://www.italianlp.it/). The aim of this work is to set up an as-automatic-as-possible procedure to overcome one of the main barriers to data accessibility, related to digitisation of data in a way allowing to process them. We developed a semi-automated workflow for text extraction and processing of data from pdf to a previously designed RDBMS. The extraction of data about location, date, authors, bibliography, archaeological findings and chronology was texted on about 1300 short communication papers (about 120000 text lines) published in the Italian journal of Medieval Archaeology (Archeologia Medievale), from 1974 to 2017. A formalised vocabulary of archaeological terms was first developed, then text extraction and NLP algorithms were applied, in order to detect, tag and insert the extracted data into the database. This method of working on data can be applied to all sources on which it is necessary to carry out similar research activities. Moreover, retrieved data are digital, accessible and reusable.

Surveying the Okak Inuit Winter Village using Exploratory Photogrammetry

James Samuel Williamson, Francois P. Levasseur, Peter Whitridge

In July and August 2018, a team from Memorial University of Newfoundland surveyed the prominent Inuit winter village site of Kivalehk, near Okak in northern Labrador. UAVs and an Emlid RTK were used to digitally record the presence of numerous burials, caches and semi-subterranean house features throughout the site to analyse their morphology and distribution, and to evaluate the efficacy of differing methods of photogrammetry, which will be discussed in this presentation. The first method involves a near real-time survey technique which allows the surveyor to target areas and features using photogrammetry, GIS, and handheld GPS tools for subsequent high-resolution photogrammetric recording and ground-level inspection. The second method tested the most useful means of data acquisition for the purposes of image-based modelling and to put forward a workflow for video-based capture using 4K cameras. The outcome of this research will lead to the possibility of improving photogrammetric modelling of landscapes, and to the ability to target landscape phenomena using consumer grade UAVs and RTKs.

Applying an Agent-Based Sailing Model to the Iron Age English Channel

Karl Smith

Our understanding of coastal communities during the Iron Age is informed by a set of assumptions about what navigators and mariners in those communities were capable of. Computational modelling is well-placed to answer questions such as: how long would voyages between different points have lasted? Do some routes carry more risk than others? How much does a navigator's ability to make sense of winds and currents, or to recognise landmarks affect the outcome of a voyage? As a part of my research I have sought to answer these questions by developing an agent-based model for Iron Age navigation in the western English Channel. This model uses hydrographic, aerodynamic, and topographic data to simulate voyages under parameter sets relating to different types of vessel, different levels of navigational ability, and different sets of landmarks. The model consists of a suite of Python scripts executing GIS tools in order to (1) evaluate sea conditions from the perspective of a mariner at sea, (2) search for landmarks using volumetric 3D visibility analysis, (3) select a heading based on an evaluation of these analyses, and (4) simulate the progress of a vessel given the selected heading and environmental conditions. This paper discusses the application of the finished model to the western English Channel, presents the results of preliminary analysis, and discusses the presentation of datasets produced by the model.

Ideology in Architecture: Analysing the Visibility of Household Shrines in Pompeii.

Max Timothy, Boyd Peers

This paper presents computational analysis of the visual integration of the Lararia (household shrines) in the Insula del Menandro in Pompeii. Lararia are an excellent example of a feature that benefits from targeted visibility graph analyses. They also test the potential application of these analyses on other bodies of material in Archaeology. Using the program depthmapX, I created visibility graphs of the individual houses of the insula by calculating the mutual visibility of each point within the system, and then representing the results as a colour gradient of relative visibility. These quantitative results deepen our understanding of household Lararia, which has previously relied disproportionately on literary and art historical analyses. The visibility graphs demonstrate that the placement of household Lararia have common qualities. Lararia are always placed to receive the strongest visual emphasis from outside the room. These rooms are nevertheless relatively removed within the framework of the houses. Conversely, a lararium in a highly visible space had coverings so that the altar itself remained unseen. In this way, the visibility graphs indicate a more complex control over the visual integration of Lararia within a household. The locations of Lararia paintings and niches within the insula indicate that the

maintenance of the Lararium shrine and associated religious practices were a personal experience and each household conducted these affairs according to ideology and space. Visibility graph analysis offers nuance to the understanding of Lararia within the structured space of the household and reveals an active duality of visibility and privacy.

'MEETING THE MINOANS' – an Assesment of Visitors' Experience on a Bronze Age Archaeological Site in Crete

Thérèse Claeys

Since the 1970s, the island of Crete has been experiencing an ever-growing increase in tourist flows to the extent that tourism industry has become its most important economic activity. Although most tourists visit the island's seaside and less its cultural and natural landmarks, many of them, however, include a visit to the archaeological site of Knossos in their program, as it is touted as one of the island's premier attractions. Moreover, Knossos keeps dominating public perceptions of the Cretan and especially 'Minoan' past. This poster explores the impact of the extended reconstruction work conducted at Knossos on its visitors and the degree of satisfaction it provides through comparison with the experience provided to visitors on another highlight of the Minoan civilization, namely the archaeological site of Malia. This experience is assessed by a combination of visitor-sourced qualitative and quantitative analyses. The ultimate goal of this on-going project is to eventually assess whether and how digital technologies can improve the visitors' experience on Minoan archaeological sites and increase their attractive power without generating their "disneyfication". To address this challenge, the study will first reflect on the effectiveness of geo-temporal tracking methods not only for quantifying visitors' movement but also for informing management decisions in the planning of visitors' circulatory patterns. Secondly, the opportunities disclosed by augmented reality, as a trendy technological advance though not experimented yet on Minoan sites, will be discussed in the framework of this poster.

Unlocking Roman Houses. Space Syntax Analysis in the nova urbs of Italica (Baetica)

Sarah Al Jarad

The Focus of my paper is on the Roman housing in Italica during the 2nd century AD within the new residential quarter called nova urbs dating up to the Trajanic period. Space Syntax Analysis is a promising method to detect and analyze patterns of daily life use and interaction within complex room structures like those found in the representative domus of nova urbs. By building Gamma Maps and Visibility Graphs on vectorised domus plans in the free software depthmapX of UCL, my project aims to define comparatively how housing was managed and organized in different buildings. Measuring the control value mean depth and the relative asym-

metry reveals the relationship between spatial structure and social activity within the domus. Main aim of the research is to point out analogies and differences in the internal organization of different houses regarding the public accessibility of building and their entanglement in the urban system. DepthmapX facilitates this comparative approach, offering a common frame of space analysis for different domus. Within this framework it is possible to identify patterns of spatial organization and relate them to Roman housing in the urban provincial context of Italica more generally. The main research questions are the following: do houses show similar patterns in the social perception of their space? Is it possible to detect differences between private space and spaces of public social interaction within the domus? Finally, is it possible to detect a form of visual performation of the architectural space, which is affecting multi-functional space concepts?

Issues of preservation of archaeological material in the process of creation of accessible data sets.

Stepan Stepanenko

Dissemination of archaeological material and accumulated knowledge through Linked Open Data has been a theme in the development of accessibility of archaeological material for a number of years. Presentation of museum artefacts through linked data is the most effective way for scholars, including young researchers, to obtain access to vast resources with relatively small time and funding contributions. However, the creation of such databases in various regions beyond the jurisdiction of the EU is prone to increasing the ease of access to geolocation of archaeological artefact clusters for the purposes of illegal excavation and trade. Moreover, such work outside of large scale projects is unfeasible for early career researchers. Examples of such issues are the numismatic and Shestovytsya collections of the Chernihiv Regional Historical Museum, Ukraine. Both collections are in the process of preparation for paper publications and the creation of a digital and accessible archive, the main issue raised by local archaeologists is not cross referencing, or linked nature of the data, but the idea of an open, or accessible database. In a country where archaeological sites are specifically, and systematically, targeted for their valuable archaeological artefacts, and an estimated seventy percent of known archaeological sites have no ferrous objects remaining in situ, an alternative to accessible sources is currently the only option for preservation of archaeological sites and artefacts. The presentation discusses methods of presentation of archaeological and numismatic material through means not easily accessible to the general public but with a systematic approach to data recording.

Using XRF spectrometry and Statistical Analysis to determine the provenance of Ancient Egyptian Faience

Michelle F Whitford, Damian Gore, Timothy D Murphy, Michael Alderson, Paul Pigram, Michael J Withford

Faience is a glass-like material that was created extensively in Ancient Egypt. Produced between the Predynastic and Roman Periods (5300 B.C. – A.D. 395), objects made using faience, including amulets, figurines, and jewellery, were often associated with funerary contexts. These objects have easily become displaced over time without records of their original context, resulting in a significant loss of historical and economical value. As faience is a glass-like material, traditional dating methods cannot be applied to determine provenance. There are currently no absolute methods for dating ancient glass-like, and therefore displaced faience artefacts remain unprovenanced. Faience is also a useful material for developing a new method to determine provenance in other ancient materials because it is ubiquitous. In this project, we develop a non-destructive method to determine the provenance of Ancient Egyptian faience. Analyses were conducted on 266 faience artefacts from the Museum of Ancient Cultures at Macquarie University, the Nicholson Museum at Sydney University, the Museum of Applied Arts and Sciences, and the Australian Museum. The sample set included artefacts with both known and unknown provenance. Elemental compositions of each artefact were determined using X-ray fluorescence spectrometry (XRF). Principal Component Analysis grouped artefacts based on their age. By analysing combinations of artefacts, artefacts with unknown provenance could be grouped with artefacts with known provenance. This revealed information about the relative age of artefacts with unknown provenance. This information can aid in authentication of faience artefacts where objects with unusual elemental composition could easily be identified and re-evaluated.

Maps as Bodies, Bodies as Maps in 3D GIS

J. Alyssa White, John Pouncett, Rick Schulting

Human bodies are inherently spatial entities, as are the patterns of lesions on skeletal tissue that palaeopathologists analyse. Yet, when the body is treated as a 'map' it is often done on an ad hoc basis, in two dimensions, and not in a format that allows for data accumulation and comparison between studies. By utilising a model of the human body, composed of a triangular mesh with a 3D coordinate system, in GIS it is possible to record, query, and analytically investigate skeletal data. Data can be incorporated into the model in a variety of ways. The skeletal elements of the model can be fragmented to allow for more precise recording of completeness. 3D features can be created to investigate patterns of skeletal pathologies, from degenerative diseases to

traumatic injuries. Extraneous 3D models of skeletal elements can be incorporated into the model. Skeletons and associated features can be attributed with relevant information. Once the data is incorporated into a geospatial format, it can then be rapidly visualised and queried in order to explore patterns by categories of interest. This method allows for the compilation and exploration of data in a faster and more consistent manner than is currently available. Data on traumatic injuries and skeletal preservation from prehistoric hunter-gatherers and early agriculturalist from the Japanese archipelago will be used in order to demonstrate the utility of this method. Outside archaeology, this method has potential for demonstrating patterns of traumatic injuries in a forensic context to a non-expert audience.

Comparison of ground control points surveying techniques for photogrammetric documentation of archaeological excavations

Joachim Pawliński, Adam Wala, Edyta Puniach, Paweł Ćwiąkała

In modern archaeology, application of UAV photogrammetry became standard tool for creating orthophotomaps of excavations, what provided several facilities in exploring archaeological sites. Apart from obvious advantages of this technology, the appropriate accuracy in geographical reference of produced maps may still bring some challenges. Proper georeference and integration of orthomosaics depend on ground control points, which coordinates may be specified by different techniques. GNSS receivers as well as traditional total stations are commonly used for that purpose. The paper presents the dependence of the quality and accuracy of final photogrammetric products on ground control points surveying method. In order to provide adequate data set for analysis, ground control points were marked in sands of Błędów Desert. Their coordinates were measured by GNSS receiver working in RTN mode, what provides the accuracy up to 3 cm horizontal and 5 cm vertical. Alternatively, precise total station was used to create a comparative data set, with angle measurement accuracy of 1" and distance accuracy of 1 mm +1.5 ppm. Measurements were followed by two photogrammetric flights above the measured object. Two different UAVs were used for this purpose: DJI S1000 with a Sony Alfa A7R camera (full-frame camera) and DJI Mavic Pro with camera equipped with a 1/2.3 inch image sensor. This allowed to compare the quality and accuracy of the material obtained from the professional, but expensive and heavy device with products generated on the basis of images taken from amateur, but cheap and light UAV.

A GIS-based approach for understanding landscape-scale mobility using stone artefacts

Matthew Barrett

Mobility is a useful but highly variable process with which to understand past human-environment interaction. Understanding mobility requires investigation at the landscape scale, which in turn requires large datasets acquired over large areas. Stone artefacts are useful for addressing questions of mobility due to their ease of recording and relative ubiquity in the archaeological record, especially where they are highly visible on the surface of particular landforms. Modern survey equipment allows for the rapid recording and piece-proveniencing of stone artefacts, providing detailed distributional data. These data can be analysed using GIS software to obtain a greater understanding of patterning over the vast spatial scales under investigation. This paper presents an example of one such approach using case studies from mid-Holocene Egypt and late-Holocene Australia. Flake to core ratios are a proxy for human movement as they provide an indication of the movement of material into or away from a given location, once the effects of initial cobble size and differential reduction intensity are accounted for. In each case study, GIS-based analysis of detailed distributional data, combined with the analysis of simple metric attributes of stone artefacts, shows how stone material, and by proxy people, moved within and beyond the areas under investigation. This demonstrates how computational approaches such as GIS can aid greatly in understanding landscape-scale human-environment interaction in the past.

An Automated Approach to Segmentation and Refitting of Fragmented Faunal Remains Using Differential Geometric Methods

Katrina Yezzi-Woodley, Jeff Calder, Peter Olver, Martha Tappen, Reed Coil, Anthony Yezzi, Cheri Shakiban, Pedro Angulo-Umaña, Riley O'Neill, Bo Hessburg, Jacob Elafandi

Many key sites for understanding human evolution have bone assemblages with hundreds of fragmentary pieces. Refitting bone fragments increases the number of identifiable specimens and allows for more refined spatial analyses. We present preliminary work in the development of methods for automatic segmentation and refitting using a small sample of experimentally broken bone fragments. Manually refitting fragments is time-consuming and daunting. Current methods for computer-assisted refits use fragments from known skeletal elements where the general refit is known. Moreover, these methods require high levels of graphical user interface, which is impractical for large assemblages. Minimal path techniques provide excellent means for segmentation. However, they require the identification of start and end points which is impractical for large samples. We base our segmentation on the work of Kaul et al. (2010) which offer a novel algorithm for detecting curves using an arbitrarily specified initial point. We extend

the pioneering work of Hoff and Olver (2014) and Grimm et al. (2016) that use differential geometric signatures to automate refits that do not require a priori knowledge of the shape of the puzzle. Curve matching algorithms apply curvature and torsion invariants along break edges to rapidly cycle through entire assemblages to identify potential refits. Our findings serve as the basis for ongoing efforts to develop methods to refit assemblages with hundreds, or even thousands, of fragments. The ability to automate the refitting of large assemblages of fragmentary skeletal remains using shape should radically transform zooarchaeological research methods.

Dorset Harpoon Head 3D Morphometric Variability in the Eastern Canadian Arctic and Subarctic

Francois P. Levasseur

The harpoon is a characteristic technological adaptation to marine environments found throughout the Arctic. A composite tool used in the hunt for marine mammals, its most diagnostic and best-preserved component is the harpoon head. Shifting styles of harpoon heads have served as chrono-cultural markers for archaeologists to understand the cultural sequence in the Arctic over the past millennia, including the Paleo-Inuit Dorset cultural period. My research investigates Middle Dorset (2300 BP to 1500 BP) local technical knowledge and the flow of ideas between sites from the Canadian regions of Newfoundland, Nunavik, and Nunavut by using 3D scanning technologies to explore morphometric variability in Dorset-era harpoon heads. Past studies of Dorset harpoon head variability have been limited to the comparison of attribute presence or absence, and to the study of overall morphology to determine typological conformity. However, this consistency in overall design allows for the selection of standardized points that characterize specific morphological features on the 3D models. With the aid of Complex Network Theory, the morphometric data exposes patterns of variability which reveal information about uniformity in intra-group manufacture, allow for the characterization of local technical knowledge, and disclose the nature of cultural transmission processes within the Dorset culture. These results also bear on the nature of variability amongst different regional groups and how individuals create variability whilst following culturally defined technological blueprints.

Recycled Blessings? Investigating a Votive Animal Mummy using Non-Destructive Neutron and X-ray Imaging

Carla Adele Raymond, Joseph J Bevitt, Yann Tristant, Ronika K Power, Anthony William Lanati, Christopher Davey, John Magnussen, Simon Martin Clark

This study involved investigation of an unusual Egyptian votive mummy (IA.2402) of unknown age and provenance, loaned by the Australian Institute of Archaeology (AIA) in Melbourne,

Australia. The AIA was interested to learn more about the authenticity and contents of the mummified bundle, while preserving the physical integrity of the object and causing as little damage as possible. Using a combination of established and novel techniques: X-ray computed tomography (CT) and neutron CT provided valuable insight, both individually and collectively, revealing a partial animal skeleton, and several layers of textile and padding. The results of the X-ray CT and neutron CT scans were reconstructed using 3D imaging software (Image J, Octopus 8.2 and VG Studio Max 3.0), allowing an ideal non-destructive study of the object These reconstructions enabled further analysis of bones, soft tissue, and textile components within the mummy bundle. Neutron CT, not yet routinely applied to archaeometric studies of mummified remains, provided valuable insight into wrapping techniques used in the mummification process of votive animal offerings. In addition to these imaging studies, pigment analysis was also performed on the coloured markings on the wrappings. This was done using Scanning Electron Microscopy (SEM) and Raman Spectroscopy in order to determine their composition, and to verify their authenticity. Radiocarbon dates were acquired on samples taken from the external wrapping and the internal contents, revealing an age discrepancy between the two. This as a result is an example of recycling votive offerings, and sheds some light on the economic and religious climate in which the mummy was made and traded.

Comparison of the quality of models created from different photogrammetric data and used to present cultural heritage in virtual reality.

Jakub Łobodecki, Kamil Choromański, Jakub Kaczorowski, Aleksandra Podbielska

The research presented here was a part of the project whose main aim was to create an interactive visualisation of several rooms in John III Sobieski Palace in Warsaw's Wilanów district. The final product will make the user able to explore the palace using virtual reality. This will create a new way to obtain information about several historical treasures and also will make it possible to get to know the palace's look in the past. For VR implementation Unreal Engine 4 was used - software dedicated to computer games production. 3D models of palace interiors were created from photogrammetric data - laser scanning and digital photography. Acquired data were complemented by surveying works, which resulted in obtaining metric data. AgiSoft Photoscan software was used to create models and generate textures. While working on the project several interesting issues around the research subject were encountered. These included inter alia data integration from numerous sources (laser scanning and digital photography), appropriate photo processing, model generalisation to create suitable graphics performance, adjusting the product for virtual reality goggles. It also was analysed what is the accuracy possible to achieve using professional equipment in comparison to mobile phone camera and how does the selection of camera affect the general quality of the final product rendered by game engine.

The article describes outcomes and possibilities of using data of different sources in the process of creating photogrammetric models. Meshes created based on photos only and supported by laser scanning were compared.

Exploring Early Neolithic materialized identity networks

Petr Pajdla

The structure of Early Neolithic burial grounds in Central Europe is explored using network analysis. Large burial grounds are quite exceptional for this area and time-period except for Linearbandkeramik (LBK) archaeological culture. Examples of sites include Kleinhadersdorf, Kralice na Hané, Nitra or Vedrovice. Grave goods comprise various types of artefacts ranging from common items like pottery vessels or lithic tools to rather rare items, for instance, spondylus shell arm-rings, beads or various types of pendants. The burials are constructed by the deceased person's community, thus expressing one's identity as observed and perceived by her/his contemporaries. This identity is reflected by deposited material, it is materialized in grave goods. The underlying idea is that different materialized identities can be derived from the variations of grave goods deposited within individual burials. These materialized identities can be effectively visualized as networks where vertices are single burials and edges are based on similarity or dissimilarity of the artefacts deposited in the graves. Constructing and interpreting such networks reveals underlying structures inside the Early Neolithic communities and allows us to compare and contrast materialized identities with real lifeways of buried individuals deduced from biological data. With this approach, we get insight both into individual and group identities within local LBK communities and we are able to compare these structures among different sites (burial grounds). The network analysis is performed in R.

Graves of war crimes in areas of Poznań. Identification using remote sensing methods

Kuba Łada-Siwiec

The main aim of the work is an attempt to answer the question: if and how it is possible to investigate the places of hidden corpses of war crimes using remote sensing methods, especially ALS? The idea of the work is a result of reflection on the following question: what is the methodology during research when it comes to developing ALS data and interpretation? Previous practice raises the issue about the possibility of developing a typology of graves and its usage in prospection. Non-invasive methods are part of a multi-stage scheme including: interviews with witnesses, historical queries, the use of non-invasive methods, data interpretation, exhumation. The greatest emphasis will be set on the use of airborne laser scanning supplemented with aerial photographs and satellite imagery. GIS will be used in order to present the integrated results in

a transparent way. The investigated areas are the regions of Poznań: urban area, fragments of forests and parks, suburban agriculture, which were affected by the events of World War II. As an example of a retrogressive investigation, there will be presented two cases: single grave pits and a mass grave. Remote sensing methods are applied in a further attempt to show a deconstruction in order to try to answer questions that have been raised.

Using Digital Photography to Identify Chemical Relationships between Objects

Heather R. Christie

Archaeology generally views photography as documentary, capturing what we saw to serve as a reminder to us and a communication device for others. This type of photography is necessary in archaeology, but digital photography can capture much more information about an object if given the chance. In this paper, I identify chemical relationships between Iron Age and Early Medieval glass beads in Scotland using a standard dSLR converted for full spectrum imaging. This is an affordable, non-contact, non-destructive technique that requires minimal specialist equipment. It does not capture precise measurements of individual elements in an object's chemical composition, nor is it intended to do so. Instead, it relies on the differential reactions of objects to near-ultraviolet (300 – 400nm) and near-infrared (950 – 1000nm) light based on their chemical composition to determine chemical relationships between otherwise typologically similar finds. Additionally, while multispectral photography has found use in archaeology for identifying pigments, underdrawings, and conservation efforts in paintings and sculpture, the spectral photography proposed here captures and quantifies the reactions of each object using a technique we can apply to any photographic subject, archaeological or otherwise. This type of spectral photography allows for a narrower differentiation between objects than generally applied using similar techniques on pigments, for example, and provides an affordable alternative to projects that cannot afford more precise chemical testing for every piece in a collection.

Data analysis on series of medieval wooden plates and bowls from northern Poland.

Katarzyna Barucha

Wooden artifacts of everyday use from medieval towns are the object of research lead by the author. The emphasis in this particular query is placed on analysing the material remains of woodturning and cooperage in medieval towns of northern Poland. The most specific products of those professions are cooper bowls as well as turned bowls and plates. Archaeological remains of those artifacts, found frequently during excavations in medieval towns, show a great similarity in each of these groups. Research carried on from 1950's in Poland reveal resemblance in shapes of described relics, wood species and woodworking techniques used for their production. Re-

searchers agree that the unification observed in woodworking, as well as in different branches of craft, is associated with guild organisations monopolising the towns' production from 13th century. The groups of artifacts that are to be analysed came from various museum collections and were obtained during archaeological excavations from towns of northern Poland. This region has been chosen for this research due to the great number of wooden crafts preserved in archaeological material. The centres with series of adequate and accessible for examination remnants are Gdańsk, Toruń, Szczecin, Stargard and Kołobrzeg. Preferred set of turned or cooperage artifacts consists of at least ten objects representing one group (turned plates/bowls; cooperage bowls). Objects are going to be examined to determine the similarities or differences in shape, size, production technique (e.g. full or partial turning) and wood species. Analyses conducted on collections of items coming from different medieval towns is supposed to indicate unity or distinction in woodworking between these sites. Wooden objects are going to be measured in diameter, height and wall thickness; other features are going to be described as well: e.g. shape, wood species, traces of processing, site of finding. Also descriptions and measurements of wooden artifacts included in publications are going to be used. The data is to be filed into Microsoft Excel table or SQL database: measurements as numbers; features as literal symbols or YES/NO disambiguation for presence or absence of feature. The exact dating of objects cannot be taken into consideration as the analysed artifacts are usually obtained from latrines which are imprecisely dated. The data are going to be analysed in search of correlations between: dimensions and production technique; site of finding and wood species; traces of processing and wood species etc. Afterwards, the correlations are going to be visualised with Microsoft Excel tools in form of charts and diagrams. Application of data analysing on particular group of objects is a trial of sorting and visualisation of the information collected during the search query. Final interpretation should answer if demonstrated relations are determined or random. An attempt to analyse and describe similarity of objects and correlations between their features will help to define various aspects of given branch of woodworking in medieval towns.

Photogrammetric documentation of architectural details in condition of archaeological field research: a case study.

Justyna Elżbieta Ruchała, Edyta Puniach

The aim of this paper is to discuss the full methodology of photogrammetric documentation of architectural details directly on the site. All work stages (the preparation of the test stand, taking photos in accordance with the principles of close range photogrammetry, the development (done with optimal workflow) and visualization of obtained result) are presented. However, in rough field conditions, the surveyor has to minimize the influence of external factors on the quality of the research material. The article focuses primarily on the preparation of a "field

photogrammetric study" in presence of strong insolation, wind and dust. In addition, the tested architectural details are characterized of similar color and texture as the underlying surface (which, according to the theory of photogrammetric studies is highly detrimental). More interestingly, the dimensions of the architectural details selected for development, are very large, which makes it impossible to change their original location naturally. In spite of this, there is the possibility of turning them to the other side. Thanks to this, it is possible to obtain the necessary photographs of both, the upper and the lower part. Against all odds the necessary images and other measurement data were collected during archaeological field research. The images, used to create the 3D models of architectural details, were taken with non-metric cameras. The article presents the use of selected photogrammetric programs which make it possible to develop two fragments of an object, and then combine them into a single, final model.

Depopulation and devastation. Linking GIS data for estimating changes in archaeological landscape of Kharaib el-Desht (Kuwait)

Paweł Lech, Marek Truszkowski, Piotr Zakrzewski

The case study of this paper is a fishing village Kharaib El-Desht, from the late Islamic period, located in the northern part of the Failaka Island (Kuwait), in the Arab Gulf. The settlement have played an important role in the food supply chain of the island and had probably existed to some extend until the early 20th century. Excavations of this archaeological site, carried out by the Kuwaiti-Polish Archaeological Expedition (KPAM), provided many important information about the fish techniques, processing and storage practices as well as about local material culture. Unfortunately, in the modern times the whole area underwent considerable changes, which were caused mainly by the large earthworks maintained during construction of a military camp, army activity during First Gulf War, and finally by devastation and ongoing erosion processes. Due to spatial development, construction investments and wide changes in Failaka's landscape, that are planned in near future, it is crucial to create accurate documentation of existing archaeological sites. This data will be used by local authorities during creating further spatial plan. Our main aim was to combine the geodetic and photogrammetric methods to acquire precise data related to the landscape features, to document all visible architectural remains of the Kharaib el-Desht archaeological site and to integrate them with the geographic information system database. Using the data acquisition equipment (TST, UAV), old satellite and aerial images we were able to create a high quality photogrammetric images and digital elevation model. Based on that we have established the most likely original layout of the settlement, estimated the range of the damages made in the past thirty years and also we have set aims for further archaeological works in the area of site.

Why The Implementation Of Modern Technologies In Museums To Popularise Archaeology Still Fails To Reach Out To Millennials

Benjamin Hanussek

"The problem is not one of a lack of public understanding of science, but increasingly one of a lack of scientific understanding of the public." (Holtorf 2011:58-59) The extensive implementation of modern technologies and digital applications as for example 3D modeling, touchscreens, virtual reality and many more in archaeological museums were introduced to serve further research but also to popularise. While research booms, proper popularisation of archaeology through these methods fail. This paper wants to target the non-immersive character of the used technologies in museums and discuss why they fail to delight and fascinate millennial generations about archaeology and the past. Humans need and want to be challenged and entertained more than ever therefore immersive experiences as escape rooms, which do not even afford digital technologies, are on the rise while archaeological museums like the Viking Ship Museum in Oslo decline in visitor numbers, especially among younger people. I want to show in the case of the Viking Ship Museum in Oslo why the use of non-immersive attempts to modernise and popularise museums with for example animated videos or free audio-guide applications does not cause younger generations to attend the venue. In addition, I seek to conclude solutions to increase popularity in public archaeology through the utilization of immersive experiences in form of digital games. As Claus Pius said "Technology does something. Not is something." Therefore, archaeology should offer technologies that help to immerse into the past instead of simply displaying it.

The shoreline remains; A landscape study of Fire cracked stone heaps

Amanda Saga Jeppsson

The fire cracked stone heaps are frequently found in Bronze Age Sweden although the heaps might be the least understood of Bronze Age features. The function of these remains is debatable: interpretations varies from grave to household indications; from sacral to profane; from piles of waste to markers of claimed land. The fire cracked stone heaps are massive deposits which occasionally contain other artefacts, for example, grindstones, ceramics, and bones from both humans and animals. The heaps are sometimes also constructed with complex inner stone patterns in forms of, e.g. circles and spirals. The remains are found in all of Sweden, but the largest concentration is in the county of Uppland. Previous interpretations of the fire cracked stone heaps have mainly been made by comparing the contents of the heaps and the surrounding archaeological remains. However, by analysing the heaps in a landscape and 3D perspective they

can instead be assessed in relation to a reconstructed shoreline, vegetation and ground elevation. In this presentation we will demonstrate that by looking at the heaps from both a macro and a micro perspective using a high-resolution landscape model it is clear that they have a placement pattern, strongly connected to the shoreline. By reconstructing the visibility of the heaps in a 3D environment, it is possible to create an alternative construction motive, get a deeper understanding of their function and to construct a non-prejudicial dating method for them.

Structure from Motion as a documentation technique. A critical approach to 3D modeling of discs at Plain of Jars 52, Laos.

Zuzanna Kowalczyk, Joanna Koczur

This paper is a discourse on issue of common understanding of documentation as an objective portrayal of reality. It provides critical reflection considering both technical and cognitive criteria. We will present a case study concerning a process of documenting a group of unique artifacts from Plain of Jars 52, Laos. The discs with figural reliefs are associated with hundreds of stone jars, their initial function has been a subject of research for almost 100 years. As a part of a project, several examples of 3D models were analyzed to assess their "correctness", which is determined by technical and aesthetic factors. The presented cases prove that the second criterion has a huge influence on our perception of three-dimensional visualization. High technical parameters (e.g. resolution) are reflected in a quality of the model, but the final judgment of "correctness" is always based on the subjective, immeasurable impression of the creator / recipient. Applying the same method in various conditions, in relation to another group of artifacts or data quality may imply completely different limitations. We will discuss the problems encountered during the modeling process as well as the advantages of using this method. We would like to present proposition for further use of the method in order to creating a database of the artifacts, providing data for further analysis, applying advanced approach to reconstruction and conservation.

Standard session 02:
Progress in WebGIS and DB solutions for Archaeology

***Mieko Matsumoto**, Museum of Cultural History, University of Oslo*
***Espen Uleberg**, Museum of Cultural History, University of Oslo*
***Volker Hochschild**, University of Tübingen, Department for Geography,*
***Michael Märker**, Deparment of Geography, University of Tübingen*
***Christian Willmes**, Institute of Geography, University of Cologne*

Medium Hall A 10.20 – 15.40, 24 April 2019

In this session we would like to bring together scientists presenting new ways to visualize and contextualize spatial data in archaeological databases. Digital field documentation is to varying degrees becoming more and more available as the significant analytical tool for archaeologists. This provides larger and far more complex datasets ever before that can be accessed and analysed. Detailed documentation of structures and contexts on the field can now be directly linked to artefact catalogues and results from digital data analyses. Authority lists and Linked Open Data will widen the range of potential utilities even more. Demands for data management plans, and the fact that many institutions move towards adhering to the FAIR data principles (that data should be Findable, Accessible, Interoperable, Re-useable), will also open new sphere of challenging, unforeseen areas of data exploitation.

The presentations could also include solutions that pass geographic, geodetic and 3D-data to visualization tools. Consideration should preferably be given to unconventional ways of combining georeferenced data from several open sources, and presenting them in unique and innovative ways.

Creating and providing context for archaeological databases, for example, by relating paleoenvironmental information or fresh ideas for spatial analysis, equally increases understanding of these databases and thus leads to progress. Presentations re-using or re-contextualizing existing archaeological datasets, as well as presentations of tools and interfaces like WebGIS (web based portal services and GIS-systems) that allow the visualization of such datasets, are also welcomed.

This session is a succession of nearly 10 years tradition at CAA. We have been presenting our own projects through this period, and invited many other researches to discuss the most updated methods and theoretical background. We believe that work with digital field documentation for visualization and contextualization of archaeological spatial data is one of the most basic, hence fundamental issues in archaeological database research.

10.20 – 10.40
Preparation of a comprehensive palynological norwegian dataset for digital re-analysis and publication as Open Data,
Christian Willmes, Espen Uleberg, Mieko Matsumoto, Helge Hoeg

10.40 – 11.00
UNESP/LARP-MAE/USP WebGIS: a Brazilian initiative to approach the Roman-Byzantine Period at East Mediterranean,
Marcio Teixeira-Bastos, Maria Isabel D'Agostino Fleming, Vagner Carvalheiro Porto

11.00 – 11.20
«Special areas» in the settlement system Iron Age - Middle Ages cultures of the East European Plain,
Sergey Chaukin

11.20 – 11.40
Early Christian Baptisteries: Geocoding, Exploring and Analysing a Spatiotemporal Dataset,
Adam Mertel, David Zbíral

11.40 – 12.00
Combining scientific and interpretive approaches to archaeological data: multi-proxy database and Web-GIS for East Europe,
Leonid Vyazov, Maxim Efimov, Timur Mardanov, Timur Timerkhanov, Ramil Sabitov, Natalia Selezneva, Julia Salova, Ayrat Sitdikov

12.00 – 12.20
Web-based data integration. A case study of Medieval coins in a multileveled perspective,
Steinar Kristensen, Ermias Beyene Tesfamariam

12.20 – 12.40
Extending the Nordic contribution to ARIADNE+,
Jens-Bjørn Riis Andresen

LUNCH BREAK

14.00 – 14.20
De facto standardisation: template database models as a path to adoption,
Ian Johnson

14.20 – 14.40
Current status of georeferenced metadata visualization in Norwegian,
Stone Age, Mieko Matsumoto, Espen Uleberg

14.40 – 15.00
Deir el-Bahari Projects : objective, realization, plans. Integration of data in the Database Digger,
Jadwiga Iwaszczuk, Iwona Zych, Tomasz Zalewski

15.00 – 15.20
Where have all my data gone, and how do I find them again?
Evy Berg

15.20 – 15.40
Making excavation reports available,
Jens-Bjørn Riis Andresen, Bolette Ammitzbøl Jurik

Preparation of a comprehensive palynological norwegian dataset for digital re-analysis and publication as Open Data

Christian Willmes, Espen Uleberg, Mieko Matsumoto, Helge Hoeg

The data management aspects to prepare a comprehensive palynological dataset, digitally collected and curated by Dr. Helge Høeg during his career as Palynologist in Norway since the 1970ies, for reuse with modern analysis methods and technologies and publication as Open Data, are discussed in this presentation. As presented on last years CAA, this dataset has distinguished potential to increase the knowledge of the norwegian paleoenvironment since the last ice age, for example by application of new machine learning based methods to this dataset. The palynological data are given in a proprietary format as .til and .tgx files originating from the MS Windows based palynological analysis software Tilia. There are around 1000 of these files for the >300 sites constituting this dataset. The process of data transformation to an open format, as well as the alignment with metadata schemas and taxonomies from the palynology domain will be discussed. An overview of the current Open Data and data management practice in the palynology domain, including some Open Data base projects will be given. The technical upload process into some of these systems were tested and will be discussed, to align and compare our approach with existing best practice in this field.

UNESP/LARP-MAE/USP WebGIS: a Brazilian initiative to approach the Roman-Byzantine Period at East Mediterranean.

Marcio Teixeira-Bastos, Maria Isabel D'Agostino Fleming, Vagner Carvalheiro Porto

According to data from the Brazilian Institute of Geography and Statistics (IBGE), 86.8% of Brazilians (nearly 208 million people) declare themselves Christian, divided between 64.6% Roman Catholic and 22.2% Evangelical. This shows that in comparison with the 91.8% of Brazilian Catholics declared in 1970, the group declined, so that the segment denominated Pentecostal in forty years increased from 5.2% of the population to 22.2%. Religious mobility is a fundamental aspect of social understanding both in Late Antiquity and in the present context, precisely because of the capacity to manage cosmologies and retain power and political relations. LARP-MAE/USP WebGIS program is framed between the most basic archaeological database research documentation for visualization and contextualization of archaeological spatial data in the Eastern part of the Mediterranean. This type of data enables us to approach for instance the correlations between the spread of synagogues and churches during Late Antiquity, beyond providing support data to many other queries. Therefore, bound together with FAIR data principles and Digital Humanities concepts. The main efforts are to improve thematic interests, methods,

and approaches, use archaeological evidence for critical historical analysis, and develop new interdisciplinary methods and approaches.

«Special areas» in the settlement system Iron Age - Middle Ages cultures of the East European Plain

Sergey Chaukin

The analysis system settlements of the Iron Age of the East European plain has localized special areas. It is identified on the following attributes: density of hillforts, difficult system of defense, existence of special type of objects "hillforts - satellites", to existence of import items, hoards and cult objects. The combination of these attributes indicates the existence of several centers in the territory East European plain in the Iron Age. The results are based on an analysis of a database of 675 settlements. On the main rivers are allocated areas with the highest concentration of hillforts. It is localized on the Moskva River, on the Volga, on the Ugra River, on the Oka river, on the Msta River. This areas consist of multivallate hillforts, "hillforts - satellites", items of import, items of cult and hoards. Lifetime of the similar centers 6 - 7 AD. The arrangement of the centers of the early Middle Ages on settlements of the Iron Age testifies to continuity of cultures of different eras. Thus, special territories which on quantitative and qualitative attributes are distinguished from the others are identified, but at the same time are similar among themselves.

Early Christian Baptisteries: Geocoding, Exploring and Analysing a Spatiotemporal Dataset

Adam Mertel, David Zbíral

GIS tools and methods of analysis have become a solid part of various research projects in historical and archaeological research. In this paper we are presenting a case study of Christian baptisteries, from the process of data collection and geocoding through data visualization to finally creating an exploratory tool and providing geostatistical analysis. Baptisteries are Christian buildings designed for performing baptism. Most of them were constructed between the 4th and 7th century throughout the Mediterranean. The objective of this research is to compile a comprehensive dataset of baptisteries and study the spatiotemporal patterns in order to provide a better understanding of this phenomenon. We took the most complete printed catalogue of baptisteries (Ristow S. Frühchristliche Baptisterien. 1998) and transformed all the records into a spreadsheet table. Then we used a geocoding tool we developed, the Historical Geocoding Assistant (http://hde.geogr.muni.cz/hga/), to geocode our records. The geocoded dataset was then visualised in a web map application (http://hde.geogr.muni.cz/baptisteries/) and in a set of static analytical maps (http://hde.geogr.muni.cz/baptisteries/piscina, http://hde.geogr.muni.cz/

baptisteries/multiples/). To be able to analyse the spatiotemporal but also quantitative patterns of this dataset in more depth, we started to construct an exploratory tool (http://hde.geogr.muni.cz/baptisteries-exploration/). Besides the visual analyses provided by those tools and maps, we produced various geospatial analyses that investigated the diffusion of baptisteries in spacetime, but also correlated this dataset with other relevant datasets.

Combining scientific and interpretive approaches to archaeological data: multi-proxy database and Web-GIS for East Europe

Leonid Vyazov, Maxim Efimov, Timur Mardanov, Timur Timerkhanov, Ramil Sabitov, Natalia Selezneva, Julia Salova, Ayrat Sitdikov

Internationally accessible data sources do not contain much information about Eastern Europe, especially Russia. Prevalence of cultural-historical approach in the Eastern European archaeology has provided for a long time some robust explanations of cultural dynamics in the vast area where one migration was followed by another. Unfortunately, it turned the development of the discipline into a permanent struggle of numerous local schools of research, each with its own local chronologies and interpretations. Scientific data accumulated by the last two decades was drowning in an ocean of typologically interpreted sites and artifacts. The issue of combining data with different level of accuracy appeared to be challenging. A dozen of databases were developed to manage that huge massive of records during the recent decades, but all of them remained unused by researchers primarily because of inability to analyze different types of data. We present the preliminary results of a new Web-based and GIS-driven database that includes both cultural and stylistic interpretations and relative chronological sequences as well as absolute datings and ecofacts. It is based on the use of a graph database (Neo4j) that allows us to store, analyze and manage complex relationships between the archaeological evidence, its context, and interpretations, in the intuitive, but sophisticated, way. The functionality of our multi-user system includes data mapping, visualization, selection, and processing. Developed analytical tools include clustering according to the attributes of the objects stored and creating the chronology for the selected areas based on summed probability distribution of 14C dates.

Web-based data integration. A case study of Medieval coins in a multileveled perspective

Steinar Kristensen, Ermias Beyene Tesfamariam

The HumGIS project, which is founded by the University of Oslo, targets GIS in humanities, and its goal is to increase the use of GIS among several disciplines in the humanist research. The system architecture experimented in HumGIS is also one of the goals of the Archaeolog-

ical Digital Excavation Documentation (ADED) project, which is a long-term collaboration between the Norwegian university museums to establish a common digital infrastructure and the accessibility of open archaeological datasets. The datasets of this multileveled paper derives from the interdisciplinary project Religion and Money at the Museum of Cultural History I Oslo. Old analogue data such as maps, excavation plans and find lists have been digitized into central geodatabases with records of coins found in medieval churches and other archaeological contexts primarily in Norway, but also Denmark and Sweden. In this paper, we focus on the scalable web-based GIS infrastructure designed using standardized web service specifications for the purpose of adaptive visualization of multi-scale archaeological datasets. The combined utilization of WFS and WMS standards in this system makes it capable to query and retrieve the medieval coin database and mash it up with other data sources such as historical topographic maps to generate high-quality visualization and analysis. This ability to examine the coin finds data in its spatial context makes it possible for researchers to understand the connection between economic activities and the history of the settlements and movement of societies in the medieval period.

Extending the Nordic contribution to ARIADNE+

Jens-Bjørn Riis Andresen

This paper presents the NAOS-initiative, which is an acronym for Nordic Archaeological Open Science. The aim of this initative is to provide better facilities for cross-border research. The initiative will give existing service-providers the necessary tools for meta-data harvesting and will integrate the research community in mapping available digital ressources to global identifiers. Finally, the initative builds on services available in the EOSC-hub in order to make searches across heterogenous databases possible.

De facto standardisation: template database models as a path to adoption

Ian Johnson

The modelling of project data, whether for an individual researcher or small research group, has been a significant hurdle in the uptake of the Heurist data management system (http://HeuristNetwork.org). Even though Heurist removes the technical hurdles of development, the effort of thinking about entities, attributes and connections is generally too hard for someone who simply "wants to get started". Our initial response to this problem was to provide a number of template databases which could be 'quarried' for suitable structures and ensure a degree of interoperability/standardization - not through prescription, but by offering the path of least

effort. However the array of choices in a generic system such as Heurist, and lack of example data or guidance on use once set up, still proved a barrier. In 2018 we started developing a more complete set of database templates which can be cloned to form a new database, including example data and a configurable 'dashboard' providing an initial view and explanation of the functions most relevant to that particular domain/database. In this paper we will describe some of the Archaeology / small museum templates we have developed and offer observations on the degree of uptake and consequent standardization effects, as well as reflecting on the difficulties in developing generic templates which strike a balance between providing a comprehensive model and creation of a system which overpowers the potential user.

Current status of georeferenced metadata visualization in Norwegian Stone Age

Mieko Matsumoto, Espen Uleberg

The increasing number of datasets to be downloaded and queried affords new possibilities but also new challenges to Stone Age archaeology. The national infrastructure for the Norwegian university museums – MUSIT (MUSeumIT) – contains metadata and photographs of archaeological finds. The work within MUSIT follows the FAIR (Findable, Accessible, Interoperable, Retrievable) principles for sharing data. It is however necessary to facilitate better opportunities for users to combine data from different sources in a web portal. The HumGIS (HumanitiesGIS) project from 2018 at the University of Oslo will create better user interfaces to digital georeferenced data from several sources. This paper will present current challenges and perspectives regarding visualization and the access and knowledge users need to be able to extract and analyse different datasets. The examples are from three sources: First, the MUSIT artefact database used at the university museums and accessible only by museum staff. This database contains detailed context information, and it is possible to analyse intrasite components. Second, the published online version of the MUSIT database (http://www.unimus.no/arkeologi/forskning/). This is a subset of the artefact database, and it is possible to conduct large scale visualization and inter site analysis, but not intrasite analysis. The third source is Intrasis (http://www.intrasis.com/) projects containing detailed documentation of structures at sites, but no artefact metadata. This digital excavation documentation is stored as separate projects and only available upon request. These excavation data will be merged and published as open data through the ADED (Archaeological Digital Excavation Documentation) project (2018 – March 2021).

Deir el-Bahari Projects : objective, realization, plans. Integration of data in the Database Digger

Jadwiga Iwaszczuk, Iwona Zych, Tomasz Zalewski

Deir el-Bahari Projects is a page currently being built, whose task is creating space for research for Egyptian monuments from the position Deir el-Bahari in Egypt. It is based on the base of Database Digger and combines extensive archiving and research tools. The Polish-Egyptian Archaeological and Conservation Mission's task since its beginning was the documentation, conservation and reconstruction of the remains of the temple. The goal of the Deir el-Bahari Projects webpage is to gather in one place as much information as possible, make it available to researchers and enable the best possible search for data primarily for scientific needs. The Database Digger had to face many challenges, among which flexibility is the most important. Documentation requirements of archeology researchers elude the standard forms. Data tables do not allow to close in a fixed number of columns / fields. Each documented object has different, often extremely different parameters. Creating a system that would order these structures and at the same time give freedom of future action is a great challenge. The created system allows for intuitive defining of new structures and data types, it allows defining validation of values in fields, but does not close on this. In addition, entries are described by tags and have a bibliography linked. Additional functionality is the use of three-dimensional models in the base structure, which enable the location of entered data and their search from any angle.

Where have all my data gone, and how do I find them again?

Evy Berg

The results from excavations carried out more than 20 years ago exist mainly on paper. There the catalogues, the interpretations and the various analyse can be found, nowadays also as scanned publications. The GIS-data collected, the database analysis or the spreadsheets with categorized finds were not taken care of on an institutional level. The individual project leader had to take care of the data on a private basis. Today, only fractions of these data may be found in national or institutional databases. The presentation will show datasets from the mid-nineties, how they look in their original state, and what part of the data is searchable and retrievable today. The possibilities of adding older data to a system that enables the data's future digital life will be explored. Also various ideas of how these data can be combined with new data, other datasets and questions of whether the original interpretations will be different will be explored. Finally, ideas about accessing data by various means will be addressed. To make these data existing as small datasets outside national or institutional structures available, they must be linked to, or incorporated in a system that will enable their future use.

Making excavation reports available

Jens-Bjørn Riis Andresen, Bolette Ammitzbøl Jurik

The advent of ”rescue archaeology” marked a fundamental change for the archaeological discipline: Archaeology became a profession. This new condition required that archaeological investigations had to be reported according to defined standards. But these reports did in most cases not enter the bibliographic systems, but were stored in more or less in-accessible archives. The case of Denmark fits very well in this general scheme. Excavation reports are considered “grey literature” and number over 10.000 for the period from 2005. All these reports are digitally produced and stored in the National Sites- and Monuments Records database (http://www.kulturarv.dk/fundogfortidsminder/), but do not meet FAIR principles (Wilkinson et. al. 2016). This paper addresses a joint attempt by the authors to remedy this problem. The solution harvests the reports from the national SMR through the OAI-PMH protocol, stores them in a Duraspace repository, indexes these, combines them with SQL-data, and presents the user with a front-end which makes them full-text searchable. The documents fulfilling the search criteria can subsequently be downloaded directly from the national SMR in order to avoid copyright violations.

Roundtable 03: Roundtable Scientific Scripting Languages in Archaeology – Limits and Opportunities of Open Research

Martin Hinz, Institute of Archaeological Sciences, Bern University
Clemens Schmid, Römisch-Germanisches Zentralmuseum Mainz
Sophie Schmidt, University of Cologne

Seminar Room 16.00 – 17.40, 24 April 2019

At last year's CAA, during the session on R in Archaeology, a suggestion was made to set up a Special Interest Group on Scientific Scripting Languages in Archaeology (SIG SSLA). We would like to comply with this proposal at this year's CAA. We would also like to take advantage of the forum to discuss the SIG's goals and agenda in a round table.

A scripting language is a programming language that allows interaction with a software interpreter to perform operations on data. It does usually not require compilation and is therefore associated with a rapid and agile development style that is particularly suitable for research, analysis and visualization of scientific data. Scripting languages may include but are not limited to R, Netlogo, Stan, OxCal, Bash or Python.

The use of scripting languages enables the user to document every necessary step in a research pipeline. Conversely, the resulting scripts can be used to reproduce analyses by other researchers if the input data is also available. Even the initial software environment can be emulated. Scripting languages are therefore ideal for reproducible research. But reproducibility can go even further: ideally it also documents the scientific production process with all inductive and deductive steps of hypothesis formation. A modern and powerful way to achieve this is version control.

There is a clear demand for dialogue in the community to broaden the impact of these improved methodological approaches, considering they still have a quite small number of users. We ovffr a draft Statement of Purpose for the SIG to discuss in this session. It is based on an internet survey following the last international CAA: (https://martinhinz.github.io/sig_sci_scripting_languages/statement.html).

We invite participants to prepare a two-minute statement or comment about this paper in order to start the discussion, which will be divided into two thematic sections. One section will focus on the general topics outlined in the position paper: Which principles are essential for scientific programming? How should they be taught? How can quality control and sustainability be guaranteed? The second section will begin to define more clearly the objectives of the proposed SIG: Which instruments and platforms can be established? What support can be provided for the growth of a more open, inclusive and reproducible research software landscape?

DISCUSSANTS

Martin Hinz,
Institute of Archaeological Sciences, Bern University

Joe Roe,
Centre for the Study of Early Agricultural Societies, University of Copenhagen

Iza Romanowska,
Barcelona Supercomputing Center

Clemens Schmid,
Römisch-Germanisches Zentralmuseum Mainz

Lizzie Scholtus,
UMR 7044 Archimède Université de Strasbourg

Standard session 04:
Digital archaeology of modern conflict landscapes

***Grzegorz Kiarszys**, Department of Archaeology, Szczecin University*
***Mikolaj Kostyrko**, University of Bamberg*

Medium Hall B, 11.00 – 15.40, 26 April 2019

In this session we are looking to bring together case studies that apply digital archaeology to the research of modern post-conflict landscapes. Conflict archaeology of the recent past is a fast-growing field of knowledge. What 30 years ago would have been considered as new and quite peculiar kinds of archaeological studies have, in the last decade, become common. Today archaeologists study landscapes altered during recent conflicts (WWI, WWII, Cold War etc.) in the same way, as any other period. While doing so, they reach out to digital archaeology - computer aided or based techniques which provide them with a better insight into their study area. Tools that help them to explore (i.e. remote sensing), reveal and analize (i.e. GIS analysis, modeling), share objects (i.e. online databases) of their interest with a wider audience.

What kind of contribution to the study of post-conflict landscapes can digital archaeology provide? How can digital archaeological tools change our (and other's) cognitive experience (enhance or cloud it?), and understanding of conflict sites? We are looking for qualitative and not quantitative case studies that will show the importance or irrelevance of digital archaeology methods in study of recent conflicts, both in its research, as well as in outreach and popularisation of archaeological study.

11.00 – 11.20
The survivorship bias and intimate landscapes of conflict,
Mikolaj Kostyrko, Grzegorz Kiarszys

11.20 – 11.40
Jewish religious heritage in the landscape of conflict. Relicts of military operations in the area of the New Jewish Cemetery in Łódź (Poland),
Anna Magdalena Majewska

11.40 – 12.00
"Festung Brünn": Remote sensing and spatial analysis of German World War 2 field fortification in the vicinity of the city of Brno (Czech Republic),
Jiří Zubalík

12.00 – 12.20
Hold position: Case study of non-destructive archaeological survey and spatial analyses of Austro-Hungarian trenches from april 1915 at Staviska hill (Polish-Slovakian border),
Martin Vojtas, Martin Fojtík, Jiří Zubalík, Jakub Těsnohlídek, Jan Petřík, Peter Tajkov, Martin Drobňák, Radim Kapavík, Richard Bíško

12.20 – 12.40
General Discussion

LUNCH BREAK

14.00 – 14.20
Landscapes of disappearance in São Paulo: data modelling and visual analytics to understand repression practices,
Patricia Martin-Rodilla, Marcia L. Hattori, Cesar Gonzalez-Perez

14.20 – 14.40
An open online minor on the archaeology of conflicts,
Wilko van Zijverden

14.40 – 15.00
Past Landscape of Pomeranian Army (1939), a remote sensing perspective,
Filip Wojciech Wałdoch

15.00 – 15.20
Nuclear "Soldiers of Freedom". Remote sensing of Cold War landscapes in Poland,
Grzegorz Kiarszys

15.20 – 15.40
The Archaeology of the Cold War in south-eastern Xinjiang (P. R. China),
Kasper Jan Hanus

The survivorship bias and intimate landscapes of conflict

Mikolaj Kostyrko, Grzegorz Kiarszys

One of the main advantages of archaeology is the ability to interpret material remains of human activities. Based on this 'evidence', archaeologists weave stories about the past. Similar circumstances occur in case of cultural landscapes registered through remote sensing techniques. Digital methods can aid in creating persuasive narrations. They allow to register and present unimaginable quantities of details, making archaeological visions very aesthetic and plastic. There is however a price to be paid for this opportunity. Researches often focus on things that are easy reachable through simple analysis of digital records. This causes a lack of criticism towards applied methods and quality of digital data. It is much more difficult to realize gaps resulting from limitations of applied methods. In statistics such a situation is referred to as "the survivorship bias", and describes the situation when conclusions are defined based on a non-complete set of evidence. We will present three case studies from different conflict landscapes focusing on their intimate stories. These narratives of everyday lives that can be easily omitted, but which also could be brought back to light with a wider scope of integrated archaeological sources and methods: remote sensing data, spatial analysis, photos and testimonies. We will refer to case studies from different periods of 20 c. WWI and WWII POW camps, as well as a Cold War nuclear depot, which will serve as examples to discuss different problems and possibilities of approaching "the survivorship bias" within archaeological studies of modern conflict landscapes.

Jewish religious heritage in the landscape of conflict. Relicts of military operations in the area of the New Jewish Cemetery in Łódź (Poland)

Anna Magdalena Majewska

The landscape of conflict is a construct that currently attracts attention in the landscape studies. Directing the analyses mainly within the framework of contemporary archaeology, it is one of the keys in reading the spatial history – the landscape memory. In the speech I will present the proposal of the expansion of the landscape of conflict idea in the discourse of Jewish material religious heritage within the framework of integrated geographic-historical and archaeological studies of heritage. As an example of this type of analyses, the study was prepared for the selected elements of the landscape of conflict (e.g. bullet traces) within the second largest Jewish necropolis in Europe – the New Jewish Cemetery in Łódź. The research was conducted using the methods of non-invasive area documentation and performing the analysis of teledetection data (including clouds of points). On this basis, also the spatial models of the material heritage were constructed, constituting the historical palimpsests.

"Festung Brünn": Remote sensing and spatial analysis of German World War 2 field fortification in the vicinity of the city of Brno (Czech Republic)

Jiří Zubalík

In recent years, several trenches of overall length 400 metres were unearthed on three sites during rescue excavations at the outskirts of Brno, Czech Republic. These trenches represent a small part of a German field fortification system. Brno was turned into "unconquerable" "Festung Brünn" (the Brno Fortress) during last months of World War 2. However, precise information about this fortification is scarce. It isn't known how many trenches were dug or how sophisticated the defenses were. Archaeological investigation, principally remote sensing techniques, are helping to answer to these questions. First, we need to reconstruct as much of "Festung Brünn" as possible. To this end, we have to applied non-invasive digital survey techniques. The most important method is the remote sensing. LiDAR and modern aerial images depict the preserved trenches, although the highest number of trenches is visible in the historical aerial photographs. We have combined all this data to digitally reconstruct this large fortified area. The survey started in close proximity to known sites which confirmed the value of the remote sensing data. Then, the survey was extended to cover the whole area around Brno. Additionally, the spatial analysis helped us to determine the combat value of the trenches (line of sight, which direction was supposed to defend). Understanding these trenches gives new insight into organisation of last desperate defense of the German army. Despite the war being lost, the Germans managed to fortify large areas around Brno. As we shall demonstrate, this fortification was sophisticated and ingeniously prepared.

Hold position: Case study of non-destructive archaeological survey and spatial analyses of Austro-Hungarian trenches from april 1915 at Staviska hill (Polish-Slovakian border)

Martin Vojtas, Martin Fojtík, Jiří Zubalík, Jakub Těsnohlídek, Jan Petřík, Peter Tajkov, Martin Drobňák, Radim Kapavík, Richard Bíško

Carpathian mountains was place of hard fights between three emperors (German, Austro-Hungarian and Russian) during spring of 1915. After one of Russian breakthroughs in Austro-Hungarian lines and an annihilation of 28th infantry regiment near Stebnik (now Slovakia), defensive line was quickly rebuilded at the Staviska hill. Archaeological survey found trenches at the ridge after 100 years in nearly intact condition. Positions of the 4th Tyrolean Rifle Regiment was build from cracked stone, most structures is still well preserved on the line and in close hinterland. Line was occupied for whole month and because Russians never tried to storm there, soldiers have enough time to build strong field fortifications, limited just by terrain and weather.

In other words, this site provide an unique opportunity to explore 1) how austro-hungarian army organised building of fortifications at strategically important positions; 2) conditions of trench life in Carpathian battlefield and 3) what part of the narrative could and couldn't have been achieved through the used methods. To achieve these aims were aplicated both classical and modern methods of documentation and non-destructive survey. With classical ground survey, consisted of metal detectoring and plan making with help of GPS and Total Station, the area provides opportunity to explore the trench line and a near logistic area, traces of soldiers daily life and possibilities of planned defence against theoretical attack of enemy. Due to use of remote sensing, where we aplicated aerial survey of LiDAR and ortophotomaps, we can survey the trenches in long distance. Thanks to spatial analysis, we can survey e.g. line of sight, slope analysis, elevation and least cost path. We are able to reconstruct positions with the help of virtual reality and comparison with period documentation, manuals and reports. Therefore, we can give a story to place of single event, what happened here in hard times 100 years back.

Landscapes of disappearance in São Paulo: data modelling and visual analytics to understand repression practices

Patricia Martin-Rodilla, Marcia L. Hattori, Cesar Gonzalez-Perez

The Brazilian military dictatorship (1964-1985) used disappearance as one of its strategies, leaving hundreds of missing persons whose fate and cause of death, until today, is unknown. Usually, missing cases are under-documented, with little information about health, location or personal objects found [1][2]. From an archaeological perspective, we have modelled and analysed the data obtained from over 2000 missing person cases that may help us to understand some of the common practices carried out by the dictatorial regime [3]. We focus on how traces of identity of unknown people may be discovered, and what malpractice signals exist in the datasets. Is it possible to look beyond raw data and assist its understanding through software-based techniques? We have applied a qualitative software approach based on assisting the knowledge generation process through a visual analytics study. Visual analytics [4] brings together some computational techniques for innovative visual representations based on cognitive principles to facilitate the reasoning on human information. It has been successfully applied in several domains: biomedicine [5], geology [6], finance [7], humanistic domains [8][9], and recently archaeology [11]. We cover the complete research process, from the data model initial stages [10] to the creation of specific software visualizations of missing people cases. This paper shows the results of the data modelling and visual analytics study, and describes how this process helped us to obtain some clues about the repression practices performed in São Paulo, further reflecting on the action of repression on bodies "that do not matter" and their identity.

An open online minor on the archaeology of conflicts

Wilko van Zijverden

Since 2013 students of Winchester University, Goethe University Frankfurt and Saxion University work together in an international fieldschool organised by HessenARCHÄEOLOGIE. One of the central themes in this fieldschool is the archaeological research of conflicts. The perception on conflicts of the past vary strongly between the participants. These differences in perception cause different approaches in research, policy and public outreach. This led to the conclusion that an international educational program is necessary. In close cooperation with the Archaeology departments of Winchester University and Goethe University Frankfurt, Saxion University will develop a minor of 30 ECTS on the topic of "The Archaeology of Conflicts". The main topic of the minor is the investigation and handling of the physical remains of national and international conflicts in Northwestern Europe of the recent past (post industrial revolution). The minor will be entirely organised as a digital classroom with the exception of an international fieldschool. In order to develop such a program a digital platform for access to courses, study materials and so on by students and others will be developed. Digital research techniques will be an integral part of this minor. It will be a challenge to incorporate these techniques in online education. In this lecture our ideas on online education of digital techniques will be outlined. The lecture is also intended as an invitation for researchers using digital research methods in this field of expertise to contribute to this initiative.

Past Landscape of Pomeranian Army (1939), a remote sensing perspective

Filip Wojciech Wałdoch

Purpose of this presentation is show first results of research project „Past Landscape of Pomeranian Army (1939), a remote sensing perspective". It aims to answer question: how been creating, functioned and how currently looks landscape of their operation? To answer them I will use remote sensing data like: airborne laser scanning, aerial photographs, archival maps, satelite imagery and geophysics. All data will be collected to the GIS database and then interpreted. Project starts in 2017 and it will last until 2021. First results show some case study of application of airborne laser scanning, aerial photographs and archival maps. Shown is the potential of these methods, but also problems with their use (for example aerial prospection). The result of the presentation is also to submit to the discussion the accepted methodology of work. To achieve even better results in the future.

Nuclear "Soldiers of Freedom". Remote sensing of Cold War landscapes in Poland

Grzegorz Kiarszys

In my paper I will present the case study of three abandoned Soviet nuclear warhead storage sites from the territories of Poland: 1. Object 3001 in Podborsko (West Pomeranian Voivodeship); 2. Object 3002 in Brzeźnica Kolonia (Greater Poland Voivodeship) and 3. Object 3003 in Templewo (Lubusz Voivodeship). My narration will be based on the analysis of Airborne Laser Scanning data, historical and modern aerial photographs, declassified satellite imagery (Corona and Hexagon), CIA reports, as well as the Polish-Russian agreements and other documents from the archives of the Institute of National Rememance of Poland. I intend to search for an answer to the questions about the cognitive potential of the archaeological perspective in studies of the remains of top-secret military sites. I am also going to argue that such an approach may be seen as a qualitative turn in the narration of recent past events and help in the protection of the abandoned Cold War military installations from further decay. Historical records of former top secret military facilities often have numerous narrative gaps. Some of information were purposely omitted in official documentation, while others were never to be registered. In the case of discussed former nuclear storage sites the gap of 23 years in declassified historical record available through Polish archives can be observed. Archaeological approach, in certain circumstances, has a cognitive potential to interpret such inconsistencies through integration and reinterpretation of archaeological and historical sources.

The Archaeology of the Cold War in south-eastern Xinjiang (P. R. China)

Kasper Jan Hanus

The Lop Nur is a lake, now mostly dried up, in the south-eastern part of Xinjiang-Uygur Autonomous Region. In late prehistory the shores of the lake were home to agro-pastoral populations who spoke Tocharian language - those people left first footprints in the landscape that we can observe today. Through the ages, the landscape was settled, abandoned and reoccupied. In the 20th century, this region was largely neglected. During the Chinese Civil War, the territory was briefly controlled by various factions, including Kuomintang, Soviet Union and Muslim separatists. Finally in 1949 Xinjiang was acquired by People's Liberation Army. The Lop Nur region did not have any major oases and was virtually free of human occupation. Therefore it was designed in the early 60's as Nuclear Weapons Test Facility. The first bomb, Project 596, was detonated on 16th October 1964. This test was followed by another forty-four explosions in four spots around Lop Nur, designated as Areas A to D. The last blast was on 29th July 1996. In early 21st century some of the decommissioned nuclear facilities were… open to the public as

so-called a "Red Tourism" destination. My paper aims to present how the application of archival and contemporary high-resolution spaceborne imagery influences our understanding of that landscape. It is intriguing that the heritage of the Cold War has similar value to two millennia old Silk Road cities as the remnants of nuclear installations are considered as "locations with historical significance to Chinese Communism".

Standard session 05:
R as an archaeological tool: current state and directions (vol. II)

Carolin Tietze, ISAAK; Christian-Albrechts-Universität zu Kiel
Sophie Schmidt, University of Cologne
Nicole Grunert, Christian-Albrechts-Universität zu Kiel

Exhibition Room B, 10.20 – 12.40, 24 April 2019

The open source, platform-independent and community-driven software environment R has become one of the most important tools for quantitative archaeologists working on a reproducible research approach and developing new packages for their analyses. Following the success of this session at the last international CAA conference in Tübingen we want to encourage scientists using R to either return and show the progress of their work. We also warmly invite new colleagues to demonstrate their fresh and new approaches. As many colleagues have not yet realized the potential of the language and its easy access way to conduct high quality research with the readily available tools in R it is most important to explore its use for different archaeological research questions.

For this session we would like to continue to survey the state of the art and the potential application of R. We invite presentations for this session that focus on questions such as, but not limited to:

- What are the specific benefits of this statistical framework in the eyes of its users?
- What are the possibilities? What are the limits?
- What future directions might the usage of R in archaeology have?
- Which archaeological package has been developed, that might be useful for other researchers as well?
- Which package needs to be developed further to improve the usability of the software for archaeologists?
- What has to be considered to optimize the workflow with R?

We would especially like to attract colleagues who demonstrate their approach with live coding or present archaeological R packages that are ready or in the making. Presentations on works in progress are very welcome. We intend to maintain a productive and inclusive exchange between both young and experienced users of all backgrounds.

10.20 – 10.40
Gorram shiny: an accessible interface for reproducible landscape archaeology with R and fieldwalkr,
Joe Roe

10.40 – 11.00
Using R to Update Minnesota's Archaeological Predictive Model,
Elizabeth Ruth Hobbs, Carla Landrum

11.00 – 11.20
3D stone tool analysis in R: An introduction to the Lithics3D package,
Cornel Marian Pop

11.20 – 11.40
sdsbrowser - an R Shiny Application for visualisation and analysis of SDS stone artefact data,
Clemens Schmid, Christoph Rinne

11.40 – 12.00
Emacs, Org-mode, R and LaTeX: Power tools in the archaeological toolbox,
Robert Mahler

12.00 – 12.20
An R package for inferring patterns of social learning from archaeological frequency data,
Enrico R. Crema, Anne Kandler

12.20 – 12.40
General Discussion

Gorram shiny: an accessible interface for reproducible landscape archaeology with R and fieldwalkr

Joe Roe

Reproducibility is one of the driving concerns behind the recent adoption of R as an archaeological tool. However, the computational skills needed to actually conduct reproducible research in R are a "rarity" amongst archaeologists (Marwick 2017). Moreover, computational reproducibility comes only at the very end of the research process. Computational archaeologists are therefore presented with two challenges. How can we take reproducibility beyond our computers and into the field? And how can we get our tools into the hands of non-specialists? I will demonstrate a new package which I hope makes progress on both these problems. fieldwalkr (https://github.com/joeroe/fieldwalkr) is an R package for spatial sampling and survey simulation. It includes tools for simulating the effect of different sample frames, sampling strategies and detection functions on the estimation of spatial point patterns. It promotes reproducible field research by facilitating more informed and statistically rigorous survey designs, and as a framework for the theoretical analysis of sampling effects. In this paper, I will focus particularly on the development of a graphical user interface for the package. Built using shiny, this alternative interface makes the package more accessible to a wider range of users. At the same time, the core benefits of a scripted tool are maintained by running fieldwalkr 'under the hood'. I will suggest that developing tools that are as accessible to as many other researchers as possible is the most impactful contribution computational specialists can make to improving the reproducibility of archaeological research as a whole.

Using R to Update Minnesota's Archaeological Predictive Model

Elizabeth Ruth Hobbs, Carla Landrum

The Minnesota Department of Transportation has migrated statistical analysis and modeling procedures for MnModel Phase 4 from SPlus to R. This change has resulted in cost savings and facilitated the transfer of the modeling program to Minnesota State University – Mankato. MnDOT and MSUM have been using R for exploratory data analysis, predictive modeling, and model evaluation. We have developed R scripts for both categorical and numeric models using a random forest ensemble learning method. We have explored and developed ArcGIS procedures for exporting data to R and importing models from R, including RBridge exploration. In the course of running models for twenty regions, we have developed insights on data preparation, sampling design, computing requirements, statistical model selection, model validation and workflow optimization. In this paper, we will share our lessons learned and experiences with R.

3D stone tool analysis in R: An introduction to the Lithics3D package

Cornel Marian Pop

This presentation introduces Lithics3D, an open-source (GPL v2) R package for automatic and semi-automatic analysis of stone artifacts based on 3D scans. The package, which is under active development and available on GitHub, has two primary goals: first, to provide ready-to-use functions for directly quantifying archaeologically meaningful artifact properties that are difficult or impossible to measure manually; and second, to greatly simplify the process of implementing such high-level functionality by providing the necessary building blocks. In this presentation the capabilities of Lithics3D will be demonstrated, focusing particularly on how researchers who are familiar with, but not necessarily experts in R and 3D analysis can implement novel, custom functionality with the aid of the low-level functions provided by the package. Current and future development directions will also be discussed.

sdsbrowser - an R Shiny Application for visualisation and analysis of SDS stone artefact data

Clemens Schmid, Christoph Rinne

SDS (Systematic and Digital documentation of Stone artefacts) is a recording system for stone artefacts proposed by Drafehn et al. 2008 [1]. It was created as an uniform coding and standardized listing system of the conventional attributes recorded at lithic inventories to enable quantitative and comparative analysis. The variable collection and data structure in SDS was compiled from several established documentation systems, most notably Zimmermann 1977 (see [1]). Naturally its long history caused technological anachronisms in the way it stores data, complicating the application of modern computational tools and methods. Nevertheless the SDS system is still in use and was implemented for material study in many archaeological projects over the last ten years. These separate individual datasets are now in danger of falling into oblivion although they are a valuable resource for cross-context data comparison as intended by the SDS creators. This paper presents our attempt to 1. collect, standardise and modernise SDS data and metadata, 2. analyse and compare different datasets with tools provided in an own R package sdsanalysis and 3. publish and visualise the datasets with the webapp sdsbrowser to make them accessible for future use. Increasing the visibility and usability of old data is of crucial importance for archaeology and the combination of R Package and Shiny App is a powerful framework to simplify this task. [1] A. Drafehn/M. Bradtmöller/D. Mischka, SDS – Systematische und digitale Erfassung von Steinartefakten. Journal Of Neolithic Archaeology 10, 2008. doi:10.12766/jna.2008.25

Emacs, Org-mode, R and LaTeX: Power tools in the archaeological toolbox

Robert Mahler

Writing a synthesis in archaeology is a complex challenge, especially when it requires large sets of data of a different kind to be collected and put in order. Using R to explore and comprehend information is just one part of this process. One usually needs a tool for code writing and interpreting at the very least and another tool for the textual side. Emacs and its Org-mode is an outlining combo that makes the whole process more consistent and more transparent in terms of scientific reproducibility. It allows every piece of research that makes up the publication to be written together in one text file. It can be compiled then and exported in one move to the format desired – most preferably LaTeX and PDF. The benefits of using R in such context and a software toolset have been examined in the writing of a comprehensive study of the Muslim necropolis on Kom el-Dikka. The study was based on a dataset drawn from analyses of skeletal remains of over 2,500 individuals excavated to date. The data was supplemented with archaeological investigation of almost 2,000 grave units to shed light on the changes that occurred in early Islamic Alexandria.

An R package for inferring patterns of social learning from archaeological frequency data

Enrico R. Crema, Anne Kandler

Since the seminal works by Neiman (1995) and Shennan & Wilkinson (2001), evolutionary archaeologists and anthropologists have been trying to infer social learning strategies by analysing the temporal frequency of different cultural variants in a population. Early applications directly employed methods originally developed in population genetics to test whether observed frequency distributions deviate from those expected under neutral evolution, regarded as functionally equivalent to unbiased learning. Instances of significant deviations were then regarded as evidence of alternative modes of social learning, most commonly conformist or anti-conformist biases. Recent research, however, highlighted a number of issues with these methods, ranging from biases introduced by time-averaging to unwarranted assumptions of equilibrium conditions. Most notably these methods were unable to tackle the problem of equifinality, i.e. situations where various learning processes can result in very similar population-level characteristics. We present an R package that implements a generative inference framework aimed at analysing which of the social learning strategies considered are consistent with the available frequency data and which are not. The package is based and expands from previous applications of Approximate Bayesian Computation in cultural evolutionary studies (e.g. Crema et al 2014,2016; Kandler and Shennan 2015).

Standard session 06:
Recent advances in spatial statistics for archaeology

***Joe Roe**, Centre for the Study of Early Agricultural Societies, University of Copenhagen*
***Francesco Carrer**, McCord Centre for Landscape,*
School of History classics and Archaeology, Newcastle University

Exhibition Room B, 8.40 – 12.40, 26 April 2019

Questions of space and place concern archaeologists from every branch of the discipline. There are many ways to approach such questions, but the application of quantitative spatial analysis to archaeology has long been an area of particular interest. This body of statistics originated in geography and ecology and was first adapted to archaeology over forty years ago by pioneering scholars such as Hodder and Orton. A "second wave" of renewed interest then came with the widespread adoption of geographic information systems (GIS) into archaeological methodology in the late 1990s and 2000s. In this session, we wish to explore advances in archaeological spatial statistics – from the intra-site to landscape scale – made in the last decade. In particular, we invite papers discussing the state of the art in spatial analysis; the application of new statistical techniques to archaeological contexts; new ways of thinking about spatial data in archaeology; advances in GIS technology; and the development of new statistical tools using scientific programming environments such as R and Python. Speakers are welcome to use archaeological case studies from their research, but the primary focus of papers should be methodological.

8.40 – 9.00
The Application of Local Indicators for Categorical Data (LICD) to explore spatial dependency in archaeological spaces,
Francesco Carrer

9.00 – 9.20
Percolation robustness and the deep history of regionality,
Michael Simon Maddison, Mark Lake

9.20 – 9.40
Analysing settlement dynamics using statistics based on archaeological theory,
Peter Demján

9.40 – 10.00
Bayesian Species Distribution Modelling of Domesticated Plants,
Marta Krzyzanska, Enrico Ryunosuke Crema

10.00 – 10.20
Statistical methods for the exploration of the spatial information in anthropogenic soils,
Jonas Alcaina-Mateos, Carla Lancelotti, Stefano Biagetti, Marco Madella

10.20 – 10.40
General Discussion

COFFEE BREAK

11.00 – 11.20
"Where did they stand?" A probabilistic approach to the study of orientation of enclosed areas in prehistoric structures,
Fabio Silva, Christina Michel

11.20 – 11.40
Spatio-temporal network analysis applied to Roman Terra Sigillata data,
Gabriele Gattiglia, Nevio Dubbini, Francesca Anichini

11.40 – 12.00
GIS and spatial statistics for cultural heritage assessment,
Ionut Cristi Nicu

12.00 – 12.40
General Discussion

The Application of Local Indicators for Categorical Data (LICD) to explore spatial dependency in archaeological spaces

Francesco Carrer

Spatial autocorrelation or spatial dependency describes how the value of spatial data varies as the distance between the data increases or decreases. Archaeological research has long been relying on this property of spatial data to explore landscape and intra-site patterns, and different statistical methods (Moran's I, Getis-Ord Gi) are routinely used to analyse spatial autocorrelation of continuous numerical values. On the other hand, the statistical analysis of spatial autocorrelation for categorical data has largely been neglected in archaeology. Cross-K and cross-L functions are increasingly used for this purpose, but their application is limited to spatial point patterns. For the analysis of other type of spatial data, like grids or regions, Join-Count Statistics is widely employed in other research fields, but to the best of my knowledge it has never been used in archaeology. One of the reasons might be related to the absence of a solid method to calculate local statistics, namely the spatial dependency of each spatial unit in the study area. Recent research carried out by Barry Boots and Michal Pietrzack et al. have provided new statistical tools to calculate local indicators of autocorrelation for categorical data (LICD). Strengths and weaknesses of these tools will be explored in this paper, to assess their applicability to archaeological contexts. These methods will then be implemented in R and tested in two archaeological case-studies at landscape and intra-site scale.

Percolation robustness and the deep history of regionality

Michael Simon Maddison, Mark Lake

It has long been argued that the different settlement patterns in Britain reflect topographical variability, for example Fox's lowland and upland zones, the "Central Province", etc. A key question is whether topographic barriers and corridors have substantially influenced patterns of connectivity that in turn underwrite a deep history of British settlement pattern. Recently archaeologists and others have turned to computational Percolation Analysis to address this question (e.g. Arcaute et al, in prep, "Case studies in percolation analysis: the distribution of English settlement in the 11th and 19th centuries compared", J. Arch, Sci.; Maddison, 2018," Using Percolation Analysis for investigating the distribution of Hillforts in Britain and Ireland", CAA 2018, Tübingen). There has been little attempt to establish the robustness of clusters/networks produced by percolation in the face of, for example, locational uncertainty. Also, the role of individual sites within a cluster has not been addressed; can a distinction be drawn between 'core' sites, and are some peripheral sites important in providing connectivity between clusters?

This paper will describe a new method of percolation analysis which attempts to address these issues, and demonstrate its application to the classic problem of the existence and bounds of a "central province" in British settlement (Roberts and Wrathmell, 2000, An Atlas of Rural Settlement in England), as well as the roles and importance of specific hillforts in Britain (Lock and Ralston, 2012, An Atlas of Hillforts in Britain and Ireland).

Analysing settlement dynamics using statistics based on archaeological theory

Peter Demján

The mechanisms of settlement and land use in prehistory can be examined by testing the hypothesis that variations in spatio-temporal distribution of archaeological evidence of settlements mirror changes of the actual settlement patterns. To test this, we need a mathematical model describing the relation between the quantity of evidence and intensity of settlement activities which produced it. This model has to take into account all of the following uncertainties inherent to archaeological data: (1) The actual time and place of past events is not known and lies within the boundaries given by dating and localization of the evidence. (2) The events took place in areas which had a certain extent in time and space. (3) The observed distribution of evidence is affected by variations in feature visibility, sampling intensity and accuracy. We can test the null hypothesis that changes in spatio-temporal distribution of archaeological evidence can be explained by fluctuations stemming from these uncertainties. If we assume that an archaeologically detected site of settlement activity (as defined by the settlement area theory) represents a spatio-temporal volume, rather than a single point in time and space, we need a probabilistic method, which considers spatial and temporal dimensions equally. We propose the evidence density estimation (EDE) function, which can be applied on radiocarbon-dated evidence as well as typo-chronologically dated evidence to produce spatio-temporal distribution maps or summed distributions representing intensity of settlement activities within the examined area. This research is supported by the MEYS grant no. CZ.02.1.01/0.0/0.0/16_019/0000728.

Bayesian Species Distribution Modelling of Domesticated Plants

Marta Krzyzanska, Enrico Ryunosuke Crema

Species Distribution Modelling (SDM) has been a rapidly developing methodology within fields such as ecology and paleobiology, but its potential within archaeology has not been fully explored. The few existing studies often rely on the Maximum Entropy algorithm (MaxEnt), which is a machine learning technique and is the most widely used approach. However, recent research suggests that the hierarchical Bayesian framework, which allows to model both ecological pro-

cesses and observation processes, may be more suitable to limited and spatially uneven data. As the Bayesian approach is receiving an increasing interest within archaeology, this paper will present its application in the modelling of the paleodistribution of domesticated buckwheat, constructed as part of the 'Crops, Pollinators and People' project. With this method, the project aims to identify factors that restricted the spread of buckwheat and map its potential routes of dispersal. With reference to this study, the paper will reflect on the applicability and limitations of SDM in research related to the spread of agriculture. In particular, it will discuss the quality of archaeobotanical data used as species occurrence records and environmental reconstructions, as well as the differences between the results obtained with MaxEnt and Bayesian methods and the impact of the modelling approach on their interpretation. In conclusion, I will consider the methodological implications of the study in the context of increasing interest in the further applications of SDMs and Bayesian approaches in archaeology.

Statistical methods for the exploration of the spatial information in anthropogenic soils

Jonas Alcaina-Mateos, Carla Lancelotti, Stefano Biagetti, Marco Madella

Chemical analysis of sediments has became a common practice in archaeology in the last decades, not only for prospecting purposes but also to identify household activity areas at the intra-site scale. Many efforts have been made to understand the spatial patterns of chemical imprints left by daily activities, which should reflect both social organization and economical strategies. However, some difficulties, such as geogenic noise, postepositional alterations, and problems of equifinality and multifinality (derived in part from the complexity of human behavior), have hampered the establishment of a standard procedure for the interpretation of these data. In this paper, we aims at discussing the use of statistical methods for the study of the spatial information in anthropogenic soils. Specifically, we present a multivariate geostatistical procedure aimed at overcoming some of the problems identified, focusing on the variation of chemical values, the identification of spatially-dependent correlations, and the study of the independent physical processes that operate at different spatial scales. This procedure will be ultimately applied to an ethnoarchaeological case of study, pointing out its potential as a exploratory tool and setting the bases for a further development of models that enable the interpretation of the chemical signatures.

"Where did they stand?" A probabilistic approach to the study of orientation of enclosed areas in prehistoric structures

Fabio Silva, Christina Michel

Prehistoric structures have been studied under the lens of landscape archaeology and archaeoastronomy in search of correlates between orientations encoded in their architecture and topographic features or celestial objects that may materialize the ontology of their builders. For the large part, such studies have been done under what could be described as a "discrete" foundation, which is to say, single measurements of orientation were taken and any uncertainties largely ignored. However, for several prehistoric structures such an approach can only be pursued by making assumptions, for example of where a prehistoric person would stand in order to observe such an alignment. Structures with large internal areas and a reduced number of entrances, such as henges, enclosures and stone circles, provide a variety of vantage points from which alignments are possible and, in many instances, the archaeological record does not provide clues to choose between them. This paper presents an innovative approach, combining GIS and R. By using Monte Carlo sampling, a probability distribution that fully encapsulates all possible orientations and their likelihood is obtained. Such distributions can then be used to infer alignments to topographic features and celestial events on much firmer ground and with full transparency over uncertainties and assumptions. A complementary top-down approach can also be employed, wherein one can find out which areas inside the structure could be used to observe a given topographic feature or celestial event. We introduce this methodology by applying it to a number of structures from prehistoric Western and Central Europe.

Spatio-temporal network analysis applied to Roman Terra Sigillata data.

Gabriele Gattiglia, Nevio Dubbini, Francesca Anichini

This work concerns the analysis of data related to Terra Sigillata, a type of fine tableware with glossy surface commonly used in the Roman Empire. The data were gathered integrating different sources and analysed during the ArchAIDE project (www.archaide.eu), an EU Horizon 2020 RIA funded project which aims to create a system for the automatic recognition of pottery. Statistical techniques were used as explorative in order to summarise main characteristics of data and identify outliers, trends or patterns. We focused on Network Analysis and on the identification of significant temporal breaks in the data. The network structure is given by linking together locations where ceramics were produced to locations where the same ceramics were retrieved, getting 3853 locations forming the vertices, throughout Europe, Middle East and North Africa. We identified communities in the network, i.e. groups of vertices (locations) being densely

connected internally but poorly connected externally. Communities were identified within the four temporal periods distinguished, characterised by different production centres emerging and declining in the different phases (Italian, South-Gaulish, Rhine productions), and showing different production dynamics. Temporal breaks were identified by an algorithm minimising the variance within intervals while maximising the variance between intervals. Communities can represent commercial routes adopted by producers, or that established themselves by geographical or historical reasons. This work also underlines how the availability of high volume of data (unfortunately rare in Archaeology), joined with data analysis, allows new insight into archaeological research.

GIS and spatial statistics for cultural heritage assessment

Ionut Cristi Nicu

The advancement of statistical tools applied to environmental sciences has been very fast over the last years; however, the same statistical tools were very rarely applied in the field of cultural heritage assessment. This paper aims to present the results of the statistical modelling from geography, using GIS, applied in the field of cultural heritage. Susceptibility maps of different natural hazards (landslides and gully erosion) are overlapped with the cultural heritage sites from an area located in the North-eastern part of Romania; the maps are made using various statistical models (frequency ratio, statistical index, analytic hierarchy process) from the available conditioning factors, and validated using the receiver operating characteristics (ROC) curves and the seed cell area index (SCAI) methods. Besides testing the predictive capability of the statistical models, our case studies highlighted the high potential of using the final susceptibility maps in the field of cultural heritage. Areas with high and very high susceptibility to natural hazards can be easily identified and related to the areas where the cultural heritage is located. In this way, recommendations can be made to the local authorities to analyse and propose mitigation measures where very high susceptibility to certain natural hazards occurs. Other uses of the landslide and gully erosion susceptibility maps are environmental and cultural heritage protection, evaluation of the present state of cultural heritage sites, disaster risk reduction.

Other session 07:
Teaching 2.0: Show me how you teach!

Carolin Tietze, ISAAK; Christian-Albrechts-Universität zu Kiel
Sebastian Hageneuer, Archaeoinformatics, Institute of Archaeology, University of Cologne, Germany

Seminar Room, 14.00 – 18.00, 26 April 2019

Nowadays, the necessity for a top-down hierarchy and presentation-discussion-style seminars are overdue for a remake as the class' content, used technologies and varieties of teaching methods have evolved. Additionally, many seminars now use more and more up-to-date technologies, including 3D, VR or AR applications, which foster an increasingly digital environment for archaeologists. This new digital movement even creates new fields of study like Computational Archaeology or Archaeoinformatics and Digital Humanities. The problem with these new fields is, that they cannot strictly be taught using the same methods as before, presenting lecturers with the need to adapt their teaching methods.

Concepts like inverted/flipped classrooms, MOOCs, blogs, simulations and even archaeogaming are starting to replace classical teaching methods gradually, although it is not quite clear in which ways these will prove to enhance the way we teach archaeology in academia.

This session wants to discuss exactly this problem. We would like to present and discuss modern ways of digital teaching in archaeology with a special interest in the evaluation of the used methods and the exchange of experiences and "lessons learned" from it. We therefore welcome contributors from all fields of archaeology (university, museum, excavation, cultural heritage) who want to share their experiences. Topics may include, but are not limited to:

- New digital approaches (blogs, films, exercises, games, simulations;)
- Evaluative field studies on new and old teaching methods;
- New applications that alleviate a steep learning curve.

This session aims to encourage discussion on the potential, problems and challenges of using new teaching methods that fit the needs of a future-oriented field of study. Participants will be asked to present their very own teaching methods within a 10-minute presentation, following a 10-minute individual discussion on their paper. The session will end with a full hour final discussion summarizing the different papers and debating the pros and cons as well as the general trend of digital teaching in archaeology. Special importance should be given to the implications that the methods presented may have for the students and in which way it might be supporting, enhancing or obstructing the learning process, and how it could inspire the student to creatively apply the new knowledge. We especially encourage presenters to evaluate their experience in order that we are able to compare different methods during the final discussion.

14.00 – 14.20
Active Learning Using VR, Sketchfab, and 3D Printing,
Todd Brenningmeyer, Brian Bergstrom

14.20 – 14.40
An online collaborative museum and associated lessons for secondary school students,
Cesar Gonzalez-Perez, Isabel Cobas-Fernandez

14.40 – 15.00
Creating Immersive Multiplayer Classroom Experiences in Site Reconstructions, *Luke Hollis*

15.00 – 15.20
Teaching with Recogito,
Valeria Vitale, Elton Barker, Rainer Simon, Leif Isaksen, Rebecca Kahn

15.20 – 15.40
A Gaming Odyssey: Improving Video Game Pedagogy in Archaeology and History,
Robert Perry Stephan

COFFEE BREAK

16.00 – 16.20
Development and first experiences with an interactive teaching movie,
Undine Lieberwirth, Axel Gering

16.40 – 17.00
Arcade Teaching: showcasing the use of video games in teaching the past,
Aris Politopoulos, Angus Mol, Csilla Ariese-Vandemeulebroucke

17.00 – 18.00
General Discussion

Active Learning Using VR, Sketchfab, and 3D Printing

Todd Brenningmeyer, Brian Bergstrom

Our introductory courses have traditionally used a top down presentation of images and information, often relying on PowerPoint or similar software to explore objects and sites using a carefully selected sequence of viewpoints. While this method of teaching can be useful, it separates students from the process of active exploration. The result is an environment of passive observation in the classroom that is very different from the type independent exploration that is experienced in the field or in a study abroad setting. For the past two years, a small number of our courses have used VR goggles and Sketchfab models to allow a more independent explo-

ration of objects and sites. In the classroom, students use Google Street View to "walk" through a site, exploring different perspectives of monuments during lectures and breakout sessions. 3Dvista is used to generate VR tours of locations that include audio as well as "viewshed" maps illustrating the viewer's position and viewing direction. This year we made VR goggles a required course material, allowing students to independently explore these VR materials outside of class. Collections of Sketchfab models, gathered for our introductory courses, provide a similar opportunity to virtually interact with and explore objects. Some of the objects have been printed in 3D so that the students can also examine them by hand. This presentation discusses some of the methods and results of our use of these approaches inside and outside of the classroom.

An online collaborative museum and associated lessons for secondary school students

Cesar Gonzalez-Perez, Isabel Cobas-Fernandez

Our first experience with archaeology and cultural heritage is often provided by secondary education. Within subjects such as History or Social Sciences, students are presented with the basic concepts of archaeology and cultural heritage, and challenged to understand why some old broken fragments of things become part of the archaeological record and perhaps considered cultural heritage. Often, this introduction is carried out in terms of famous monuments such as the Great Pyramids or Machu Picchu, far removed from the student's immediate environment, and by using old-fashioned approaches that confer intrinsic value to these monuments, thus neglecting the relevance of the local communities. Our research aims at fixing these issues. A web-based software system, named KaleidoScape, was developed as a teaching and assessing tool for archaeological and cultural heritage-related contents within the Landscapes & Sustainability subject. After an initial briefing by the teacher, students worked in small groups to investigate their immediate surroundings and identify things that might have archaeological or heritage relevance. Then they documented these things into the system through texts, catalogues, images, sounds, videos and maps. Then, the teacher assessed these contents and students were able to refine and amend them. Finally, a selection of the contents created by the students was published by the system to a publicly-available online museum (http://kaleidoscape.verdewek.com). After two years working with KaleidoScape, results show that students learn about their immediate surroundings, become active agents in them, and become capable of understanding the archaeological record and cultural heritage in terms of community-awarded value.

Creating Immersive Multiplayer Classroom Experiences in Site Reconstructions

Luke Hollis

In partnership with the Giza Project (Harvard University) and the GizaX MOOC on behalf of Professor Peter der Manuelian, Archimedes Digital is developing a multiplayer virtual reality classroom experience that will enable Manuelian to conduct tours of the Giza Plateau and monuments over multiple time periods and occupations. The teaching environment is used in partnership with GizaX as well as classrooms in the US and China to enable professors to meet virtually with their students to conduct a tour of the Giza Plateau as is relevant to class materials. The virtual reality experience has a partner mobile application that leverages augmented reality technology in the galleries of the Harvard Semitic Museum to allow museum visitors to translate the hieroglyphs of the Dream Stela of Thutmose IV between the paws of the Great Sphinx (Giza) and view the Sphinx in the Old Kingdom, New Kingdom, and contemporary periods. Both the VR and the AR applications are backed by data services from the Giza Project's and Semitic Museum's collection databases which educators may choose to reference to pull artifacts into the 3D environment at their discretion while creating lectures. The media related to the artifacts displayed in the 3D environment includes 3D objects scans, 360 video, 2D video, audio, and images as well as traditional collection metadata. Lectures are created in a slideshow editing environment which is familiar to users of Microsoft PowerPoint, and each slide may teleport users to a new part of the Giza Plateau and monuments.

Teaching with Recogito

Valeria Vitale, Elton Barker, Rainer Simon, Leif Isaksen, Rebecca Kahn

In this paper we discuss the pedagogical application of a free online tool for semantic annotation of digital dcuments called Recogito (recogito.pelagios.org) and developed by Pelagios Project. We explore examples of its use in different classroom contexts, and how the introduction of this tool can enhance the learning process. Recogito enables users to work directly on text and images and capture information about them deemed of interest, by annotating entities like places, people and events, or by adding tags and comments to words or phrases for search and analysis. Relying on the identifiers provided by historical gazetteers such as the Pleiades Gazetteer of the Ancient World, Recogito enables the georesolution of place references, thus helping the students to visualize a narrative's geospatial content and structure and, in effect, create maps from texts. Thanks to the process of annotation, via a simple and user-friendly interface, students become co-creators of content by identifying key ideas and structuring the reading of them. In addition, by allowing users to work simultaneously (and/or asynchronously) on the same document(s),

Recogito is of special value as a teaching tool where students can both work collaboratively and be assessed for their individual contributions.

A Gaming Odyssey: Improving Video Game Pedagogy in Archaeology and History

Robert Perry Stephan

By encouraging students to actively participate in the learning process, video games allow students to engage, play, and ultimately learn of their own accord. Despite contemporary pedagogical shifts towards digital technologies and active learning models, video games remain peripheral tools. This study identifies the various factors which have hindered the incorporation of video games into post-secondary education and demonstrates the efficacy of this approach through a case study from a course on Classical history. There are three primary reasons why commercial video games have generally been overlooked within secondary education in the Humanities and Social Sciences: (1) a perceived lack of historical accuracy, (2) problems with curriculum relevancy, and (3) logistical difficulties in game utilization. This paper addresses these issues using Ubisoft's Assassin's Creed: Odyssey as a case study. In this new action-adventure game, the protagonist enlists as a mercenary in the Peloponnesian War, traveling through ancient Greece and engaging with famous characters and monuments of Classical antiquity. One means of addressing the perceived limitation of video games is through the incorporation of primary sources. For example, the historical fiction narrative can be compared to Thucydides' account, while the highly detailed urban fabric of Athens might be analyzed in light of the archaeological remains of the Acropolis. By detailing a series of collaborative exercises in which video games might be combined with primary source material – historical or archaeological – this paper provides a model for productively utilizing video games as a learning tool.

Development and first experiences with an interactive teaching movie

Undine Lieberwirth, Axel Gering

SfM (Structure from Motion) is one of high sophisticated digital documentation methodologies which plays an important role not only in Digital Archaeology but also in latest measurement technology and even smartphones. This trend makes this method very attractive to archaeology, historical building research and hence, their students. A digital method should be taught via digital media. The idea was luckily supported by neighbour institutes at our university – an interdisciplinary development team was born to create a teaching movie. This presentation tells the story of the development, first uses and publication of an interactive teaching movie series about 'Structure from Motion in archaeology' (first part) and 'Structure from Motion in archi-

tecture' (second part, http://ostiaforumproject.com/). We describe the transition process from static teaching material towards the 'virtual classroom', show the challenging road of creating a 'hybrid product' by maintaining scientific and academic standards within a new environment and introduce the video evaluation process we applied for getting an objective revision of the first teaching experiences. Finally, we discuss the options of Open Access publication for academic videos to share knowledge. The summary reflects the idea of going towards a 'digital university', the efforts and benefits of such a project in proportion to the lifetime of digital media and its technological content. What we not debate is that there is no doubt that university teachers have the duty to develop archaeological science and the student's competence, thereby making both ready for the digital age.

Arcade Teaching: showcasing the use of video games in teaching the past

Aris Politopoulos, Angus Mol, Csilla Ariese-Vandemeulebroucke

While approaches to digital media in education have explored gamification or serious gaming as part of their methodology, the potential of video games in the classroom has remained largely untapped. In this paper we will be exploring the use of video games as an innovative method to teach culture and the past in both the classroom and beyond. Three different avenues will be explored for the use of video games in education: games as an analogy; games as carriers of and subject to culture; and game-making as history-making. The first is centered on the use of specific video games to investigate theoretical concepts such as civilization or collapse in teaching the archaeology of the Ancient Near East. This is done on the basis of a series of BA courses taught at the Faculty of Archaeology, Leiden University. Secondly, we will look at games as carriers of culture in Digital Humanities courses and in the space of Culture Arcade, an interactive exhibition of video games made by or about peoples from around the globe. This exhibition shared meaningful stories and deep cultural knowledge through art, narratives, language, music, and characters and was curated by the authors. Finally, we will be discussing game-making as a creative practice for teaching the past, focusing particularly on the use of the Twine platform as part of course projects and in workshops. The process of developing multi-linear, interactive narratives enables a democratization of the past in which Twine-makers can rethink and re-create the past.

Roundtable 08:
Teaching Digital Archaeology

Till Sonnemann, University of Bamberg
Grzegorz Kiarszys, Department of Archaeology, Szczecin University
Arianna Traviglia, University Ca' Foscari of Venice

Exhibition Room B, 8.40 – 12.40, 25 April 2019

Courses teaching basic 'digital' methods to archaeologists, from equipment to software use, have surged in recent years, particularly in Europe, with the goal to provide students with a bit of extra knowledge in digital techniques to survive in the market. Supported often only by university politics for its innovative character to help modernise archaeology, in many curricula the digital element is still fighting for a permanent position. While accepted by 'real' archaeologist as a useful tool, digital topics nevertheless often are rare orchids in the vast field of archaeology. This seems particularly true in traditional archaeology courses, where students often choose their career path for very specific, sometimes utopian, reasons with one goal to become a field or dirt archaeologist.

Digital Archaeology offers the opportunity to include a great variety of courses and subjects. At the same time archaeology curricula can be very tightly specified and, in such cases, it becomes more difficult to fit in special topics because of BA restrictions. Additionally, students may question the value of adding such additional course elements: "Is the method being taught fully acknowledged? There can only be so many applied computer courses or introductions to digital techniques, software and programming, that could provide a new view on archaeological topics".

In this session we ask: "What are the digital basics that all students should be equipped with at BA level? How much further should a MA Level course reach? What courses have been particularly successful, which ones failed, and for what reasons? How do students accept the challenge? We want to bring together colleagues who focus on teaching and developing courses on digital archaeology and discuss openly our successes and the problems we can expect to meet. Our goal is to form collaborative networks and hopefully share methods and exercises. We will ask prospective participants, wishing to take part in the session, to fill out a questionnaire. Presentations should be no longer than 10 min with focus on the questions provided.

This session will feed into a Roundtable called "Thinking out of the classroom: developing a strategy for sharing knowledge and resources for education and training in digital archaeology".

8.40 – 8.50
Teaching Digital Archaeology at European Universities,
Till Frieder Sonnemann, Mikolaj Kostyrko

8.50 – 9.00
Education of Digital Archaeology at Polish universities, different approaches,
Roman Antoni Szlązak

9.00 – 9.10
Understanding how everything worked out so well. Teaching computer databases for archaeologist at the University of Warsaw,
Michał Piotr Gilewski, Nazar Buławka

9.10 – 9.20
Teaching Digital Archaeology at Leiden University,
Karsten Lambers

9.20 – 9.30
Teaching Archeomatics at the University of Tours,
Elisabeth Lorans, Xavier Rodier

9.30 – 9.40
Teaching digital archaeology in Italy: still utopia or already reality?
Arianna Traviglia

9.40 – 9.50
Developing a master's degree in Digital and Computational Archaeology: a view from Germany,
Eleftheria Paliou

9.50 – 10.40
General Discussion

COFFEE BREAK

11.00 – 11.10
Challenging students by integrating digital archaeology,
Ronald Visser, Wilko van Zijverden

11.10 – 11.20
Learning to See vs Learning to Understand. Why is Teaching Digital Archaeology so Difficult?
Grzegorz Kiarszys

11.20 – 11.30
Problem- and Project-based Learning in Digital Archaeology: Potential and Challenges,
Costas Papadopoulos

11.30 – 11.40
Teaching 3D archaeological documentation in the field and classroom,
Jari Pakkanen, Ann Brysbaert

11.40 – 11.50
Archeoinformatics and the Archaeological Digital Initiative: Successes and Challenges Teaching Digital Archaeology,
Scott M. Ure

11.50 – 12.40
General Discussion

Teaching Digital Archaeology at European Universities

Till Frieder Sonnemann, Mikolaj Kostyrko

Having been implemented into the archaeological curriculum of many European universities, digital subjects have brought archaeology into the 21st century. Depending on the focus of the course work, or the lecturer, various subjects appear as compulsory or optional topics to choose from: GIS, statistics and networks, remote sensing, geophysics, 3D-scanning, visualization techniques, computer programming, data bases, to name a few, often in combination with different archaeological or heritage themes, or linking to the natural sciences, mathematics, informatics, geography or digital humanities. The courses are still mostly implemented in traditional archaeology or heritage careers as part of BA and MA studies, and seldom offered as a full course. Nevertheless new MA courses are being planned and implemented. The talk intents to present and discuss the outcome of a questionnaire filled out by lecturers from different European universities on their involvement in teaching digital methods. Not claiming to be exhaustive, the introductory talk intents to give an overview of the various and different approaches on how digital archaeology is currently being taught at European universities and hopes to lead to an open discussion in this roundtable session.

Education of Digital Archaeology at Polish universities, different approaches

Roman Antoni Szlązak

In the era of fast growing computerization, skills related to broadly understood Digital Archaeology are increasingly sought after in the labor market. Despite the demand declared by the employers, teaching of Digital Archaeology to university students as well as post-graduate teaching is still suffering from a lack of resources. The lecture will discuss the problem of teaching Digital Archaeology on the example of Polish universities. In Polish law the issue of teaching computer usage in archaeology is not well regulated, which makes polish universities to solve this problem on their own. The Paper will present the results of the survey made at universities and the labor market. The idea of the survey came out of the plans for organizing an international project dealing with this issue.

Understanding how everything worked out so well. Teaching computer databases for archaeologist at the University of Warsaw.

Michal Piotr Gilewski, Nazar Buławka

In this paper we would like to present our experience related to a course we designed and carried out for the students of the Institute of Archaeology at the University of Warsaw. The objective was to introduce both the theory and the practice of using archaeological databases to new generations of students. Another aim was to introduce students to the formalized manner of research, implied by both typical databases' questionnaire-like design and the latest database trends like semantic technologies. For this course, a lot of preparation went into searching for software solutions that could be free of charge and easily used to create relational databases, publish them on the internet, and allow students to work together online. However, what was crucial to the success of the course were the workshop-based classes, which allowed to engage the students' higher-order thinking skills, but to do so at a differentiated pace. Furthermore, it helped the students overcome a serious obstacle, since computer databases are generally perceived as difficult to learn on one's own. Despite this and the fact that all participants of this experimental class had had no previous background in computer databases, students' active involvement and their rapid advances proved that the technologies are very intuitive and in demand for junior researchers. The success of this class seems to suggest that computer databases are one of most relevant digital techniques to be taught in the curriculum of modern archaeology and is a subject that fits well into a one-semester course length.

Teaching Digital Archaeology at Leiden University

Karsten Lambers

In this paper I will critically review the teaching of Digital Archaeology at the Faculty of Archaeology at Leiden University. Computer applications have been taught to Leiden undergraduate students since the 1990s, such that today courses in digital field techniques, basic statistics, databases and GIS are undisputed core elements of our Bachelor's programme. However, courses on advanced topics such as predictive modelling used to be optional or sporadic elements of our programme. This changed in 2016 when we were able to add the new focus area 'Digital Archaeology' to our existing MSc programme 'Archaeological Science'. This new programme now allows us to teach advanced courses, e.g. on procedural modelling or simulation, to dedicated students. However, the main advantage for the students is that they can now write their Master's thesis with a methodological focus on digital data and computational tools in archaeology. This enables them to acquire in-depth computational knowledge and skills, which are

in high demand on the labour market, but also to engage with their chosen topic on a higher theoretical level. While the new MSc track is a success, it also faces important challenges, such as the tight schedule of a one-year programme and the widely varying prior knowledge of our international student population. Another such challenge, the ongoing renewal of our entire education programme due to political, financial and administrative considerations, currently obliges us to rethink the structure and contents of our teaching programme in Digital Archaeology, which will be reflected in this talk.

Teaching Archeomatics at the University of Tours

Elisabeth Lorans, Xavier Rodier

By the neologism Archeomatics, built with reference to geomatics in geography, we refer to association between archaeology and computer science generally called Digital Archaeology but closer to the Archaeological Information Science proposed by Marcos Llobera. Since 1988, Archeomatics is taught at the University of Tours in a master degree to develop new types of archaeologists mastering the most recent digital methods at Post-Master and Doctorate levels. Attached to the CITERE-LAT laboratory, this new master degree benefits from a strong partnership in training and research in rescue archaeology with INRAP. Our goal is to train future archaeologists in the field practice, particularly to meet the expectations of rescue archaeology, as well as those of innovative methods and research, based on the implementation of first hand data. Students can plan their course according to their career objectives and their main interest (spatial analysis in urban or rural environments, architecture and construction techniques, zooarchaeology and studies of artefacts, from Protohistory to Modern Times) but always focusing on computerization of all archaeological research processes from excavation to dissemination. Regardless the students' initial knowledge in computer sciences, Archaeomatics was included from the beginning in BA level and then more strongly in MA level. Since September 2018, training in archaeology and archaeomatics has been one of the courses offered by the Higher School of Heritage Intelligence, which broadens the prospects for opportunities in all heritage professions by offering modular training with thematic courses on heritage as well as digital humanities.

Teaching digital archaeology in Italy: still utopia or already reality?

Arianna Traviglia

This talk will provide an overview of the teaching of Digital archeology in Italy looking at the efforts the Italian Universities have been doing in the past 15 years to align Italian archaeology

programs to those that are still mainly related to North Europe curricula. While new practices related to the development and adoption of technological tools during archeological investigations have profoundly changed the way many professionals and academics approach archeological work, this change in Italy is not reflected in teaching practices and has had minimal influence in University programs. A few virtuous examples of courses exist but they are a sheer minority. Reasons for that can be ascribed from one side to the bureaucratic difficulties still encountered in Italy trying to change State-standardised curricula, especially at BA level, and from the other to a resistance in including such topics within a traditional curriculum from a certain type of academia, with the result of confining them to seminars or workshop to which few hours are dedicated. The outcome is that the skills and the competencies that students are equipped with when they complete their University degrees can vary enormously from one University to another with strong implications on the graduates' capacity of being absorbed by a job market that looks more and more eager to hire computer-skilled personnel. Alternatives are (often expensive) post-graduate level intensive programs or, even worse, private courses provided by organisations often without necessary knowledge of archaeology.This presentation will provide both an analysis of the Italian situation as a result of a survey and a definition of what digital skills are needed from national students to tackle the job market (especially in the very unique Italian cultural heritage panorama), with an eye on proving useful information for other countries.

Developing a master's degree in Digital and Computational Archaeology: a view from Germany

Eleftheria Paliou

Courses on digital and computational archaeology have been part of European higher education curricula for more than three decades, but their adoption has been to date far from uniform. While many institutes of archaeology currently offer introductory courses for undergraduate and postgraduate students on coding, GIS, databases or CAD, only a handful of universities, mainly in the UK, the Netherlands and Germany, support master's programmes in archaeological computing that include a range of advanced courses. Such programmes are frequently being shaped by different academic traditions, funding structures, educational legislation and policies and can greatly differ in terms of content, scope and level of specialisation. In this respect archaeology departments and academic staff in Europe face sometimes unique challenges in establishing and sustaining structured degree programmes in digital archaeology. This paper will discuss and critically reflect upon the experience of developing a two-year master's degree in Archaeoinformatics (Digital and Computational Archaeology) at the University of

Cologne. It will firstly look briefly into teaching digital archaeology in German universities as this is reflected in IANUS database (https://www.ianus-fdz.de/it-empfehlungen/lehrangebote), before addressing the challenges involved in establishing for the first time a two-year master's degree programme. The focus will be upon the relationship between internationalisation and sustainability, supporting versatile degree structures and the synergy between Archaeoinformatics and Digital Humanities.

Challenging students by integrating digital archaeology

Ronald Visser, Wilko van Zijverden

At Saxion University of Applied Sciences we have been teaching practical archaeology for over 10 years. Teaching digital archaeology has always been an integral part of the Bachelor-curriculum. The digital basics are covered within the first two years of the 4 year course. The following years more advanced digital tools are taught, but only for those students that choose the specialization digital archaeology. However, we do expect our students to develop their skills further during assignments or projects. Recently, we have revolutionary changed our educational model, moving away from single small courses and changing to a more holistic and integrated approach that teaches (digital) skills and knowledge related to real world projects. The integration helps students to understand the application and use of various tools better. During the round table I would like to show challenges and chances for both teachers and students in both educational methods.

Learning to See vs Learning to Understand. Why is Teaching Digital Archaeology so Difficult?

Grzegorz Kiarszys

Modern remote sensing techniques and archaeological geophysics have amazing potential. Reading and understanding of digital data visualizations seems to be very straightforward, probably due to widespread use of some popular computer applications like Google Earth, open source GiS and Geoportals. Aerial photographs and 3D visualizations became a kind of common language. However, focusing only on teaching practical skills may not be enough. Interpretation of obtained results of applied methods requires different skills, than processing digital data. It involves cognitive processes and critical approach. How to connect those two completely different realities - digital records and archaeological theories? The 18th century Irish philosopher George Berkeley noticed that we do not perceive with our sight anything more than light, colours and shapes. Access to the material world leads through our senses. Therefore we can only reach its materiality indirectly, through ideas. Pure perception is not enough to gain an

understanding of the phenomena we observe. We need to refer to the preliminary knowledge through which we name and recognize things we are involved with. Without this knowledge the world would forfeit its reason. Similar circumstances occurs when we attempt to interpret archaeological record. Learning to see is relatively simple, learning to understand requires both expertise and critical thinking.

Problem- and Project-based Learning in Digital Archaeology: Potential and Challenges

Costas Papadopoulos

Digital Archaeology teaching has the potential to empower students with the skills required to become producers rather than passive consumers of knowledge (Cocco 2006). Project-based and Problem-based Learning (PBL) construct a framework through which students engage with authentic challenges (Bell 2010; Herrington & Herrington 2007) in a collaborative, engaged, and reflective environment. The ethos of maker culture that emphasises creativity and learning through doing, enables a collaborative and experiential learning through which students work together to complete an end product that materialises their knowledge and understanding (Helle et al. 2006). In this process, reflective learning approaches and peer-feedback make them responsible for their own learning and their weaknesses become strengths to improve their practice (Ertmer & Simons 2005). Finally, the process of co-creation and the management challenges that collaborative projects pose, provide them with new mechanisms to critically respond to different situations as well as with the necessary competencies for careers in academia and industry (Cain & Cocco 2014). This paper draws from the author's experience in teaching digital archaeology courses within a digital humanities (DH) setting. Using examples from his own practice and discussing the challenges that a diverse DH classroom poses, it will argue that project- and problem-based approaches to learning equip students with the necessary skills to respond to an increasingly competitive digital and creative economy in academia and beyond. References Exceed the word limit - Can be provided on request

Teaching 3D archaeological documentation in the field and classroom

Jari Pakkanen, Ann Brysbaert

The 3D field-documentation courses of the Finnish Institute at Athens were started in 2014 and they have been run at the Bronze Age site of Tiryns in the Argolid and at the Archaic to Hellenistic town at Ambelakia on Salamis. Their aim has been to train students without previ-

ous experience in archaeological documentation to work with reflectorless total stations and photogrammetry. In 2014–2016 and 2018 these courses and fieldwork were run in collaboration with Leiden University. In these field-courses students were introduced to both equipment and software used in intensive 3D feature-by-feature documentation. They learn to use reflectorless total stations as a drawing tool and the advantages the method has over traditional static total station work with prism. The second technique taught was photogrammetry, including how to combine the produced line-documentation with photogrammetry models. Students quickly learned the principles of 3D work and how to use the hardware and post-processing software. Behind the fast learning process lies in the one-to-one teaching and the hands-on work with in-situ archaeological remains. The time in the field and number of repetitions need to be intense enough so that the procedures become automatic. This paper aims to illustrate the field-course processes and how used methods have developed over the years. It discusses how the obtained skills have fed into the subsequent studies and research of the students and colleagues who have participated. Teaching on the field courses is compared with running classroom-based 3D documentation teaching at Royal Holloway, University of London.

Archeoinformatics and the Archaeological Digital Initiative: Successes and Challenges Teaching Digital Archaeology

Scott M. Ure

Over the last decade we have recognized the growing importance of teaching students the importance of acquiring basic skills in digital archaeology. In an attempt to meet these needs we developed the Archaeological Digital Initiative (ADI). This initiative is a collaborative effort between faculty, staff, and students to incorporate state-of-the-art technology into archaeological practices to streamline data collection, reduce redundancy and error, improve efficiency, and capture data not previously visible or recognized. Students are involved in brainstorming and problem solving new ways to improve archaeological data collection, processing, and manipulation. Perhaps more importantly, students are given hands-on experiences to practice digital archaeology in real-world applications. This effort has led to collaborative projects between students in archaeology, museum studies, computer science, and mechanical, electrical, and aeronautical engineering. In conjunction with the ADI, we started an archaeoinformatics class in 2014 which focuses on the fundamentals of GIS, GPS, and digital surveying and mapping. In addition, we are incorporating unmanned aerial systems (sUAS) fights and data processing in the class. In this paper we discuss the successes and challenges experienced with the ADI and teaching archaeoinformatics.

Roundtable 09: Thinking out of the classroom: sharing knowledge and resources for education and training in digital archaeology

***Philip Verhagen**, VU University Amsterdam, Faculty of Humanities*
***Matthias Lang**, eScience-Center, University of Tübingen*
***Yasuhisa Kondo**, Research Institute for Humanity and Nature*
***Stephen Stead**, Paveprime Ltd & ACRG, Southampton University*

Exhibition Room B, 14.00 – 15.00, 25 April 2019

In this roundtable, we invite participants to think with us on the future of education and training in digital archaeology. Despite the successes of digital approaches in archaeology, teaching to university students as well as post-graduate teaching is still suffering from a lack of resources. Dedicated curricula are scarce and definitions of best practices are largely absent, resulting in a highly variable proficiency of graduates in digital methods and techniques. We assume that much of this problem is related to the global system of university education, where sharing of educational resources and practices is not actively encouraged, while at the same time putting much burden on individual staff members to develop educational programmes with limited resources. We therefore feel that CAA, as a global organisation, could and should play a pivotal role in setting examples for good education and training and providing a shared knowledge base for its members that can lead to a higher quality of educational practice.

The question that we want to address in this roundtable is how we can profit from the experience of the CAA community to make sure that the available knowledge on education and training is better shared among its members and the wider archaeological community. Topics that could be discussed are the development of Open Access courses and training data sets, the development of specific learning goals and quality criteria for curricula, and the organisation of practical working sessions at CAA and other conferences. On the basis of this debate, we aim to establish focus groups to work on the issues identified.

14.00 – 14.15
Thinking out of the CAA conference,
Philip Verhagen

14.15 – 14.30
The ETO-SIG approach to modularisation: A Position Statement,
Stephen Stead

14.30 – 14.45
Share trainings to improve the skills in digital archaeology,
Xavier Rodier, Elisabeth Lorans

14.45 – 15.00
Don't JUST think archaeology,
Lutz Schubert

Thinking out of the CAA conference

Philip Verhagen

CAA is in a unique position to gather practitioners in digital archaeology worldwide to exchange knowledge on every aspect of computational methods. However, despite multiple conference sessions on teaching digital archaeology and the creation of a formal SIG on this subject, there is still little to show that CAA is actively fostering and facilitating the exchange of teaching resources and expertise beyond the realm of the annual conference. In this contribution, we therefore want to present a number of potential tools and an organisational structure to improve the sharing and growth of knowledge on teaching among CAA members and beyond. We will then discuss with the audience whether these are practical and feasible, in order to arrive at a prioritized list of actions for the SIG.

The ETO-SIG approach to modularisation: A Position Statement

Stephen Stead

The ETO SIG believes that there are distinct differences between Education, Training and Outreach and that these differences are best served with different materials, aims and objectives. By Education we mean the transfer of knowledge about the theoretical elements of the domain. The intent is to instil the ability to reason and make judgements that will support the student throughout their career. It is our believe that developments here occur at a generally slower pace than the changes in software tools and field equipment. By Training we mean the development of the particular skills needed by a student to perform tasks using specific equipment and software tools. These skills will change relatively quickly as new versions of software and equipment are developed. By Outreach we mean the presentation of aspects of digital archaeology to non-practitioners to aid them in their appreciation of the work performed by digital archaeologists. This may be coupled with elements of Education and even Training where the intent is to transition the audience into becoming practitioners in the future. Our intent is to modularise the suggested curriculum to separate Educational, Training and Outreach elements. This has several advantages. The first is that institutions with access to different software and equipment resources can still share Educational modules. The institutions will be able to plug-in Training modules that allow students to gain practical experience of the theoretical Education they have received with the software and equipment available locally.

Share trainings to improve the skills in digital archaeology

Xavier Rodier, Elisabeth Lorans

There are more and more cursus in digital archaeology (for all or part of teaching) but there are not really more students and especially not more opportunities for them. At the same time we need young researchers with strong skills in digital data processing in archaeology, in other words, what we call at the University of Tours archaeomatic and what Marcos Llobera calls Archaeological Information Science. People with Post-master and PhD degrees are expected to work both in laboratory and in the field, particularly in preventive archaeology. Indeed, one of the teaching challenges is to transfer theory, methodology and tools developed in research laboratories to daily practice of archaeology. To get closer to that aim, we would like to discuss the possibility of collaboration between our different training groups. We need to imagine how to implement all the possibilities of exchange between cursus in digital archaeology and student mobility between our courses, in order to build a european or more international cursus. The final aim is to improve the robustness of trainings and therefore the skills of students.

Don't JUST think archaeology

Lutz Schubert

Digital archaeology brings together archaeology and computer science, yet frequently it is treated from either perspective alone, without respecting what is needed from the other field of study. The courses are thus typically constrained in scope and will not allow the student to become proficient in both aspects, the "digital" and "archaeology". This talk will specifically address the IT side and suggest learning aspects that could be useful for a digital archaeology student to not only be able to apply the knowledge in the field, but also to drive research and development forward.

Standard session 11:
Pre-modern cities and complexity

***Eleftheria Paliou**, University of Cologne*
***Georgios Artopoulos**, The Cyprus Institute, Nicosia, Cyprus*
***Iza Romanowska**, Barcelona Supercomputing Center*
***Katherine Crawford**, University of Southampton*
***Tuna Kalayci**, Laboratory of Geophysical - Satellite Remote Sensing & Archaeo-environment Foundation for Research & Technology, Hellas (F.O.R.T.H.) Institute for Mediterranean Studies (I.M.S.)*

Exhibition Room A, 14.00 – 18.00, 26 April 2019

Some of the major challenges in the study of ancient urbanism concern change and evolution in cities and settlement structures. How did socio-political organisations move from simple to complex? What triggers urbanism in human societies through time? How do settlements grow and regional centres emerge? How do cities define and transform the local ecosystems and vice versa? How are movement patterns structured within and between cities?

The idea that cities are highly complex systems tied together through interactions between various factors was introduced in urban studies and archaeology many years ago, but it is only in the last decade or so that there have been more consistent efforts to examine this complexity using quantitative and computational tools – the so-called "new science of cities". This new synthesis of urban studies builds strongly on complexity science, social physics, urban economics, transportation theory, regional science, urban geography and network science. A number of computational tools and methods that have been used by archaeologists fall under this emerging interdisciplinary field, but there are also numerous underused techniques that show high potential for furthering our understanding of past cities and the activities that occurred within.

This session invites papers that seek to examine past cities, urban life, and urban mobility as complex phenomena by applying computational methods, for example:

- spatial interaction models;
- settlement scaling;
- space syntax;
- transportation network analysis;
- pedestrian simulation;
- analysis of urban morphology (fractals);
- agent-based modelling.

Or any other digital techniques designed to study interactions, flows, urban dynamics, morphology and scaling. We also welcome papers that use quantitative methods and spatial analysis to interpret urban data, as well theoretical papers that discuss the prospects and challenges of the science of cities in archaeology

14.00 – 14.20
Settlement scaling theory, agent based models, and ancient trade,
John William Hanson

14.20 – 14.40
Using the Energetic Calculator for Ancient Buildings (EnCAB) to Understand the Growth of Cities from the Perspective of Labor Capacity,
Federico Buccellati

14.40 – 15.00
Re-investigating the long-term dynamics of urban hierarchies in Italy in the Iron Age and Republican and Imperial periods through rank-size analysis: Continuity or change?
Francesca Fulminante, J.W. Hanson

15.00 – 15.20
Modelling the origin of polis in Anatolia. From conceptual to computational approaches,
Dries Daems

15.20 – 15.40
To Move as One: Simulating Crowd Movement Dynamics in the Ancient City,
Katherine A Crawford

COFFEE BREAK

16.00 – 16.20
Modelling spatial relations at Choirokoitia,
Georgios Artopoulos, Iza Romanowska

16.20 – 16.40
The evolution of the historical transport networks of the Iberian Peninsula,
Pau de Soto

16.40 – 17.00
Interlocking Geographic and Social Urban Mobility. The Social Network of Etruscan Elites during the Romanisation: a Strategy of Resilience?
Raffaella Da Vela

17.00 – 17.20
Who lived in that Roman house? Computational models applied to the differentiation of typologies of Roman houses,
Ada Cortés, Pau de Soto

17.20 – 17.40
Measuring the city – methods of layout reconstruction of regular medieval locations in Central Europe,
Anna Maria Kubicka, Maria Legut Pintal

17.40 – 18.00
Untangling Complexities of the Cretan Postpalatial Built Environment,
Tia Sager

Settlement scaling theory, agent based models, and ancient trade

John William Hanson

Over the last few years, there has been a great deal of excitement about the possibility of using agent based models to shed new light on fundamental aspects of the ancient economy. One of the limitations of existing models, however, is that they do not take sufficient account of the effect of the scale on patterns of production and consumption. This contrasts with recent work on complex systems, which suggests that there is a consistent relationship between the sizes of settlements and levels of specialisation and diversification in contemporary settlements, including relative numbers of individual crafts and trades. This includes the specific observation that the numbers of individuals involved in retail tends to scale sublinearly, while the numbers involved in creative sectors scales superlinearly. In this talk, I will offer a new agent based model of traders in ancient cities (developed in collaboration with Tom Brughmans), which allows us to investigate the effects of assuming different scaling factors for the first time. This reveals one or two surprises about the roles of traders in ancient cities, which contribute to our view of the links between urbanisation and economic development.

Using the Energetic Calculator for Ancient Buildings (EnCAB) to Understand the Growth of Cities from the Perspective of Labor Capacity

Federico Buccellati

The Energetic Calculator for Ancient Buildings (EnCAB http://www.encab.net) examines the process of construction leading up to the first use of the building, exploring this process by disarticulating it into discrete steps, using algorithms to quantify the 'cost' in terms of labor and materials. These algorithms are presented as a web-based calculator which allow users to compare their results to a range of examples and explore the types of sources used in generating each algorithm. B. Trigger defines political power as the ability to control energy, and use that energy not only to maintain and expand that society but also to invest in non-utilitarian purposes. EnCAB can be used as a tool to calculate the labor that political entities invest in different types of architecture, eg. city walls, temples, irrigation systems and palaces. These construction projects are indirect indicators of a communities' ability to invest energy in growth and control resources, giving scholars one snapshot onto some of the social dynamics driving increasing complexity in the development of cities. In order to map diverse types of change in urbanism, multiple snapshots can be generated and compared. Diachronic change at a single site can be analyzed by generating multiple snapshots from different chronological horizons; synchronic comparisons can be made between sites of different sizes within the same region to understand

how urbanism is tied to settlement sizes and roles. The paper will discuss EnCAB as a tool, propose research methodologies and present case studies relating to urbanism.

Re-investigating the long-term dynamics of urban hierarchies in Italy in the Iron Age and Republican and Imperial periods through rank-size analysis: Continuity or change?

Francesca Fulminante, J.W. Hanson

Over the last decade, rank-size analysis has become one of the main methods for investigating urban systems in the ancient world. There is still debate, however, about the utility of this method, owing to uncertainties about how these relationships should be interpreted, including whether deviation from log-normal should be seen as the result of economic development and increasing connectivity and integration or as the result of the erroneous pooling or partitioning of systems. In this talk, we will reassess these methods by considering the ways in which rank-size relationships can be seen as the outcome of the emergent behaviour that is the hallmark of complex systems. We then attempt to improve on earlier work in three ways: by collating recent evidence about the urbanism of Italy in the Iron Age and Republican and Imperial periods to look at the long-term dynamics of urban systems; by using new work to look at numbers of inhabitants, rather than inhabited areas; and by using statistical techniques to test rank-size relationships. To do this, we use the equation that has been suggested by Hanson and Ortman in a recent article in the Journal of Roman Archaeology to convert existing evidence for the inhabited areas of sites into numbers of inhabitants. We then use coefficients to describe the shape of the rank-size curve based on the areas on either side of the log-normal line, allowing us to track differences in deviation over time and shed new light on the extent of continuity and change.

Modelling the origin of polis in Anatolia. From conceptual to computational approaches.

Dries Daems

Cities can be generally considered as a form of settlement consisting of a spatial concentration of people, creating pockets of social interaction and information exchange. From a complex systems perspective, constituent interactions give rise to cities as emergent social units. Urban scaling studies have shown that "energized crowding" effects of interaction result in increasing returns to scale in economic growth and community formation, but also induce scalar stress leading to community fission. An urban community develops social, economic and political structures in response to positive and negative outcomes of energized crowding. In recent years, complex systems and urban scaling approaches have started to gain momentum in archaeology,

with applications on Roman, Medieval European, and Mesoamerican urban systems. However, for these approaches to gain general acceptance in our discipline, more applications are still needed. For this paper, I wish to present a case study of the development of urbanized and political communities – so-called poleis – in Achaemenid and Hellenistic Anatolia (5th – 1st centuries BCE). I will show how a conceptual model of the origin of polis can be translated into a computational model based on complex systems and scaling perspectives, by focusing on key properties such as social interaction and information exchange between social actors within and between poleis. I will present the preliminary outlines of an agent-based model of polis systems as hubs in a settlement network, pulling in flows of people, information, and resources through the interaction with each other and an overarching Imperial government.

To Move as One: Simulating Crowd Movement Dynamics in the Ancient City

Katherine A Crawford

Pedestrian movement formed one of the primary types of mobility that occurred within the ancient city. Despite its prevalence, the topic of pedestrian mobility has seen only limited attention within archaeological research of urban contexts. One of the primary approaches has sought to understand pedestrian movement through the application of computational methods like space syntax, where movement is considered purely in terms of how a city's street network structured random movement patterns. Within such approaches, the dynamics that occurred between both individual pedestrians and the urban landscape is lost. In order to begin addressing this issue, a new agent-based model developed in NetLogo will be presented that questions how crowd movement dynamics with a specific destination can be modelled, using Ostia, Rome's ancient port, as a case study. Several different movement algorithms commonly used to model crowd dynamics will be applied to determine which approach ensures that the greatest number of agents remain within the moving crowd. The outcome of this research provides the foundation for future enquiry into directed crowd movement studies. In particular, it can be used to address topics ranging from various ancient urban phenomena like urban processions/parades, evacuations, and riots/social unrest, to issues such as the accessibility of individual streets within a city. By engaging with one of the city's most common urban dynamics, it is possible for the study of group movement dynamics to provide a more nuanced perspective concerning the relationship that existed between people, groups, and the past urban landscape.

Modelling spatial relations at Choirokoitia

Georgios Artopoulos, Iza Romanowska

A UNESCO heritage site, Choirokoitia is an important Neolithic settlement in Cyprus occupied between 7th and 5th millenium BC. The settlement consisted of mudbrick and stone circular houses enclosed by a sequence of defensive walls. The organisation of private and communal spaces indicate a high level of social organisation and planning. The rich data from thirty years of excavation can now be integrated into a comprehensive framework. The aim of the Choirokitia 3D project is to apply multiple computational modelling techniques to develop a better understanding of spatial relations and their evolution at the site. Modelling and simulation of individual and group interaction can reveal hidden or overlooked hierarchies of spaces and spatial structures in the settlement and their transformations through time. The project aims to identify specific functional areas in the urban tissue, eg. central and peripheral zones, main movement arteries, important buildings or spaces. By applying multiple computational modelling methods including space syntax and agent-based modelling we can compare and contrast their outputs and provide indications for future modellers regarding their robustness and specific sensitivities. Finally, visualizing the transformation of the settlement throughout its two millennia of development will enable quantitative testing of existing hypotheses regarding the evolution of the settlement and the social structure of its inhabitants. In addition, this research will contribute to the creation of a Virtual Tour that will visualize and effectively integrate the rich archaeological and environmental data to provide the visitors with the most complete picture of life in Choirokoitia yet.

The evolution of the historical transport networks of the Iberian Peninsula.

Pau de Soto

The configuration of a territory is a long-term evolution in which many factors influenced its shape and morphology. One of the most visible elements that help historians to analyse its configuration is the location of the urban settlements and all the transport infrastructures (by land, river and sea) that connected them. In this paper, the Iberian Peninsula transport networks have been analysed in four different timeframes (Roman Times, Medieval Era, Modern Era and the XIXth Century). By comparing the historical transport networks, it is possible to discover the continuities and differences between each period. Those changes let us relate each network with the political and economic situation of the Iberian Peninsula. This information

is extremely useful to define the role of the political decisions in the design and organization of this territory and their impact in its economic situation. Methodologically, Networks Science analyses are applied to the historical intermodal transport systems. The results of these mathematical processes let us visualize and understand the morphological configuration of the transport networks and determine distribution and mobility patterns and their connectivity degree, and the changes and continuities between periods. In this paper, the methodology of the project will also be presented, from the creation of a transport model of time and cost expenses using historical information to the application of weighted SNA to analyse the connectivity of each historical networks.

Interlocking Geographic and Social Urban Mobility. The Social Network of Etruscan Elites during the Romanisation: a Strategy of Resilience?

Raffaella Da Vela

This paper presents the evolution of the social network of Etruscan families of the urban northern centers of Volterra, Chiusi, Fiesole and Perugia during the process of Romanisation. The network of kinship is analysed using Social Network Analysis (SNA) and integrated with a geographic network of the cities and the minor settlements on their territories. A methodological introduction will illustrate the preconditions of the archaeological and epigraphical sources as well as of the social structure, which allow us to reconstruct the network of Etruscan urban elites, their presence in neighbouring cities and minor centers, and their social mobility. In the following, the network of the kinship of local families will be presented and analysed diachronically as a longitudinal network between 350 and 50 BCE. After a discussion on kinship strategies and on the meaning of social mobility, the social network and its evolution will be related to the change within the network of geographic connectivity between main cities and minor settlements. The two networks of kinship and connectivity are interlocked and will be analysed in their interdependence. Aim of this research is to answer the following research question: what is the relationship between elite mobility and geographic connectivity? Can we detect forms of forced mobility due to traumatic events, such as conflicts, exile and climatic or economic deterioration of the landscape? And finally: is the mobility of Etruscan elites a strategy of resilience, to maintain the cohesion of the social structure and local leaderships during the process of Romanisation?

Who lived in that Roman house? Computational models applied to the differentiation of typologies of Roman houses

Ada Cortés, Pau de Soto

One important part of ancient urbanism studies has focused on analysing the typology and evolution of 'private' household. Part of these particular buildings with both public and private functions evolved over time, showing the different necessities of the society of each period. The Tetrastylon project aims to solve a surprising issue related with one, often poorly identified, Roman house. Under the identification of "Atrium House", two different typologies with important social significance have been merged. On the one hand, researchers have identified the canonical axial Roman house (with some small variations due to urbanistic evolutions) with an open court (Atrium). On the other side, under the classification of "Atrium House", scholars have also identified another domestic structure which is built around an atrium but following a Greek scheme of house. This typology of Roman house, which chronologically appeared after the influence of classic Atrium House, has only been detected in Roman cities with a Greek background. The project work frame is concentrated on the Magna Grecia and Sicily during the last centuries of the Republican Era, when a big part of the Greek colonies became Roman cities or were under the influence of Rome. This area of the Roman Empire is a good territory to analyse an important number of these houses and the effect of changing a Greek peristyle for an atrium within a Hellenistic scheme of house. Furthermore, this type of house has been detected in different places of the Roman Empire but the concentration of examples in this area seems to be more significative. This project takes into account several archaeological analyses on the Roman houses, but in this paper we want to present one of the methodological approaches of Tetrastylon which has been designed to use computational models to analyse the structure and functioning of this 'new' typology of house. Using Space Syntax and Visibility Relational Models, both domestic structures will be confronted with the aim of finding crucial and unquestionable differences between those building models. The results of these techniques will generate new data that will complement the archaeological and historical information about these houses, offering a new perspective about the social behavior of their owners and about the complexity of Roman urbanism.

Measuring the city – methods of layout reconstruction of regular medieval locations in Central Europe

Anna Maria Kubicka, Maria Legut Pintal

Towns with regular plans that include market square and perpendicular streets, surrounded by defensive walls were phenomena generated from West-European pattern of town planning and improved during colonization of Central Europe (especially in Silesia). Settlements were re-delineated or located on a green-field using a system of regular grid. However, different types of a transformation influenced the original division of plots over the centuries. The aim of this project is to reconstruct the first urban pattern delineated in 13th century and the basic units of measure by application of two different quantitative methods into the data collected from several towns of south-east Poland. In this paper we would like to present an initial phase of the research, with a focus on verification of methods already used by medieval scholars to reconstruct plans of 13th century foundation of towns. Traditional method of modular analysis applied by historians of urban planning is based on units of length known from historical sources. By adjusting the unit to the most characteristic values of length, it is possible to indicate which units of measurement were used and to reconstruct the original plots division. Second method is built on the opposite assumption that does not establish the existence of the basic unit of measure in dataset. The method is called cosine quantogram and was already used in metrological studies of Greek and Roman architecture.

Untangling Complexities of the Cretan Postpalatial Built Environment

Tia Sager

Periods of social instability hold particular value for archaeologists investigating the development of architectural language. Such phases, in which we might see destruction and rebuilding, offer glimpses into the processes of architectural creation and innovation in a condensed sequence. Architectural language (or style) can develop rapidly or fade following such moments of unrest, echoing both changing and enduring ontologies, power dynamics, and aesthetics. While scholars are formulating new ways in which to understand architectural modification within the ancient urban environment, approaches that consider the integration of multiple methodologies may be necessary to tackle this complex phenomenon. Towards the end of the Neopalatial Period (ca. 1450 BCE), Crete is the scene of significant social transformation and a series of island-wide destructions. The subsequent periods, often termed 'Postpalatial', produce new forms of architecture (as seen at Knossos, Haghia Triada, Gournia, Kommos, and others) and settlement patterns that reflect changing socio-political aesthetics on the island.

Because of complex problems with chronology, possible Mycenaean influence, hybridity , regional affinities, and extensive reuse and remodelling of earlier Neopalatial architecture, the built environment of Final Palatial and Postpalatial Crete (LM II-IIIB) has been understudied and generally poorly understood. Through a case study centred on Kommos, a multi-period site on the south coast of Crete with an impressively published built environment that undergoes well-documented modifications in the Postpalatial period, this paper will test the potential of a systematic integration of several methodologies. These will include space syntax analysis, GIS analysis, phenomenological approaches, and 3D modelling, in order to provide a synergistic approach to understanding architectural modification and the changing architectural language of the Postpalatial period on Crete.

Standard session 13:
Ethics in Digital Archaeology: Concerns, Implementations and Successes

L. Meghan Dennis, University of York

Medium Hall B, 8.40 – 10.40, 26 April 2019

An increase in digitally derived data and digitally situated methodologies has brought with it a new set of ethical concerns. CAA has attempted, as one intervention, to address these considerations with the creation of a code of ethics. This code was formally adopted by the membership at the 2018 Annual Conference. Though the contents of this code provide guidance to digital archaeologists, on-the-ground realities can prompt scenarios of ethical confrontation that require creative thinking and adaptations of practice.

This session aims to provide a venue for sharing experiences of ethical consideration in digital archaeology, both within the academic and private sectors. Papers will discuss the application of ethical theory and ethical guidelines to past and present projects. In addition, papers will examine initiatives for addressing ethical concerns within future projects. A synthesis of experiences over the first year of CAA's Code of Ethics and reflections on growth in ethical consideration within the sector will be made, and necessary adaptations and evolutionary changes in ethical decision making within the digital sphere will be discussed.

8.40 – 9.00
Where are the Codes of Ethics for Digital Archaeology?
L. Meghan Dennis

9.00 – 9.20
Towards A Digital Ethics of Agential Devices,
Jeremy Huggett

9.20 – 9.40
Ethics and the Big Data Paradigm,
Lorna-Jane Richardson

9.40 – 10.00
Models and Metadata Revisited: Changes in Online Digital Bioarchaeological Practice,
Priscilla Ulguim

10.00 – 10.40
General Discussion

Where are the Codes of Ethics for Digital Archaeology?

L. Meghan Dennis

In order to understand the state of current practice in archaeological ethics, a review was conducted to determine what, if any, codes of ethics relating to digital archaeology were in place within the archaeological sector. Codes of ethics were collected via a broad program of internet search for archaeological organizations, societies, and professional groups. Manual keyword searches were conducted, as well as the solicitation of examples via social media channels. This resulted in the examination of the web-presences of 116 archaeologically oriented groups. Isolated guidelines within each code of ethics were subject to open-coding textual analysis facilitated via the NVivo program of software. This paper will present preliminary results from the review, illustrating areas of shared ethical consensus across the sector, with particular focus on the presence and absence of ethical guidelines pertaining to digital archaeology.

Towards A Digital Ethics of Agential Devices

Jeremy Huggett

As algorithms and their devices increasingly acquire agency, the need to address their ethical issues becomes ever more urgent. The range of digital devices used across archaeology and the algorithms which drive them are progressively black-boxed as they become more and more complex, but the lack of transparency, the absence of explanation, and the increasing authority of these devices, together with the levels of trust, reliance, and expectations placed upon them, can create either a vicious or virtual circular relationship between the human and digital agent. In particular, as these tools – from software analytics to drones to bio-mimetic robotic devices – increasingly display autonomous behaviours they require a consideration of the ethics of their design, development, and application. What limits should be applied to their use? Can these agential devices contain ethical programming, and consequently exhibit ethical behaviour? Do the responsibilities and liabilities lie with the device, the designer, the user, or in some combination? The development of ethics in this area is still in its infancy: for example the IEEE is planning a publication in 2019 looking at the ethical issues associated with the design and use of autonomous systems, and archaeologists can learn from and build upon the digital ethics debates that are beginning to take place elsewhere. Furthermore, we have a responsibility to do so.

Ethics and the Big Data Paradigm

Lorna-Jane Richardson

As global use of social media has increased, there has been considerable debate around the phenomenon of what can be termed 'Big Data'. This refers to not only the large volumes of data about people's views and personal opinions, choices and behaviours that are produced and accumulated online, but also speaks to a process of social change. Public archaeology has witnessed a growing interest in this method of social research (including that of the author), which uses or discusses data extracted from archaeology-related digital media platforms, frequently without the inclusion of any ethical statements on how these data were collected, stored and processed, nor what permissions were gained to use this material. One of the key considerations overlooked when researching Big Data is the ethical aspect of data scraped or extracted from the Internet. Public data may not in fact be considered to be 'public' by participants, and infers that all participants in activities and discussions online give implicit permission for their data to be collected and analysed, when it is very difficult to find out if this is the case when using a quantitative approach to online data. This paper will explore the many unique ethical dilemmas that arise from the use of 'Big Data' methodologies, drawing from the wider experience of Internet Studies, and consider issues such as privacy, digital capitalism and surveillance.

Models and Metadata Revisited: Changes in Online Digital Bioarchaeological Practice

Priscilla Ulguim

Today bioarchaeologists are exploring opportunities to engage, inform, collaborate and interact with diverse audiences across the globe using digital media and new technology. As bioarchaeology has entered the digital age, concerns over privacy, security, and the long-term implications of sharing digital bioarchaeological data have grown. The debate over ethical best practices in recording, sharing and storing data has played out online, in workshops and conferences. Sessions at HEA 2013, EAA 2015, WAC 8 2016, and UCL in 2018 have produced a series of studies and proposals for best practice in data acquisition, sharing and storage. How have these discussions and debates influenced digital bioarchaeological practice? Have research approaches changed? To address these questions this paper compares and contrasts practice in online digital bioarchaeology between 2016 and 2018. New data on online practices for recording and sharing human remains online was gathered and compared to results from the 2016 "Models and Metadata" review, which analysed how digital bioarchaeological data was shared on online

platforms. In turn, paper suggests further improvements and changes required to increase the adoption of ethical practices and support researchers in the development of projects using digital bioarchaeological data.

Standard session 14:
Modelling Data Quality in archaeological Linked Open Data

Kai-Christian Bruhn, i3mainz – Institute for Spatial Information- and Surveying-Technology, University of Applied Sciences Mainz
Allard Mees, Römisch-Germanisches Zentralmuseum
Florian Thiery, Römisch- Germanisches Zentralmuseum (Mainz, Germany)

Exhibition Room B, 14.00 – 15.40, 24 April 2019

Today, increasing quantities of data are published by archaeological institutions. At the same time, interconnecting these data following the concept of "Linked Data" is becoming more and more popular. The current evolution from "Linked Data" via "Linked Open Data" (LOD) towards "Linked Open Usable Data" enables a wide array of archaeological applications. However, this development of an increasing LO(U)D-cloud implies challenges in handling complex facets of data quality. Therefore, modelling the handling of data quality becomes an increasingly important issue. This is especially valid for archaeological data, which are based on a complicated network of concepts from different knowledge domains.

Even very carefully compiled datasets can contain errors and ambiguities. Unrecognised errors multiply exponentially in scenarios of data reuse: not only incorrect data and conclusions are the result, but possibly also a loss of confidence in web-based resources. Moreover, modelling data quality to share knowledge about uncertainty is necessary to produce and publish transparent Linked Open Usable Data.

The success of the session "Guaranteeing data quality in archaeological Linked Open Data" at CAA International 2018 has raised awareness of many challenges related to this topic and encourages pursuing the debate.

For this session we invite contributions that addresses e.g. following issues:

- Identifying and strategies for correcting inconsistencies within the data;
- Identifying sources and dangers of incorrect or ambiguous data;
- Identifying duplicates across different LOD sources;
- Keeping track of the provenance of data as a means of solving errors and identifying their source;
- Defining metrics in order to rate data in respect to their quality;
- Setting up methodologies and tools in order to label or certify data sets based on their quality;
- Compiling trust levels based on various inputs such as provenance and quality level;
- Modelling uncertainty and vagueness in LOD (e.g. thesauri and CIDOC CRM);
- Dealing with ambiguities resulting from multiple links in the LOD cloud;

W encourage presenters to derive the problems from real-world datasets and to formulate proposals for solutions, preferably demonstrating (prototypes of) realised data driven web applications. As we target a broad and diverse audience because of the thematic relevance, the challenges described should also be integrated into their archaeological context (excavation, museum, archive, etc.).

14.05 – 14.30
Uncertain information, the Dark Matter of archaeology – use cases from numismatics,
Karsten Tolle,David Wigg-Wolf

14.30 – 14.55
ARS3D - Documenting facts and interpretations of African Red Slip Ware,
Florian Thiery, Ashish Karmacharya, Louise Rokohl

14.55 – 15.15
Linked (Open) Data with Provenance for Prehistoric Mining Archaeology,
Gerald Hiebel, Annette Hornschuch, Leandra Reitmaier-Naef, Phillip de la Casa, Gert Goldenberg, Klaus Hanke, Erica Hanning, Markus Staudt, Thomas Stöllner, Peter Thomas, Manuel Scherer-Windisch

15.15 – 15.40
General Discussion

Uncertain information, the Dark Matter of archaeology – use cases from numismatics

Karsten Tolle, David Wigg-Wolf

Archaeologists are confronted with uncertainty constantly. Often it is part of their material, but also arises from research that relies on the work of others that may have been done in the past on other methodologies, thus requiring the handling of incomplete or questionable information. Today we are able to store and preserve more information: the number of archaeological finds continues to grow together with the information, and approaches like Linked Open Data (LOD) are now starting to link this information together. But this linking is not free of uncertainty, for example in the case of Celtic coinages for which there are different typologies but between which there are no 1-to-1 relationships. This leads to challenges in mapping and uncertainties that have to be coped with. At CAA 2014 in Paris we presented our approach on modelling uncertain data in RDF (LOD). However, in the field of numismatics uncertain data is still hardly presented in LOD resources. Even we only export certain data to Nomisma.org. This is due to the fact that, besides the difficulties of modeling, query systems also need to be able to handle it and those people using the data need to be aware of the uncertainty. In our presentation we will show where we are at present in Nomisma.org and our system Antike Fundmünzen in Europa (AFE), where we still see the barriers, and what we feel should be the next steps in order to enable us to use the enormous amount of uncertain data meaningfully.

ARS3D - Documenting facts and interpretations of African Red Slip Ware

Florian Thiery, Ashish Karmacharya, Louise Rokohl

The African Red Slip Ware (ARS) is a central archaeological object type for the understanding of late antique world of ideas, their exchange and socio-economic history. The 3-year project ARS3D, funded by the German Federal Ministry of Education and Research (BMBF), started in February 2018 and aims to document, digitise and publish the relief-decorated ARS, located in the Römisch-Germanischen Zentralmuseum (RGZM). The ARS3D project will publish the facts and archaeological interpretations of these ARS objects. In this process the ARSs are 3D scanned and processed to create their 3D surrogates. These 3D models support archaeological interpretations which should be documented. Here we present our ontology that forms the structural fundament for the documentation and the underlying triplestore as data repository. The axioms are primarily based on CIDOC-CRM with few additions to fulfil our requirements. In addition, we included axioms to provide structure for storing meta- and para- information generated during the creation of 3D models. We have also included axioms from PROV-O, the W3C compliance ontology for structuring the provenance information of the 3D generation

process. An interactive web application provides the graphical user interface of this ARS data repository. In this paper we consider data quality aspects for: 1) Provenance quality that affects the archaeological interpretations. 2) Archaeological factual quality on ARSs such as iconographical descriptions by bibliographic references and external resources, e.g. Icon Class to access the LOD cloud. 3) Identifying the provenance and storing chronological information.

Linked (Open) Data with Provenance for Prehistoric Mining Archaeology

Gerald Hiebel, Annette Hornschuch, Leandra Reitmaier-Naef, Phillip de la Casa, Gert Goldenberg, Klaus Hanke, Erica Hanning, Markus Staudt, Thomas Stöllner, Peter Thomas, Manuel Scherer-Windisch

We want to present an approach how to model prehistoric mining technology transfer in the Eastern Alps with Linked (Open) Data as an interpretation of physical evidence. To infer a technology transfer we use the CIDOC CRM ontology with the CRMarchaeo extension for archaeological excavations and the CRMinf extension for argumentation. These allow us to relate interpretations of technology transfer to the observations and physical remains they are based on and thus keep the provenance of the argumentation. This structure of representing data enables as well the inclusion of experimental archaeology and ethno archaeology research results in the argumentation process. The approach is exemplified with data on prehistoric mining indicating a specific way of smelting called the "Mitterberg process", named after the biggest producer of Alpine copper in the Bronze Age. For this purpose, we integrated data from three different areas spreading over 400km that have been investigated by institutions from Austria, Germany and Switzerland. Each institution has its own way of representing and documenting their research data with spreadsheets, databases and Geoinformation systems and in order to investigate technology transfer we had to first integrate the data. on a conceptual level. We applied the CIDOC CRM ontology and the DARIAH Back Bone Thesaurus for the conceptual integration and used semantic data standards of RDF and SKOS for the implementation. With the generated linked data we address the research question of the temporal and spatial spread of the "Mitterberg process" over the Alps and visualise different hypothesis.

Standard session 15:
Issues of scale in archaeological computational modelling

***Benjamin Davies**, The University of Auckland*
***Colin Wren**, University of Colorado - Colorado Springs*

Seminar Room, 8.40 – 10.40, 26 April 2019

Archaeology aims to interpret and explain patterns in the material record. That patterning may occur at a wide range of spatial scales, from microscopic traces in sediments and residues to global scale patterning in the distribution of technologies and material culture. These patterns may develop in an instant or accumulate over millennia, and are subject to change through time. The explanatory models that archaeologists develop must not only incorporate these spatial and temporal scales but must often operate across them to accommodate the emergence of wide scale patterning in the present from individual scale actions in the past. Whether represented using GIS, ABM, networks, equations, or otherwise, considerations of scale are fundamental to the venture of archaeological modelling, creating sources of frustration and inspiration for understanding the past. In this session, we aim to bring out some of the challenges of computational modelling in archaeology, particularly with respect to issues of scale. We interpret this broadly: scale can pertain to the behaviours under study, the analysis being undertaken, or representation as a model. Whether spatial, temporal, organisational, or even computational, we welcome papers that can provide insights into issues of scale in archaeological modelling.

8.40 – 9.00
Where local meets global. Reconsidering the trajectory of settlement development in Central Asiatic oases in pre-Achaemenid and Achaemenid times,
Nazarij Buławka

9.00 – 9.20
From picking up a sea snail to models of long-term occupation of the South Africa Middle Stone Age coastline,
Colin D. Wren

9.20 – 9.40
Issues of Social Scale in Archaeological Models of Exchange,
James R. Allison

9.40 – 10.00
Estimating Neolithic spread rates at different scales: Europe and the Near East versus the Western Mediterranean,
Joaquim Fort

10.00 – 10.20
Complex data over large spatial and temporal scales: local understandings of national significance,
Chris Green, Anwen Cooper

10.20 – 10.40
Sharpen the image: Determining scales for questions of hominin dispersal and migration,
Ericson Hölzchen, Christine Hertler, Christian Sommer, Christian Willmes

Where local meets global. Reconsidering the trajectory of settlement development in Central Asiatic oases in pre-Achaemenid and Achaemenid times

Nazarij Buławka

In the 7th century BC when the Central Asia has become a part of Achaemenid Empire (later stretching from Egypt to India), it already consisted of flourishing states of Margiana, Bactria, Sogdiana, Aria, Parthia and Khwarezm. Those historical regions were incorporated into larger economic and settlement system. This event should have had impact on the settlements spatial arrangement and hierarchy. The history of research of this issue 19th and early 20th century in Central Asia goes back to late. It is connected with the study of so called Yaz culture (1350-300 BC), layers of which were first uncovered by R. Pumpelly at Anau-depe in Turkmenistan . Despite of a long research, archaeologists have failed to indicate development of settlement model in pre-Achaemenid and Achaemenid times via settlement pattern analysis. This paper will try to answer what were the trajectories of settlement development in this period basing on field survey results of Italian-Turkmen Mission of Archaeological Map of Murghab Delta and Polish Turkmen Archeological Mission in Tedjen river area in Turkmenistan. The paper will focus on different scales of analysis of the landscape, spatial statistics of point patterns and other GIS methods, and will touch different settlement location theories.

From picking up a sea snail to models of long-term occupation of the South Africa Middle Stone Age coastline

Colin D. Wren

Archaeologists have set themselves a ridiculously challenging task, taking the remains of individual actions and scaling up to millennia long sequences of biological and cultural evolution. Agent-based modelling brings a new tool to bridge this gap by modelling local scale interactions and observing their effects on global scale patterning. However, the justification of the model design needs a solid theoretical framework to guide model design and parameterization to help bridge spatial and temporal scales. Here we present an agent-based model of a human foraging system with diverse resources from a heterogeneous landscape. We use human behavioural ecology to guide our model design and incorporate data from ethnography and specially designed foraging experiments to parameterise the model. We model sub-hourly decisions of individual foragers and scale-up to accumulations of archaeological deposits representing thousands of years of the South African Stone Age. This foraging system platform then allows us to ask questions regarding sustainable population sizes, the impact of shifting sea-levels on Middle Stone Age adaptations, and the role of foresight in the successful exploitation of shellfish.

Issues of Social Scale in Archaeological Models of Exchange

James R. Allison

The earliest attempts to model exchange systems in archaeology often assume exchange occurred between groups of people, usually conceptualized as "villages". In contrast, many recent agent-based models of exchange conceive of households or individuals as agents that interact. This shift in the social scale at which models are constructed is interesting in part because it coincides with larger shifts in archaeological theory. This suggests that the granularity (or social scale) of the models is in large part theoretical. Processual archaeology and cultural ecology put the focus on systems and the adaptation of whole societies. Since the 1980s, several theoretical trends in archaeology have converged to turn attention more toward individuals. These trends include the popularity of various strands of post-structural social theory, the use of behavioral ecology or other approaches based in Darwinian evolution, and the incorporation of complexity theory, with its emphasis on emergence and self-organization. In this paper, I go back to agent-based models of exchange from the late 1970s and early 1980s to explore the consequences of recasting them at a different social scale. How does reframing the models in this way require revisions to the underlying assumptions? Is it sensible to simply substitute individuals for villages and have the individuals interact in the same ways that villages interact in the original models? What conclusions, if any, change when we model interaction among village residents rather than villages?

Estimating Neolithic spread rates at different scales: Europe and the Near East versus the Western Mediterranean

Joaquim Fort

Joaquim Fort Universitat de Girona, Catalonia (Spain) joaquim.fort@udg.edu Traditionally, Neolithic spread rates have been estimated by performing time-space linear regressions. This approach has been successfully applied in studies that consider all of Europe and/or the Near East, and it has been sometimes refined by using spatial interpolation techniques [1]. But in the spread of the Neolithic along the Western Mediterranean, the distance covered is relatively small and the spread rate is substantially faster (as compared to the average across the Near East and Europe) [2]. For these reasons, the temporal scale is much smaller than in traditional estimations of Neolithic spread rates. Thus we need very precise dates to estimate the spread rate of the Neolithic in the West Mediterranean, and we cannot simply use all data (as in previous analyses) but have to use only the earliest dated site for each region. It is also necessary to select the data very carefully (e.g. by excluding long-lived samples). This highlights that the scale

considered, as well as the dispersal mechanism of the population (in this case sea travel) have strong effects on the necessary approaches to perform reliable estimations of Neolithic spread rates. [1] Fort J, Pujol T, Vander Linden M, Modelling the Neolithic transition in the Near East and Europe. American Antiquity 77 203-220 (2012) [2] Isern N, Zilhao J, Fort J, Ammerman A J, Modeling the role of voyaging in the coastal spread of the early Neolithic in the West Mediterranean. PNAS 114 897–902 (2017)

Complex data over large spatial and temporal scales: local understandings of national significance

Chris Green, Anwen Cooper

The English Landscapes and Identities project (EngLaId: ERC, 2011-6), was an ambitious undertaking which aimed to collate and interpret archaeological data for England between the Middle Bronze Age and the Domesday survey, a period of c.2,500 years. The team built a database from existing local and national resources which contained over 800,000 spatially located records of archaeology. Naturally, patterns of variation in this very large dataset operated at a variety of different spatial, temporal, and typological scales, which were complex to disentangle and to understand. This paper discusses how the project team developed computational modelling systems for extracting spatial variation from the EngLaId dataset in a manner which allowed the definition of local measures of national significance. The methods developed were applied initially to the definition of 'significant' concentrations of finds reported by members of the public (to the Portable Antiquities Scheme) and then further refined and applied to the EngLaId dataset as a whole. This resulted in a series of models of the 'complexity' of English archaeology in a particular time period, which can be used to approach questions regarding population density and persistence of place. Author 2 & Author 1. 2017. "Big questions for large, complex datasets: approaching time and space using composite object assemblages." Internet Archaeology 45. Author 1, C. Gosden, Author 2, T. Franconi, L. Ten Harkel, Z. Kamash & A. Lowerre. 2017. "Understanding the spatial patterning of English archaeology: modelling mass data from England, 1500BC to AD1086." Archaeological Journal 174(1), 244-280.

Sharpen the image: Determining scales for questions of hominin dispersal and migration

Ericson Hölzchen, Christine Hertler, Christian Sommer, Christian Willmes

Continental scale hominin geographic expansions can be traced back since at least 2 million years with the first expansions out of Africa. The research on these expansions encompasses a variety of temporal and spatial scales. Therefore, understanding hominin geographic expan-

sion as a whole, these scales need to be understood. Agent-based simulations approach this task by manifesting scales in terms of agent definition, environmental resolution and discrete time steps. However, there is no consensus on how to apply the appropriate scale on a research question for agent-based simulations. This may lead to misconceptions of simulation models and misinterpretations of simulation results. In our talk we present two examples of agent-based models of hominin dispersal and migration that address research questions on different spatio-temporal scales. One model addresses the earliest expansions out of Africa and the other Neanderthal mobility in Western Europe. By these examples we want to present criteria on which to determine the scale of agent-based simulation models, how to use different scales as a means to approach a research question and moreover to determine appropriate scales for a research question. Accordingly, we will also discuss the technical aspects of scale, such as the effects of different projections on simulation results.

Roundtable 16:
Where does global meet local? Finding common ground for multiscalar analysis of settlement and land use dynamics

***Philip Verhagen**, VU University Amsterdam, Faculty of Humanities*
***Laure Nuninger**, Chrono-Environnement UMR 6249 CNRS / ModeLTER - MSHE C.N. Ledoux USR 3124 CNRS*

Small Hall, 16.00 – 17.20, 26 April 2019

Spatial modelling of regional settlement systems has made great strides since the introduction of GIS in the 1990s. Many regional datasets were created and completed, allowing for quantitative and spatial analysis of settlement patterns from a landscape perspective. Also, the study of settlement patterns has recently seen important advances with the introduction of statistical simulation methods to model and analyse chronological uncertainty.

However, the comparison of settlement systems between regions in order to understand long-term social, environmental, economical and political change at a national, continental or even global scale is a field where methodological progress has been slow. Current approaches seem to either favour a simulation modelling approach, trying to fill the gaps between sparse data points, for example using advanced diffusion models or agent-based modelling; or they rely on reducing the complexity of archaeological and palaeo-environmental data to produce standardized spatio-temporal analyses of large data sets.

In this roundtable, we invite participants to explore with us new and effective approaches to analyse and model settlement and land use trajectories within a multiscalar context. In particular, we want to address the following questions:

- How can we exploit existing datasets, stemming from different scientific and heritage management traditions, for cross-border and cross-disciplinary studies? Current developments in data collection and curation, spurred on by the 'linked open data revolution', have led to an increasing availability of all kinds of data. However, the analysis of LOD for scientific research is still highly experimental and successful examples are dependent on the creation and maintenance of a common ontology.
- How can we develop common procedures for diachronic analysis, applicable to both large-scale questions and regional settings? Regional settlement data is fine-grained and needs local expertise to be exploited to full effect. What are the shared characteristics of local datasets that will allow for comparison on a larger scale, and are these useful for understanding questions of social, environmental, economical and political change? What ways are available to model and predict the characteristics of coarser-grained data sets, or even of zones where data is absent, and can these be combined in a common analytical framework?

- How can we build a bridge between different theoretical and conceptual frameworks? For example, to what extent can large-scale simulation modelling results be tested with regional archaeological data sets? And how can we connect settlement data to data sets that cover very different aspects of past land use and settlement, like palaeo-environmental data, transport and communication networks, or other off-site activities?

16.00 – 16.20
The fabric of a rural landscape, round trip from space to field survey (Loir-et-Cher, France),
Clément Laplaige, Nathanaël Levoguer, Xavier Rodier

16.20 – 16.40
Multi-scale insight into the archaeological study of an Andean archipelago settlement system,
Thibault Saintenoy

16.40 – 17.00
Attempting to make agent-based models more applicable to regional settlement models,
Colin D. Wren

17.00 - 17.20
General Discussion

The fabric of a rural landscape, round trip from space to field survey (Loir-et-Cher, France)

Clément Laplaige, Nathanaël Levoguer, Xavier Rodier

The LiDAR allows renewing the study of the landscape fabric. As part of the SOLiDAR program, we have detected fossilized crop boundaries extending over a hundred square kilometers in the forest massifs around Blois and Chambord. The existence of these forest massifs has been documented since the end of the 11th century. The most common way to date these boundaries is to study the objects from the buildings connected to them. However, the dating of a habitat does not provide the time boundaries of the parcel to which it is linked. The forty sites connected to this frame were dated from the artefacts recovered in pedestrian survey. The analysis of the data suggests that this plot system has functioned from proto-history to the 10th century. The morphology and dating of the frame are similar to what it has been observed a few kilometres upstream from the Loire, in Beaugency. In addition, we have implemented some OSL dating of linear microreliefs to estimate the beginning and end of accretion periods of these structures. The results reveal an implementation of some structures at the change of era but a continuation of the aggradation until the 15th century. Although not generalizable to the entire massif, these observations provide elements for understanding the structure of the landscape over time. The challenge is to combine micro-local information on agrarian boundaries and habitat with macro analysis of the grid in order to better understand the fabric of the landscape.

Multi-scale insight into the archaeological study of an Andean archipelago settlement system

Thibault Saintenoy

Discussant

Attempting to make agent-based models more applicable to regional settlement models

Colin D. Wren

Agent-based models of past human society have traditionally come in two flavours, one highly abstract and difficult to directly compare to the archaeological record due to its abstraction and one highly specific but still unlikely to "match" the archaeological record. A potential middle ground of archaeological agent-based models that strike a balance between these two positions have not been sufficiently explored. Here I will discuss a way forward where an abstract approach to modelling, but with specific parameterisation and landscapes, can still lead to novel insights into settlement patterns that are consistent with regional archaeological datasets. I illustrate this point using a foraging, mobility, and settlement model of Stone Age South Africa.

Standard session 17:
Empowering Archaeology of the Senses through digital approaches

Giacomo Landeschi, Lund University
Heather Richards-Rissetto, University of Lincoln-Nebraska

Large Hall A, 11.00 – 15.40, 26 April 2019

A major challenge of contemporary archaeology is to build formal-based narratives about the Past that allow for human perception and agency. Archaeologists are making use of digital tools and technologies to develop innovative approaches to take a situated perspective of human interactions in ancient landscapes. By "placing" human actors in specific physical and cultural contexts, we can explore the role of built and natural environments in structuring ancient experiences, which in turn, influence social, political, economic, and ideological interactions. While material culture together with other data sources provide the basis for bridging modern experiences with potential experiences of past peoples within landscapes, few formal methods exist to construct these narratives; however, recent advances in archaeological computing are affording new approaches.

In recent decades, archaeologists have begun to employ digital methods to simulate and quantitatively explore human experience in the past, or at least, to get some clues about the ways by which humans manipulated ancient spaces to convey symbolic messages, create identity, and structure interaction. Human senses, as defined by Aristotle, act as an important proxy to investigate the social dimensions of ancient spaces and places. Sight and hearing, but even smell, touch and taste can now be captured, analysed and reproduced in a digital environment through state-of-the-art technology that can contribute to deeper explorations of spaces and their relation to constructing a sense of past places.

The purpose of this session is to foster discourse on the way different digital tools and technologies such as Virtual Reality (VR), Augmented Reality (AR) Mixed Reality (MR), haptic devices, Geographic Information Systems (GIS), and more can lead to the development of formal methods that help create multi-sensory narratives to provide deeper insight into the study of ancient space and place. We invite all those specialists interested in applying advanced digital tools in the field of Cultural Heritage to present papers on the human sensorium as a possible gateway to the Past and as a way to foster discourse on methodological and interpretative challenges to building formal-based narratives that allow for human perception and agency. We solicit presentations on a range of issues such as, but not limited to, formal methods, research applications, technological challenges and affordances, and theoretical frameworks.

11.00 – 11.20
Back again to GIS? The need of mapping multisensoriality,
Giacomo Landeschi

11.20 – 11.40
The claim markers of the Bronze Age; A study of viewing and understanding the fire cracked stone heaps in Sweden,
Amanda Saga Jeppsson

11.40 – 12.00
Re-imagining the First General Assembly: How 3D Modeling and Archaeology are Shedding Light on the Beginning of American Democracy at Jamestown,
Lisa E. Fischer, William Balderson, Cynthia Deuell, Mary Anna Hartley

12.00 – 12.20
Visual acuity and 3D GIS as means for investigating visibility of iconographic programs in historic churches - St. John the Theologian cathedral in Nicosia (Cyprus) as a case study,
Martina Polig, Despina Papacharalambous, Sorin Hermon, Nikolas Bakirtzis

12.20 – 12.40
General Discussion

LUNCH BREAK

14.00 – 14.20
See Augustus (?) Visual communication and political change in the Roman Forum between late republic and early principate: A 3D computational approach,
Alexander Braun

14.20 – 14.40
Immersive Archaeological Data Visualization and Interpretation in the Field and through VR Classroom Experiences,
Luke Hollis

14.40 – 15.00
Multisensory Experiences & Narratives in Archaeological Landscapes—Sound, Vision, and Movement in GIS and Virtual Reality,
Heather Richards-Rissetto, Kristy Primeau, David Witt, Graham Goodwin

15.00 – 15.40
General Discussion

Back again to GIS? The need of mapping multisensoriality

Giacomo Landeschi

Despite the incredible advances occurred in the field of Virtual Reality, immersive systems and the growth of more complex devices fostering advanced multisensory experiences, where visualization and auralization play a predominant role, archaeologists and specialists still need to 'map' the results derived from such simulations. Mapping implies the idea of improving and making transparent the process of data interpretation, by quantifying the outcome derived from the observation of any measurable phenomenon. Being the past human experience a result of an interaction between people and their surrounding environment, senses act as one of the possible proxies to 'measure' and try to understand that experience and possibly to shed some light on the way the ancient space was built and lived by its original inhabitants. Therefore, any visual, acoustic or other sensory-related phenomenon that can be digitally measured, to be fully readable and comprehensible needs to be mapped in a geolocated platform where it can be represented according to different values of frequency and intensity. Indeed, the multilayered and multiscalar nature of GIS is still an essential feature for representing complex phenomena and the possibility offered by recently-developed three-dimensional platforms increases the possibility to deal with such complexity. New questions then arise around the role of GIS to develop a multisensory study of the past: is any kind of sensory experience representable? Is temporality real in place? How can we deal with movement? How transparency and uncertainty can be dealt with?

The claim markers of the Bronze Age; A study of viewing and understanding the fire cracked stone heaps in Sweden.

Amanda Saga Jeppsson

The fire cracked stone heaps are frequently found in Bronze Age contexts in Sweden. The placement and purpose of the heaps are incomprehensive, and the understanding of the remains has varied through the 20th and 21st century. The heaps are constructed by a massive amount of fire cracked stones and might contain a variety of artefacts, and they can also have complex inner stone patterns. Through analysing the fire cracked stone heaps location, it is clear that the heaps have a placement pattern which is connected to the contemporary coast. This placement might be explained through interpreting the heaps as markers in the landscape for claimed land. By using a 3D model in which the heaps of fire cracked stones, reconstructed shorelines, vegetation and a ground elevation are included it is possible to recreate a digital Bronze Age landscape. The most important attribute for a land claim marker is its visibility in the landscape, and through

recreating one the visibility of the heaps can further be analysed using the spatial analyst tool "line of sight". To understand the visibility of the heaps the "line of sight" was adapted to include multiple observer points both from the coast and from land. Vegetation and ground elevations were used as sight obstacles. By comparing the visibility of the heaps from the ground versus the seaside, the results become an indication of how the Swedish Bronze Age culture moved, claimed and changed their surrounding landscape.

Re-imagining the First General Assembly: How 3D Modeling and Archaeology are Shedding Light on the Beginning of American Democracy at Jamestown

Lisa E. Fischer, William Balderson, Cynthia Deuell, Mary Anna Hartley

Jamestown, most recognized for being the first successful English settlement in North America, is where the American democratic experiment began. 2019 marks the 400th anniversary of representative government in English America with the convening of the first general assembly in Jamestown's church from July 30 to August 4, 1619. The Jamestown Rediscovery project to examine James Fort has been ongoing for 25 years and recently the team completed digging the site where the assembly met. The excavation is incredibly complicated because two later 17th-century churches as well as numerous graves have "cut" the remains of the original building. However the recent archaeology has revealed new information about the church, including its construction method and interior floorplan. Using software, including AutoCAD and 3D Studio Max, the team is analyzing the archaeological data to visualize this significant building in 3D. However we can go beyond just virtually reconstructing the church to re-interpreting the sense of the event. Primary sources and the general assembly records are making it possible to locate the positions of key actors, including the governor who presided over the meeting as well as the elected burgesses, within the 3D structure and to digitally render various viewpoints. This research is helping to better understand the events that occurred over the six days; to visualize the perspectives of different actors and how their positions might have influenced the proceedings; and to improve the accuracy and sense of the events in first-person programming interpreting the first general assembly.

Visual acuity and 3D GIS as means for investigating visibility of iconographic programs in historic churches - St. John the Theologian cathedral in Nicosia (Cyprus) as a case study

Martina Polig, Despina Papacharalambous, Sorin Hermon, Nikolas Bakirtzis

This paper presents the development and application of an innovative 3D-GIS based contribution to art historical research, focusing on the investigation of the organization, perception and

interpretation of iconographic programs of historic churches. The case study is the post-byzantine church of St. John the Theologian in Nicosia, Cyprus, richly decorated with wall paintings depicting a unique iconographic narrative. The visual experience inside the church of its visitors is thus instrumental in understanding the iconographic program's role as a conveyor of socio-political messages that go beyond the religious experience and thus provide a glimpse of the Greek/Orthodox cathedral's historic meaning and character during the Ottoman rule in Cyprus. The paper describes a visibility analysis of the iconographic program based on visual acuity in a 3D-GIS environment. The church was 3D documented inside-out and high-resolution images of the iconographic program were acquired. A GIS environment was created with the texturized 3D model; wall paintings were separated in different layers as representing different scenes, delineated by the art historian studying the monument. The visibility of the scenes from key positions in the church was investigated based on visual acuity, the distance of each scene to a given observation point and the size of the smallest detail necessary for the identification of a scene. The influence of different light conditions on human eye-sight was considered approximating the original lighting inside the church, the geometry of its interior and light reflection conditions as influenced by materials and colours of the frescoes and furniture.

See Augustus (?) Visual communication and political change in the Roman Forum between late republic and early principate: A 3D computational approach

Alexander Braun

The Forum Romanum belongs to the most prominent sites of the ancient Roman world. It was the centre of politics and communications, a place of representation. During the reign of Augustus the Forum Romanum was subject to several construction programs of the princeps, his family and followers. This led to the postulation in classical archaeology and ancient history that the meaning of the Forum changed to become a "private monument" to Augustus and his family. In order to put this notion into question, to analyse how the visual communication and political changes manifested in the built environment to the view of visitors 3D visibility analyses were conducted for the built environment of the Forum Romanum around the year 50 BC and 14 AD. With the use of modern GIS methods provided by ESRI CityEngine and Arc GIS in combination with 3D modelling programs it was possible to conduct vector based 3D visibility analyses and to quantify the potential visibility of the built environment, the prominence of speakers on the rostra as well as the places for visitors to see "the most" of said built environment for both phases. The non-verbal messages of the built environment are part of the multi-sensory narrative of the Forum Romanum. The prominence of these messages allows to draw conclusions on the representation and communication outline and strategy in the Forum

Romanum. The visibility analyses allowed to quantify the prominence of the non-verbal messages in order to explore the narrative offered on the square.

Immersive Archaeological Data Visualization and Interpretation in the Field and through VR Classroom Experiences

Luke Hollis

At Archimedes Digital, we believe archaeological data and site narratives should be presented in tandem in a single cross-platform interface and have been creating a web, VR, and AR platform for visualizing, searching, and building narratives with archaeological data. In achieving this end, we have been inspired by digital humanities projects such as the Harvard Art Museum's Tour Builder and the Recogito annotation environment to create a geospatial data presentation environment where administrators and editors may publish site narratives and embed artifacts from their digital collections platforms directly so that end users may explore their excavations in 2D and 3D environments. A major challenge that we faced while creating this platform was creating a content editing environment (akin to a Medium.com editing experience) that incorporated saved searches from the faceted search tools, IIIF image viewers, and 3D object embeds, all with captions and optional collections metadata viewable in the reading environment. While the narratives constructed in this editing environment are largely for educational or interpretative purposes, they also at some point in future iterations could be used for publishing digital editions of more traditional research. The interpretative narratives created on the platform developed by Archimedes may be viewed via geolocation in virtual environments (such as site reconstructions that may be viewed in VR) and augmented reality on mobile devices while users are in the field. Users may start the app and read narratives based on their GPS while they are viewing a 3D reconstruction of the site they are visiting.

Multisensory Experiences & Narratives in Archaeological Landscapes— Sound, Vision, and Movement in GIS and Virtual Reality

Heather Richards-Rissetto, Kristy Primeau, David Witt, Graham Goodwin

Cyberarchaeology—defined both as "the integration of the latest development in computer science, engineering, science, and archaeology" and simulating a "potential past" in a 3D "cyber-environment"— allows for multi-sensory interaction with data in virtual environments affording new approaches and leading to new questions, new knowledge, and changes in archaeological practice. Archaeologists are employing a variety of digital tools to develop new methodological frameworks that combine computational and experiential approaches that is

leading to new multisensory research. In this paper, we explore the potential roles of GIS—as a computational approach—and Virtual Reality—as experiential—to be employed to develop new formal methods to investigating vision and sound in ancient landscapes. Acoustic tools allow us to process sound data from the field to integrate into GIS along with LiDAR and 3D modelling data to perform viewsheds and soundsheds. We create multisensory experiences in VR with spatial sound using an immersive headset (Oculus Rift) and touch controllers (for movement) to experiment with building formal-based narratives about the past. We trace our on-going process to develop formal methods for investigations on the role of the senses in structuring human interaction and experience in ancient landscapes. Through case studies at two UNESCO World Heritage Sites—Chaco Canyon in the U.S. Southwest and Copan in Honduras—we discuss the affordances and challenges of specific digital technologies for multisensory research that allows for new narratives of the past.

Standard session 18:
Immersive Digital Media in Archaeology: Memory, Place and Performance

***Gareth Beale**, University of Glasgow*
***Julian Richards**, Archaeology Data Service University of York*
***Nicole Smith**, University of Glasgow*

Medium Hall A, 14.00 – 17.40, 26 April 2019

The emergence of immersive digital media (including VR, AR and other forms of mixed reality) has created a wealth of new opportunities for archaeological storytelling and data representation. However, immersive media and mixed reality technology remain in a state of rapid flux. Archaeologists are innovating and experimenting with these technologies and archaeological applications of immersive media have been quick to emerge. With a rich history of media innovation and non-digital immersive storytelling archaeology seems uniquely well placed to produce new and exciting immersive media forms. This session will ask:

- How do immersive experiences contribute to our ability to conduct and communicate archaeological research?
- How can archaeological expertise contribute to the innovation and development of rapidly evolving immersive media forms?

The goal of the session is to explore the diversity of immersive media practice within archaeology and to recognise the unique contribution which archaeology is currently making to the development of these media. We invite participants with experience of practical or theoretical research in the use of immersive media to contribute papers to this session. We welcome submissions from those working in areas outside of archaeology including media arts, heritage, human computer interaction, interactive media design, animation and games.

Our intention is to use this session as the basis for a co-authored publication on immersive media in archaeology, heritage and the arts.

14.00 – 14.20
Using immersive acoustics to communicate archaeological narratives: Listening to the Commons and the Voice and Vote Exhibition,
Catriona Cooper, Damian Murphy

14.20 – 14.40
Evoking memory through immersion: the case of the Laocoon cast at Glasgow School of Art,
Stuart Jeffrey, Mark Breslin, Lauren Glasgow, Steve Love, Matthieu Poyade, Damien Smith, Jordan Trench

14.40 – 15.00
'Riddle Mia This' – A Mobile, Augmented Reality, Museum Puzzle Experience,
Samantha Thi Porter, Colin McFadden

15.00 – 15.20
Experience Castlegate: Augmented reality and the possibilities of heritage-led urban regeneration,
Dawn Hadley, Steve Maddock, Nick Bax, Matt Leach

15.20 – 15.40
Digital Archaeoludology,
Cameron Browne, Eric Piette

COFFEE BREAK

16.00 – 16.20
Developing and using immersive experiences at Caistor Roman town,
Will Bowden, Pat Brundell, Natasha Harlow, Adam Martin-Jones, Alex Mullen

16.20 – 16.40
Within the Walls of York Gaol: Immersive media and archaeological storytelling,
Gareth Beale, Nicole Smith, Anthony Masinton

16.40 – 17.00
Lochbuie, a Bronze Age focal point of astronomical knowledge,
Gail Michele Higginbottom, Vincent Mom

17.00 – 17.20
Virtual Avebury: an immersive partnership,
Kate Welham, David Burden, Rosamund Cleal, Elizabeth Falconer, Ralph Hoyte, Phill Phelps, Neil Slawson, Nicola Snashall

17.20 – 17.40
Contextualizing Cultural Heritage with Augmented Reality - The Temple of the Weather God in Aleppo, Syria,
Arie Kai-Browne, Thomas Bremer, Kay Kohlmeyer, Sebastian Plesch, Susanne Brandhorst

Using immersive acoustics to communicate archaeological narratives: Listening to the Commons and the Voice and Vote Exhibition

Catriona Cooper, Damian Murphy

In 1778 women were banned from entering the public galleries of the House of Commons. At the beginning of the 19th century stories begin to emerge of women gathering around a space known as the Ventilator: a small space above the ceiling of the Chamber. This narrative has largely been forgotten or obscured by the suffrage movement of the later 19th and early 20th century but is part of the long history of women and politics. 2018 was the 100-year anniversary of some women in the UK getting the vote and as part of the celebrations UK Parliament hosted a major exhibition, Voice and the Vote, at the Houses of Parliament. The Listening to the Commons project brought together a team of collaborators including archaeologists, historians and acousticians to reconstruct the soundscape of the Ventilator to form part of the exhibition. The exhibition was very successful with over 100,000 visitors over the 3 months it was open. In this paper we will reflect on the methodology we used for recovering the soundscape, the challenges faced integrating this into the exhibition and the success of offering a mixed reality immersive experience. We highlight with the emergence of VR, AR and Mixed Reality for archaeological storytelling taking a multisensory approach can offer different but exciting immersive experiences that can communicate different narratives and offer emotive responses to stories not felt through vision alone.

Evoking memory through immersion: the case of the Laocoon cast at Glasgow School of Art

Stuart Jeffrey, Mark Breslin, Lauren Glasgow, Steve Love, Matthieu Poyade, Damien Smith, Jordan Trench

Immersion is an approach increasingly in demand for visitor and cultural attractions. This can include the use of a wide range of technologies, from large video-mapped in-stallations for wider audiences to Head Mounted Displays for more intimate experienc-es, 360 films, spatialized audio for explorations into Virtual Reality (VR) and Aug-mented Reality (AR) in-site specific contexts. However, there remain a number of ob-stacles to its broader adoption: audience perception, technical constraints, day-to-day operational, investment in technology and the demands of meaningfully integrating rich and complex datasets into the immersive experience. The Glasgow School of Art (GSA) and the digital studio ISOdesign have undertak-en an interdisciplinary pilot project fund-ed by UKs Arts and Humanities Research Council 'Next Generation of Immersive Experiences' funding strand. This paper presents research into immersive representations of place, memory and performance through a prototype interactive

exhibit. As source material, the project has used a plaster cast of a renowned classical statue of Laocoon and his sons which was destroyed in the recent fire at the Glasgow School of Art, and this, now lost, artwork forms the basis the case study which this paper will discuss. We will not only detail the co-design development process of the projects primary outputs, an immersive and interactive AR/VR experience, but also the subsequent evaluation and the first steps towards a preliminary set of guidelines to inform work on future projects.

'Riddle Mia This' – A Mobile, Augmented Reality, Museum Puzzle Experience

Samantha Thi Porter, Colin McFadden

Escape rooms are an increasingly popular form of immersive entertainment in which a group of people are 'locked' in a space and must solve a series of puzzles to accomplish an objective (e.g. escape from jail, solve a mystery, or steal a work of art). In addition to being fun, these experiences are also being leveraged for purposes such as team building and education. Although escape rooms traditionally inhabit relatively confined physical installations, the medium is increasingly integrating new technologies, such as augmented and virtual reality, and being brought into larger spaces. Taking advantage of the popularity of escape rooms and new accessible tools for augmented reality (AR), we collaborated with the Minneapolis Institute of Art to develop 'Riddle Mia This'. The free mobile app uses a combination of AR, a messaging system, and physically placed clues to take visitors on a puzzle adventure through the museum. We will discuss the technical, logistical, and design challenges involved in developing a game for such a large, dynamic institution. These include practical concerns (How will users navigate the space?) as well as more abstract considerations (How do you craft an engaging story that focuses users on the art in the museum and not the technology in their phone?). The project was developed in Unity, and the source code is being made available via Github. We hope our case study can be used as a model for other institutions seeking to create their own immersive experiences

Experience Castlegate: Augmented reality and the possibilities of heritage-led urban regeneration

Dawn Hadley, Steve Maddock, Nick Bax, Matt Leach

This paper reports on a project exploring the use of Augmented Reality to harness community engagement to inform urban regeneration strategies. Its focus is the medieval castle of the northern English city of Sheffield, which has had an enduring legacy for its inhabitants despite being demolished in 1650, and it now lies derelict; both investment and creative energy are required to realise an ambition to regenerate this rundown district. Using the unpublished archives of

excavations of the castle, archaeologists, architects and computer scientists, have collaborated to develop an Augmented Reality app incorporating a 3D model of the medieval castle, and imaginings of how the former presence of the castle could be used to inspire design ideas. Urban regeneration is too often delivered using top-down development models, bearing little relation to local identity. Disengagement from a sense of place can have catastrophic implications for the future of developments, undermining the required generation of footfall through lack of interest in the newly (re-)made place. The app is being used to engage the public with their heritage and to empower local community groups to work with urban planners and local government to demand imaginative regeneration, ultimately ensuring its successful integration into urban living, which will increase the likelihood of economic sustainability. This paper will document the underpinning research on the archaeological archives, the development of the app and its use in collaboration with the city council and community heritage groups, including the successes and the challenges encountered.

Digital Archaeoludology

Cameron Browne, Eric Piette

All humans play and all human cultures have their particular games; games are an important part of our cultural heritage. But while there is much tangible archaeological evidence of ancient games, the rules for how these games were played is typically lost. Our understanding of ancient and early games is incomplete and based on often unreliable interpretations of partial evidence, leaving huge gaps in our knowledge about them. There is a wealth of traditional game studies from historical, anthropological, archaeological, ethnological and cultural perspectives. There is also a wealth of computational game studies, and Game AI is now maturing as a research field in its own right. However, there has been to date little overlap between computational and historical studies of games. The Digital Ludeme Project (http://ludeme.eu), a five-year ERC-funded research project recently launched at Maastricht University, aims to address this gap by: 1) Modelling the full range of traditional games in a single, playable digital database. 2) Reconstructing missing knowledge about traditional games with unprecedented mathematical rigour. 3) Mapping the development of traditional games and explore their role in the development of human culture and the spread of mathematical ideas. This project will produce a "family tree" of the world's traditional games, with which the dispersal of games and related mathematical ideas might be traced throughout recorded history. This will pioneer a new field of study called Digital Archaeoludology (DA) which involves the use of modern computational techniques for the analysis and reconstruction of traditional games from incomplete descriptions, to provide new tools and techniques for improving our understanding of their development.

Developing and using immersive experiences at Caistor Roman town

Will Bowden, Pat Brundell, Natasha Harlow, Adam Martin-Jones, Alex Mullen

This paper will discuss the results of a project to create an immersive VR experience at the site of the Roman town of Venta Icenorum in Norfolk (UK). The project, funded through the Arts and Humanities Research Council's Next Generation of Immersive Technologies scheme and realised in collaboration with Jam Creative Studios, allows visitors to the site to experience a VR version of the Roman forum and interact with individual "Romans" via their mobile devices, while physically moving through real space. The environment and the characters draw directly on a long-term archaeological research project and the experience allows the use to drill down into further layers of information should they wish. Creating the experience provides interpretative challenges, such as recreating an authentic late 3rd-century British Latin for the characters to speak, and the technical challenges of markerless VR that ensures that the real world movement of the user is tracked by the virtual environment on their phone. The project is also conducting detailed evaluation of the user response to the experience to inform future iterations of the experience. The paper will conclude by examining the relationships between archaeological methods, interpretation and the creation of immersive VR, asking whether a more reflexive relationship between archaeological research and VR reconstruction could have deeper impacts on the questions that archaeologists ask and the methodologies that we use to answer them.

Within the Walls of York Gaol: Immersive media and archaeological storytelling

Gareth Beale, Nicole Smith, Anthony Masinton

The Within the Walls of York Gaol Project is a collaboration between York Museums Trust, the University of Glasgow and the University of York to design innovative immersive media installations specifically for a museums context. The project, led by a mixed team of specialists in human computer interaction, archaeology, exhibition design and digital arts, successfully developed innovative digital installations which demonstrated that the museum could be a 'go to' venue to experience experimental and emerging media forms. The success of the WWYG project and its predecessor Viking VR was possible because both projects were rooted in the local creative community. Through a series of networking and hack events associated with the project a diverse community developed and (a) contributed to the WWYG project and (b) used the network as a springboard for new projects and initiatives. Our research demonstrated that by engaging in dynamic and reflexive collaborative design the museum has the capacity to be a catalyst, incubator and venue for regional digital creativity. This presentation will present the

results of the WWYG project for the first time and will examine the impact of collaborative design practice on the development of innovative immersive media experiences for archaeology.

Lochbuie, a Bronze Age focal point of astronomical knowledge

Gail Michele Higginbottom, Vincent Mom

We have been studying the megalithic monuments in western Scotland for a considerable period, and uncovering more and more fascinating landscape and skyscape systems that have been set up by the users of these stones to observe the sky and connect the sky and the land. Our prime approaches are the adaptation or adoption of particular forms of statistical analyses, 2D and 3D GIS and immersion software. In the last years we have focused on the standing stones on Mull. Mull, situated at the west coast of Scotland, harbours about 40 standing stone sites, ranging from single stones to short stone rows and to a full stone circle (Lochbuie) made up of 9 stones. Although exact dating is not available for each site on Mull, the general expectation is that these monuments were erected during the middle to late Bronze Age period. In this presentation we will focus on Lochbuie, the most complex site on the isle. In particular the geometric arrangements of the Lochbuie site constituents (3 separate standing stones, a Neolithic-EBA kerbed cairn, a small stone and a stone circle) as well as the individual components. Through the application of adapted statistical analyses, 2D/3D GIS and immersion models it will be revealed that Lochbuie was a possible hub for a number of significant solar alignments compared with other Bronze Age sites whose focus, in the majority, was the Moon. To illustrate our results we will include a number of astronomical videos of the Lochbuie landscape.

Virtual Avebury: an immersive partnership

Kate Welham, David Burden, Rosamund Cleal, Elizabeth Falconer, Ralph Hoyte, Phill Phelps, Neil Slawson, Nicola Snashall

This paper examines the impact of Virtual Avebury, an AHRC/EPSRC Immersive Partnerships funded project that ran for 9 months in 2018. The research was based around Avebury stone circle in Wiltshire, U.K., the largest known Neolithic stone circle in the world, which forms part of the Stonehenge and Avebury World Heritage Site. Virtual Avebury created a 3D, fully immersive simulation of Avebury Stone Circle (visual simulation in Unity 3D and embed a layered soundscape), as it may have appeared circa 2,300 BCE, and was a partnership between Bournemouth University, the National Trust, virtual reality developers Daden Ltd and soundscape specialists Satsymph. The simulation was evaluated through public engagement at Avebury itself, with over 700 participants taking part, and detailed survey responses from

over 350 people. Here we present the findings from Virtual Avebury with a particular focus on how immersive experiences contribute to our ability to engage different sectors of the public with archaeological research. In particular, we examine data in relation to age and gender, and consider mechanisms to increase and extend the impact of immersive technologies to groups (for example older women) that demonstrated significant reluctance to try Virtual Avebury, but reported significant enjoyment and benefit from the experience when they did. We discuss the reasons for this, as well as exploring how experiencing Virtual Avebury in 2,300 BCE affected the reactions of visitors to physical Avebury in the present day.

Contextualizing Cultural Heritage with Augmented Reality - The Temple of the Weather God in Aleppo, Syria

Arie Kai-Browne, Thomas Bremer, Kay Kohlmeyer, Sebastian Plesch, Susanne Brandhorst

With the increasing interest of major technology companies to incorporate Augmented Reality into mobile consumer devices an entire new market for immersive applications conveying knowledge of cultural heritage is emerging. Since mobile devices are being used throughout all social classes this represents an extraordinary yet challenging opportunity to arouse interest in cultural heritage independent of the educational background. Nonetheless, these technologies also enable researchers a more comprehensive view on complex situations, i.e. archaeological sites with multiple phases and extensive stratigraphic relations, which can be disseminated more easily through the use of Augmented Reality. In the case study of the Temple of the Weather God in Aleppo, Syria, a scaled 3D-print of the central scene, depicting the Weather God, King Taita and two inscribed stelae, is used as basis for an augmented scene of the entire temple. The 3D-model is additionally enriched with textual and visual information regarding the inscriptions, art history as well as the different building phases of the general architecture. This methodological approach can easily be transferred to embedding archaeological artefacts within their spatial context, which is especially valuable for museums where the artefacts are usually displayed detached from their origin. This enables laymen as well as researchers to get a more in depth view of the artefact and its original context, thus offering a valuable tool for knowledge transfer using innovative technology.

Roundtable 19:
Our knowledge is all over the place!

Paul Reilly, University of Southampton
Stephen Stead, Paveprime Ltd & ACRG, Southampton University
John Pouncett, Institute of Archaeology, University of Oxford

Exhibition Room B, 16.00 – 18.40, 26 April 2019

During CAA2018 Huggett et al (2018) issued a grand disciplinary challenge to produce a consensus-based, end-to-end, digital archaeology knowledge map with which to locate evolving archaeological practices without stifling digitally creative disruptive developments. In a hugely complex and expanding knowledgescape, digitally-enabled knowledge maps will give practitioners a better chance to share our collective disciplinary knowledge (both by giving and receiving), while avoiding unnecessary duplication, exposing gaps, and fostering greater resilience in our knowledge sharing practices and knowledge bases. They are intended to digitally enhance questions of the generic form: "what do we already know about ... where does it reside, and how can I gain access to this knowledge/tool/method/ insight/expertise/etc?"

This round-table seeks to seed a pan-archaeology forum to produce a preliminary high-level model of digitally-enabled archaeological knowledge practices (explicit and tacit) and capabilities and begin the process of mapping our assets, resources, communities, best practices, and gaps. Maps are not static entities and can be rendered in many different projections. They are contingent on need. We therefore fully expect a variety of (evolving) mapping approaches. In under 5 minutes each, participants will present a single-slide a map (model) which encapsulates the scope of knowledge practices and capabilities required to operate effectively within their competency/sector (inter alia, commercial unit, GLAM, research organisation, funding agency, government agency, etc). These maps will provide the initial inputs for a discussion aimed at developing a broader (e-2-e) composite model of the digitally enhanced archaeological enterprise that can be taken to the broader CAA community and beyond to be refined and expanded. Our ambition in this session is to provide a framework onto which digital methods and approaches for specific practices in different archaeological contexts can be mapped and then harnessed to support day-to-day work practices and research.

References:

Huggett, J., Reilly, P. and Lock, G., 2018. Whither Digital Archaeological Knowledge? The Challenge of Unstable Futures. *Journal of Computer Applications in Archaeology*, 1(1), pp.42–54

DISCUSSANTS

Our Knowledge is all over the place! - So What?
Paul Reilly, Stephen Stead

A Brasilian Perspective in the Wake of a Knowledge Catastrophe,
Pricilla Ulguim

On the Current Impossibility of Creating Digitally-enabled Knowledge Maps,
Tuna Kalayci

Queering digitally mediated access to archaeological knowledgemaps,
Katherine Cook

Feminist perspective on digital access to Archaeological Knowledgemaps,
Colleen Morgan

A Public Archaeology perspective on digitally mediated access to KnowledgeMap,
Lorna Richardson

People Telling the Stories, the Stories Telling about the People,
Daria Hookk, Nikita Pikov, Vsevolod Bumastrov

Knowledgemaps focussing on excellence and precarity within the academy,
John Pouncett

Korean perspective on digitally mediated knowledgemaps of archaeology,
In-Hwa Choi

Mapping the bibliography of Citânia de Sanfins (Portugal). New methodological approach for a historiographic model
Natália Botica, Sílvia Maciel, Rebeca Blanco-Rotea, Manuela Martins

Other session 20:
Recent Developments in Digital Numismatics – Breaking down barriers

***Ethan Gruber**, American Numismatic Society*
***Karsten Tolle**, University of Frankfurt*
***David Wigg-Wolf**, Römisch-Germanische Kommission (RGK) des Deutschen Archäologischen Instituts*

Seminar Room, 8.40 – 10.40, 25 April 2019

Numismatics has seen significant advances in the digital sphere in recent years. Whereas initially computer applications were mainly restricted to statistical analysis and modelling (e.g. estimating the size of coin issues, or the analysis of coin finds), and recording collections or inventories of coin finds in stand-alone databases, the discipline has very much embraced the manifold possibilities that technical advances in the last decade have offered.

In particular, the nature of coins as mass-produced, serial objects with relatively standardised core data mean that with projects such as nomisma.org numismatics is very much at the forefront of the development of the application of Linked Open Data and the Semantic Web in the Digital Humanities. Other fields which have seen intense activity include the application of 3D-modelling as a means of documenting and presenting coins (the digital replacing the long-standing analogue practice of 3D-documentation with plaster casts), and of image recognition, not just for the automatic identification and classification of individual coins but, for example, also as a means of automatically identifying objects in the fight against the illegal trade in coins (e.g. the FP6 project, COINS: Combat on-line illegal numismatic sales).

The aim of the session is to present examples of recent work and advances in Digital Numismatics. In the past numismatics has often been seen as an isolated discipline with little (interest in) interaction with other fields. Therefore the session will place a particular emphasis on examining how the lessons learned from the various numismatic projects can be applied to other areas of the Digital Humanities, and how Digital Numismatics can be better integrated into the broader field of archaeology as a whole.

The session will take the form of a series of short presentations (c. 5 minutes), followed by a moderated discussion. Presentations are particularly invited from non-numismatic domain experts with a view to also examining what lessons numismatics can learn from the experience of those working in other fields.

8.40 – 8.45
U Eight Years of Nomisma.org: Past, Present, and Future
Ethan Gruber, Sebastian Heath, Andrew Meadows, David Wigg-Wolf

8.45 – 8.50
Recording barbaric psuedo-legends in digital databases
Adam Degler

8.50 – 8.55
British Celtic Coins Online,
Chris Green, Courtney Nimura

8.55 – 9.00
Applying Linked Open Data to non-standardised typologies: the example of Celtic coinages,
David Wigg-Wolf, Karsten Tolle

9.00 – 9.05
Breaking down barriers between detectorists and professionals - the Danish recording scheme for metal detector finds DIME (dime.au.dk),
Andres Dobat

9.10 – 10.40
General Discussion

Eight Years of Nomisma.org: Past, Present, and Future

Ethan Gruber, Sebastian Heath, Andrew Meadows, David Wigg-Wolf

Nomisma.org is an international collaboration to define the intellectual concepts of numismatics following the principles of Linked Open Data (LOD). Established in 2010 as a proof of concept, the project has grown considerably since then. While technical aspects of the project have been published at previous CAA conferences, beginning with "Semantic Web Technologies Applied to Numismatic Collections" at CAA 2012 in Southampton, this paper is focused primarily on Nomisma's evolution as a community, without which these technical achievements would not have been possible. Beginning as an informal discussion about numismatic data standards at the British Museum in 2011, the first official European Coin Find Network - Nomisma joint meeting occurred in Frankfurt the following year with 15 participants. The seventh iteration of this meeting was held earlier this year in Valencia, drawing 60 participants working in Greco-Roman, Medieval European, and Islamic numismatics. Likewise, the Nomisma scientific committee has established discipline-specific working groups, enabling the expansion of the scope of the LOD thesaurus into other periods and cultures beyond its Greco-Roman foundation. Similarly, many international numismatic projects have been built on the Nomisma infra-

structure: more than 30 museums and archaeological datasets have contributed data for nearly 200,000 physical specimens to date, a significant enhancement since CAA 2012. This paper will summarize Nomisma's progress since 2010 with an eye on what the future holds for the project.

Recording barbaric psuedo-legends in digital databases

Adam Degler

The aim of the presentation is to propose ways the pseudo-legends on barbaric coins from the 3rd to 4th c. AD can be recorded in the digital databases. These legends were either imitating Roman legends or they played only ornamental role. Diligent record of the pseudo-legends is not only the question of need, but also may help in identifying links between coins and groups of coins. Together with the analysis of portrait types and reverse motives, it should enable us to determine workshops and chronology of the barbaric coinage. I will propose some practical solutions based on my experience in work on pseudo-legends on barbaric coin.

British Celtic Coins Online

Chris Green, Courtney Nimura

The Celtic Coin Index (CCI), housed at the University of Oxford's Institute of Archaeology, contains over 50k paper cards of Iron Age coins from Britain and is the largest collection of British Celtic coins in the world. Since its inception in 1961 it has been digitised in various forms; in 2004 it was absorbed by the Portable Antiquities Scheme which now contains nearly 45k records of Iron Age coins. However, the CCI faces a number of challenges because of its current fragmented state, with records being held both in paper and digitally in a variety of disconnected locations. In this paper we will introduce our current project, which aims to rationalise these separate datasets and create a fully Linked Open Data database of British Celtic Coins Online. We will also discuss this new project in connection to other archaeological databases with which we have been involved (English Landscapes and Identities; European Celtic Art in Context).

Applying Linked Open Data to non-standardised typologies: the example of Celtic coinages

David Wigg-Wolf, Karsten Tolle

Online resources based on the concepts published by Nomisma.org, such as Online Coins of the Roman Empire (OCRE) Hellenistic Royal Coinages (PELLA), have served to prove the enormous potential of Linked Open Data in the field of numismatics. However, these projects are based on typologies for coinages that were mass-produced and standardised, and where unam-

biguous attributions to particular types are very much the norm. The situation with many Celtic coinages is significantly different: often the coinages cannot be divided into clearly distinguishable types, but instead display a gradual, flowing development of iconography with no distinct divisions or breaks. The typologies into which they are arranged by numismatists are by nature very much subjective. Furthermore, there is often more than one commonly used typology for some coinages, with no 1:1 correlations between typologies, but instead complex, interwoven relationships. In this presentation we will inspect how the Nomisma.org project is tackling the difficulties inherent in providing the LOD framework for Celtic coinages. The lessons that we are learning can be applied not only to other fields of numismatics with non-standard typologies, but also to classes of archaeological objects with similar challenges and conflicting typologies.

Breaking down barriers between detectorists and professionals - the Danish recording scheme for metal detector finds DIME (dime.au.dk)

Andres Dobat

Over the last decades, recreational metal detecting practiced by amateur archaeologists has produced some of the most significant discoveries in Denmark, within numismatics and archaeology. In autumn 2018, the DIME (https://www.metaldetektorfund.dk/) portal was officially launched to facilitate the user driven recording of metal detector finds produced by members of the public and to hereby contribute to a solution of the above-mentioned challenges. The concrete and operational aim of DIME is to provide a portal for the registering and hence safeguarding of the increasing number of metal detector finds and to make them accessible for the general public and for research. The more overarching vision behind the DIME project is to realize the potential of recreational metal detecting as a medium to implement an inclusive and democratic approach to heritage management in Denmark and to advance the incorporation of principles of citizen science and crowdsourcing in archaeology. The presentation will focus on the functionality and the underlying vision behind the DIME portal, and how it is anticipated to be used as a digital research infrastructure, in numismatics and archaeology.

Standard session 21: Challenges and opportunities of machine learning in archaeological research

***Alex Brandsen**, Leiden University*
***Iris Kramer**, University of Southampton*
***Wouter Baernd Verschoof-van der Vaart**,*
Faculty of Archaeology / Leiden Centre of Data Science, Leiden University

Exhibition Room A, 8.40 – 12.40, 26 April 2019

For over two decades there have been sporadic presentations of diverse machine learning (ML) applications to digital archaeology at the CAA. In recent years there is a notable increase of papers using ML in archaeology, which may be ascribed to the success of Deep learning and Convolution Neural Networks (CNNs) across various disciplines that were previously described as being too complex for using machine learning. Applications using deep learning now show high performance on challenging tasks ranging from computer vision to natural language processing. In digital archaeology we have seen and foresee applications of these techniques including automated object detection in remote sensing data, artefact image classification, use-wear analysis, text mining, paleography, predictive modeling, 3D shape analysis and recognition, and typology development.

Our aim for this session is to bring together the previously scattered ML research to discuss practical as well as theoretical approaches for ML in digital archaeology.

For practical approaches we would encourage a critical dialogue to identify individual and shared problems, opportunities, and solutions. We invite authors to provide a thorough explanation on their approach and engage on some of the following questions: How do you structure archaeological datasets which are often small, incomplete, and noisy? What considerations applied to your choice of ML technique and how did was this technique tuned to your particular research? Which threshold do you find appropriate to determine the success of your method? What was your desired outcome and how did your final results compare to this? If your outcome resulted in a lot of new data that needs further manual validation, how do you plan to verify this? Do you foresee other applications for your method within archaeology or in other fields?

Our request for theoretical approaches can be more broadly interpreted. Some examples include: creation of annotated benchmark datasets, sharing of developed methods, data (or data structure), and code, data science challenges, conventions for data structure and performance metrics, need for collaboration or special interest groups, insights from ML fields outside of archaeology, ethics of ML in archaeology, education of ML in archaeology, rapid publishing of new ideas, future gazing.

8.40 – 9.00
Introduction
Alex Brandsen, Iris Kramer, Wouter Verschoof-van der Vaart

9.00 – 9.20
Combination of machine learning methods of image and natural language recognition on ancient coin data,
Sebastian Gampe, Karsten Tolle

9.20 – 9.40
Improving the discoverability of zooarchaeological using Natural Language Processing,
Leontien Talboom

9.40 – 10.00
On seriation and clustering of pottery deposits: from methodological aspects to predictive modelling,
Danai Kafetzaki, Jeroen Poblome

10.00 – 10.20
From manual mapping to automated detection: developing a large and reliable learning data set for archaeological object detection,
Ralf Hesse, Wouter Baernd Verschoof-van der Vaart

10.20 – 10.40
Developing the Durham University Museum Artefact Collection (DUMAC) for Machine Learning Applications in Cultural Heritage,
Matthew Roberts

COFFEE BREAK

11.00 – 11.20
SkyEye, a machine learning software to detect archaeological structures in LiDAR Dataset,
Nathanaël Le Voguer, Clément Laplaige, Xavier Rodier

11.20 – 11.40
Application of object detection and semantic segmentation in structure-from-motion mappings of historic mining sites,
Wilhelm Hannemann, Jessica N. Meyer

11.40 – 12.00
Use of convolutional networks for archaeological feature detection in geophysical surveys,
Martin Olivier

12.00 – 12.40
General Discussion

Combination of machine learning methods of image and natural language recognition on ancient coin data

Sebastian Gampe, Karsten Tolle

We are currently working to combine two machine learning methods: Image Recognition (IR) based on Convolutional Neural Networks (CNN) and Natural Language Processing (NLP). We already successfully implemented both approaches separately on numismatic data, more precisely on data from Online Coins of the Roman Empire (OCRE) and Corpus Nummorum Thracorum (CNT). Our goals by combining them is to further improve the overall performance (rate of correct results) and also to a) better understand the problems for each single method on these data and b) try to identify inconsistencies (errors) in the existing ground truth data. More precisely: The IR approach is trained to identify the portrait of roman emperors on the obverse side (currently we reach a Top 1 accuracy of 91%). The NLP method uses the coin descriptions entered by humans to locate subjects, objects and verbs. This way we can extract also the depicted person from the already existing description. The results of both methods are compared with the available type descriptions and checked for divergences/errors via transition to Resource Description Framework (RDF). Hence, together with our domain experts we can understand why these divergences happen and either correct the error or use this information for improvement during the retraining of the IR or NLP models. So far, we are working mainly on coins of good quality. The challenge is to apply it also to coin finds with medium or poor quality, where it sometimes is even not easy to define the ground truth for it.

Improving the discoverability of zooarchaeological using Natural Language Processing

Leontien Talboom

The amount of digital archaeological data has grown rapidly in recent years, much of which is textual data contained in unpublished fieldwork reports resulting from contractor-led research, making it harder for users to discover relevant data. This paper will discuss research exploring the use of Natural Language Processing for the discoverability of zooarchaeological data within textual documents. This includes the creation of a Named Entity Recognition (NER) tool using deep neural networks, which has shown promising results. The model outperforms previous classifiers on all evaluated datasets, is fast to train, and suitable for smaller datasets. The importance of data preparation, controlled vocabularies and the involvement of domain experts were important factors for creating a reliable and useful tool. In order to show the utility of automated metadata extraction systems, a search tool and pipeline were developed, allowing

users to search and filter archaeological reports according to animal remains present in these textual documents.

On seriation and clustering of pottery deposits: from methodological aspects to predictive modelling.

Danai Kafetzaki, Jeroen Poblome

Of all archaeological material, pottery provides the most complete dataset for assessing chronological sequences of deposits. Count, weight, functional types, and stratigraphic information can assist as variables to quantitatively infer relative chronology. In recent years, machine learning algorithms have increasingly supplemented archaeological approaches to seriation. In this case study, we present the results of a seriation of Sagalassos Red Slip Ware (25 BCE – 700 CE) datasets, using the Principal Component Analysis algorithm to regenerate the relative time sequence of the deposits. The 9 previously defined chronological phases provide labels for our observations used in the validation of the results. Initially, the unsupervised learning application provides the first component that is used in seriation, as well as additional components that can be used in a multi-dimensional time approach to deal with the complex nature of temporality. We then select components based on factor loadings, so that the new axes convey the diversification of phases. For this lower-dimensional dataset, clustering algorithms are implemented to decide on group membership of the contexts. Finally, we predict and evaluate the estimated relative position of contexts in other SRSW datasets, based on a combination of this data-driven approach and specialist knowledge application. We illustrate every aspect of the developed method using Rstudio and JavaScript, allowing archaeologists to observe and interact with every step of the analysis and incorporate prior information where needed. This paper will thus show how machine learning algorithms and visual analytics can be used to refine and complement traditional archaeological methods.

From manual mapping to automated detection: developing a large and reliable learning data set for archaeological object detection

Ralf Hesse, Wouter Baernd Verschoof-van der Vaart

Machine learning is rapidly gaining importance in the analysis of remotely sensed data and in archaeological prospection in general. Large and reliable learning datasets are a central requirement for machine learning approaches, and the development of these still require manual mapping / tagging of archaeological objects. In Baden-Württemberg (Germany's third-largest federal state; 35,751 km2), full area coverage, ALS-based archaeological prospection has since

2009 resulted in almost one million mapped archaeological objects, including, for example, over 3000 newly discovered barrows and 29,000 charcoal kilns. The resulting dataset presents opportunities to develop large training datasets for archaeological object detection. In this paper, the development process of such a learning dataset, and potential resulting challenges, will be discussed. A workflow will be presented that was developed to not only generate a usable dataset for machine learning, but also to incorporate a qualitative control step. This control step was implemented to rate the archaeological objects to their visual "reliability", and to reduce the number of misinterpretations.

Developing the Durham University Museum Artefact Collection (DUMAC) for Machine Learning Applications in Cultural Heritage

Matthew Roberts

In this session we will discuss the creation of a dataset developed from a pre-existing museum digital archive, used to support research into machine learning and computer vision applications in cultural heritage and collections management. The dataset is drawn from the Durham University Oriental Museum's archive of Egyptian and Asiatic artefacts, and is organized into six broad classes (spanning human figurines, animal figurines, and vessels) based on regional provenance, homogeneous structure and stylistic motifs. Using this data we have experimented with the use of neural network transfer learning for single-label, multi-class classification problems related to museum collections, and will discuss the challenges in adapting museum digital records to the purposes of machine learning. This includes topics such as negotiating the initial acquisition, organizing and labelling the data, testing and revising the dataset, and methods for representing or providing narrative to our results. We also consider the choice of software architecture based on factors such as open-source availability and wide-spread adoption or support within the machine learning community. Finally, we conclude with a discussion of how this type of computer vision research has immediate relevancy to the goals and purposes of cultural heritage, and suggestions for those seeking to create similar collection datasets.

SkyEye, a machine learning software to detect archaeological structures in LiDAR Dataset.

Nathanaël Le Voguer, Clément Laplaige, Xavier Rodier

The goal of this paper is to present the first results produced by the SkyEye software, developed by the Laboratoire d'Informatique Fondamentale et Appliquée (University of Tours), in collaboration with the Laboratoire Archéologie et Territoire (CITERES, CNRS/University of Tours) and the SOLiDAR research program. This software, by using images extracted from a DTM

(Digital Terrain Model), aims to automatically detect archaeological structures. The first step is to do a manual research and vectorise some of the structures. Then, we use them to create binary images which are classified by the software and compared to the pixels on the 8 bit DTM image using an SVM (Support Vector Machine) classifier. Afterwards, the software is able to recognize these types of pixels and their neighbours based on their grayscale values (representing altitude differences). It will recognize similar structures on another DTM image by analysing the value of the pixels. For this presentation, we will focus on two examples, firstly with linear structures (embankments) and secondly with point structures (charcoal burning platforms) ; and on two different wooded areas in the Centre region of France. The software was first developed for linear structures, therefore it has a good recognition rate for these remains. The use for discrete structures, more recent, needs to be improved but the results are encouraging. One of the main issues is that the software is extremely dependent on the quality of the data and on the learning datasets in particular. Manual exploration is necessary to build the learning datasets as well as for post-control to confirm results and improve determination rates.

Application of object detection and semantic segmentation in structure-from-motion mappings of historic mining sites

Wilhelm Hannemann, Jessica N. Meyer

One aim of the BMBF-sponsored research project "Altbergbau 3D" is to make inaccessible parts of the World Heritage Site "Rammelsberg" visible and resulting data available for transdisciplinary study and interpretation. Structure-from-Motion (SfM) photogrammetry has been used for the archaeological documentation of various historic mining sites over the past years due to its applicability in rough, spatially confined spaces. This method results in high-resolution 3D models as well as a set of several thousand photos with known 3D orientation. This paper shows the application of deep-learning methods for automated object detection and semantic segmentation in 3D scenes of a mining environment. The huge amount of photos allows the application of 2D image-based methods in order to extract relevant and non-relevant information. A transfer into 3D is done by using the orientation parameters from SfM. Two different machine learning tools will be presented: One network, trained on a set of specific mining-related objects like rock bolts and boreholes, is used to identify those objects at the full extent of the site and compute their approximate 3D position. This allows a quick determination of the spatial distribution for further interpretation. Another network is trained on a small set of manually segmented photos, where specific unwanted parts like chain link fabric are labelled on a pixel level. The trained network is applied to the full set of photos. Labelled parts can be

masked during the computation of a dense 3D point cloud with the aim of getting a less obstructed view of the walls.

Use of convolutional networks for archaeological feature detection in geophysical surveys

Martin Olivier

In this paper, we will introduce the use of convolutional neural networks for feature detection in magnetostatic archaeological surveys. They consist of a small dataset of a hundred of high resolution geomagnetic surveys undertaken both in France (Briquetage de la Seille project, Lorraine, National Museum Of Archaeology, Saint-Germain-en-Laye) and in Britain (Departement of Archaelogy, University of Oxford). Using a simple network architecture, we first constructed a classifier which detects archaeological targets in segmented (96x96px) images, and obtain a 85% percent accuracy with a relatively short training time on consumer grade GPU. We have then introduced the use of YOLO (You Only Look Once, Redmon et al. 2018), a fast and novel object detection technique on the same dataset. YOLO allowed us to not only detect archaeological targets in the entire image, but to also draw accurate bounding boxes around them, providing us with reliable information about the number of objects within the survey and their size. Using YOLO, we obtained a high accuracy on the classes of objects detected (about 95%), although the accuracy was lower about position and size of the boxes. We conclude by providing further pathes to improve the system and we evaluate the relevance of Deep Learning in object in object in remote sensing data.

Standard session 22:
Digital Infrastructures for Archaeology: Past, Present and Future directions

Julian Richards, Archaeology Data Service University of York
Holly Wright, Archaeology Data Service University of York
Franco Niccolucci, PIN

Medium Hall B, 10.20 – 17.00, 24 April 2019

This session invites papers reflecting on the direction of development for research infrastructures in archaeology at the project, local, regional, national or international level. The successful completion in 2017 of the first phase of ARIADNE, an EC Infrastructures-funded project spanning 23 partners in 18 European countries, produced a greater understanding of how large-scale infrastructures can contribute to the development of archaeological knowledge (www.ariadne-infrastructure.eu). This spanned a variety of deliverables, and featured the ARIADNE Portal (portal.ariadne-infrastructure.eu). It also resulted in a better understanding of how project-based, local, regional and national infrastructures can work together to support and strengthen their own internal efforts, and participate in cross-border initiatives. The lessons learned within ARIADNE have informed the structure of the next phase of the ARIADNE infrastructure (ARIADNEplus), which will focus on broadening participation across Europe, and understanding best-practice worldwide. This session will be an opportunity to reflect on the results of the first phase of the ARIADNE project, to provide context with contributions from local, regional, national, or project-based infrastructures to discuss ongoing challenges, accomplishments, and wishes for the future. It will introduce the next phase of ARIADNE, and create a forum for ongoing discussion of the role, and direction of development of archaeological infrastructures in coming years.

10.20 – 10.40
Introduction

10.40 – 11.00
Where is the data?
Ulf Jakobsson

11.00 – 11.20
My data manager is a robot!
Valentijn Gilissen, Hella Hollander

11.20 – 11.40
The ARIADNE project at INRAP: inception, implementation and future,
Kai Salas Rossenbach, Amala Marx,

11.40 – 12.00
OpenArchaeo: an application to query archaeological data via CIDOC CRM,
Olivier Marlet, Xavier Rodier, Thomas Francart, Béatrice Markhoff

12.00 – 12.20
Czech archaeology in the Digital Environment – Digitizing Archaeological Agenda in Theory and Practice,
Jan Hasil, David Novák

12.20 – 12.40
ZBIVA web application,
Benjamin Stular

LUNCH BREAK

14.00 – 14.20
Archaeological Map of Bulgaria in ARIADNE and ARIADNEplus,
Georgi Nekhrizov, Nadezhda Kecheva

14.20 – 14.40
'A puzzle in 4D': using semantic technologies for the integration of resources from a long-term excavation project,
Edeltraud Aspoeck, Gerald Hiebel

14.40 – 15.00
The Swedish Digital Archaeological Workflow in Action,
Marcus J. Smith

15.00 – 15.20
The ADED project - a Norwegian infrastructure for excavation data,
Christian Emil Smith Ore, Espen Uleberg, Jakob Kile-Vesik

15.20 – 15. 40
Ísleif: a network-based approach to site survey,
Adolf Fridriksson, Gisli Palsson

COFFEE BREAK

16.00 – 16.20
ARIADNEplus for public/community archaeology,
Andres Dobat

16.20 – 16.40
CENIEH: A relevant source of digital paleoanthropological datasets for ARIADNEplus,
Mohamed Sahnouni, Maria Isabel Sarro Moreno, Cecilia Calvo Simal

16.40 – 17.00
Prospects and Potential for the National Digital Repository of Archaeological Site Reports,
Yuichi Takata, Akihiro Kaneda, Miyu Konuma, Sadakatsu Kunitake

Where is the data?

Ulf Jakobsson

When the first archaeological data was deposited to the Swedish National Data Service (SND, www.snd.gu.se/en) in late 2011, we were not prepared at all. Our management system, built for social science survey data, could not handle the new types of metadata that were required to make the archaeological data searchable, findable, and visible in our data catalogue. The management system was partially adapted in late 2012 when data for almost 400 archaeological surveys had been deposited and processed. However, the online catalogue and the search functionality had to be expanded and that took time. In 2013 the ARIADNE project was launched with SND as one of the technical partners. One of our tasks was to help develop and implement the services for the ARIADNE portal. Technical knowledge acquired during the project meant that the search system and the catalogue at SND could be developed to a basic level so that the archaeological data finally could be found and accessed. SND's new portal search engine based on the same technology as ARIADNE's portal, has been operative since early 2017, with new filters, map search, and a lot more. The ARIADNEplus project starting in 2019 will provide for further services, tools and a better catalogue. As a technical partner, we are looking forward to implement some of these as well… This presentation will show that the exchange of technical knowledge between project partners in international and national collaborations has the potential to raise the quality and service level in research infrastructures.

My data manager is a robot!

Valentijn Gilissen, Hella Hollander

For over 10 years, data managers at DANS have improved the FAIR quality of datasets from archaeology submitted to the DANS EASY self-deposit archive. The archiving workflow traditionally comprised manual processing of individual datasets, which can be a time-consuming task. As the volumes of data we receive increase over time, there is a growing need for supporting ingesting and validating large quantities of datasets. Workflows are becoming more reliant on machine to machine API's such as SWORD protocols. One way to deal with this issue is to ensure that the datasets are already managed for accessibility and interoperability by the data creator, eliminating the need for post-ingest processing. Workflows are established with data providers wherein the provider commits to the creation of FAIR data, guided by the data managers or systems. Experiences, guidelines and tools from participation in international projects PARTHENOS and ARIADNE are foundations of new dynamics wherein large volumes of archaeological datasets are processed. We will share our experiences with the legacy of project participation to the benefit of working towards dataset processing on an increasing larger scale. Three use-cases are presented: -The SWORD-ingest of Dutch archaeological datasets by the

network of governmental depots into the central DANS hub. -Mass migrations and transformations of archived data to new standards. -The promotion and integration of local data from the Portable Antiquities of the Netherlands (PAN) in an international network, making use of thesauri, data mining and Linked Open-Data techniques.

The ARIADNE project at INRAP: inception, implementation and future

Kai Salas Rossenbach, Amala Marx

INRAP, the French National Institute for Preventive Archaeological Research, was created in 2002 by a French Law that constitutes the application of the European Convention on the Protection of the Archaeological Heritage of Valletta (Malta). The institute ensures the detection and study of the archaeological heritage affected by development and infrastructural works. It coordinates and disseminates information to the scientific community and promotes archaeological heritage through public outreach and education programs. Six years ago, INRAP integrated the ARIADNE project partnership with all the questionings that can be raised in a national institute with a massive fieldwork activity, many data and a start of discussions and actions leaded by the digital transformation. Aware of the quantity and disparity of the digital data created from excavation since 15 years, our institute had difficulties to progress on the subject of their management. The reasons was not a lack of internal qualification or idea but essentially because of legal issues and the commercial positioning of a public institute for preventive archaeology in a competitive context. The ARIADNE project was the opportunity to progress quickly methodologically, technically and philosophically on this subject taking into account an European context overcoming certain national issues. We will present in this paper what was the inputs of the ARIADNE project for our institute and what are the prospects within ARIADNEplus.

OpenArchaeo: an application to query archaeological data via CIDOC CRM

Olivier Marlet, Xavier Rodier, Thomas Francart, Béatrice Markhoff

MASA (Memory of Archaeological Sites and Archaeologists) is a French consortium of the Very Large Research Infrastructure Huma-Num and brings together several archaeological research teams at the national level. The interoperability of archaeological databases has been a priority issue for the MASA Consortium since its beginnings in 2012. The consortium has thus made French archaeologists aware of the need to make archaeological data openly available online and to use as a common semantic structure the CIDOC CRM, an ontology dedicated to the cultural heritage, with some of its extensions more specifically dedicated to archaeology. In addition to the implementation of good practice guides for matching vocabularies with standardized thesauri (PACTOLS), significant work has been done to make various databases interoperable by mapping them with CIDOC CRM. The exposure and exploitation of these databases then

necessarily requires the establishment of a triplestore. While there are not many archaeological data triplestores, their interrogation by a SPARQL endpoint is not enough user-friendly to prompt our colleagues to work towards the interoperability of their data. In addition to the implementation of a MASA triplestore, the Consortium also aimed to provide an interface specifically designed for archaeologists to query several datasets in an intuitive way. This interface, called OpenArchaeo, allows to query both the MASA triplestore and other sources of archaeological data mapped with the CIDOC CRM. As MASA data is itself mapped to CIDOC CRM, the MASA triplestore can also be used by other interfaces such as the ARIADNE portal.

Czech archaeology in the Digital Environment – Digitizing Archaeological Agenda in Theory and Practice

Jan Hasil, David Novák

In the last years, Czech archaeology took several important steps in the process of digitizing its agenda. Following previous projects (including ARIADNE), in 2016, the Archaeological Information System of the Czech Republic (AIS CR; http://www.aiscr.cz/en/) was built as a national solution for research management, data gathering, curation and presentation. Since 2017, its main part – the Archaeological Map of the Czech Republic (AMCR) – is in operation and it already covers fieldwork activities of more than 100 licensed archaeological organisations. The paper summarises our approaches and practical solutions, with focus at the possibilities of infrastructures integration on the national and European level. The importance of archaeological theory and its connection to the practice will be stressed as a key to make infrastructures suitable for researchers. With the upcoming ARIADNEplus project, the role of national-wide infrastructures in the process of facilitating international research will be discussed.

ZBIVA web application

Benjamin Stular

Zbiva database is an archaeological database for eastern Alps and its surrounding regions in the early Middle Ages and has been actively developed since 1987. It consists of three parts: • archaeological sites • graves • artefacts. The initial v1 was a closed system based on a single PC. The v2 was designed in year 2000 in order to facilitate the transition to the web. The current v3 is a web mapping application (http://zbiva.zrc-sazu.si). The content is searchable using full text (Elasticsearch) or structured search (SQL) and map-based search. Zbiva is available in three languages, Slovenian, English and German. However, the free text descriptions are available only in Slovenian and the English speaking users are encouraged to use an online translation of choice. Being a part of ARIADNE helped us move the development of v3 forward within our own institution. Seeing the ARIADNE as a community rather than just a project was useful

both for sharing expertise and providing leverage to improve our internal infrastructure. As an example, the results of ARIADNE's "Users' needs" analysis encouraged us to shift the design from being attractive to the widest possible audience – as it is the case in majority of similar web applications – to being the best possible tool for a highly motivated researcher. And what a difference that makes!

Archaeological Map of Bulgaria in ARIADNE and ARIADNEplus

Georgi Nekhrizov, Nadezhda Kecheva

"Archaeological map of Bulgaria" is a legally established national archaeological information system containing collected data for archaeological sites on the territory of Bulgaria. Different types of standardisation have always played a leading role in the information system. ARIADNE project gave a lot of opportunities. Some of these included mapping the data to a standardised vocabulary and the metadata to a standardised reference model, translation in English, accessibility of legacy data, spatial location of archaeological sites, dataset publication and availability at an international level, overcoming fragmentation and isolation. Problems encountered and ontological mapping are also discussed. ARIADNEplus gives more possibilities to focus in details on 3D visualisation of artefacts and archaeological sites.

'A puzzle in 4D': using semantic technologies for the integration of resources from a long-term excavation project

Edeltraud Aspoeck, Gerald Hiebel

The aim of the 'A puzzle in 4D' project is to prepare the digital and non-digital records from the Austrian long-term excavation project at Tell el-Daba (TD) in Egypt for long-term archiving and open-access online publication. Excavations at Tell el-Daba (TD) took place since 1966, revealing evidence from a society with far-reaching contacts across the eastern Mediterranean (12th to 18th dynasties, i.e. early second millennium BC). Because of the long period of excavations, during which developments in information technology led to a change from analogue to born-digital recording and excavation methodologies evolved, the TD archive contains a huge and heterogeneous resource of digital and non-digital photographs, plans, drawings and written documentation. These resources are prepared for long-term preservation. In this presentation, we will talk about the approach we are taking to data integration. We use the CIDOC CRM ontology with extensions as a reference model to structure our data and apply semantic web technologies to perform the actual integration of the data. This approach has been influenced by the ARIADNE infrastructure project. We will also present the technology stack developed for preservation and publication of this resource, comprising digital asset management system (repository), semantic mapping tool, triple store, and a python/Django based integrative web

application, that also has the potential to enable access to the data through a map interface based on Web GIS technologies.

The Swedish Digital Archaeological Workflow in Action

Marcus J. Smith

At CAA 2014 in Paris, the author presented a paper outlining a programme of work being carried out at the Swedish National Heritage Board. The programme, named Digital Archaeological Workflow (DAP), was to run for five years and aimed firstly to streamline the flow of archaeological data between different actors in the Swedish archaeological process, and secondly to ensure that this data was preserved and made accessible. DAP was intended to to address a series of problems of accessibility and siloed data which had hampered Swedish archaeology for a number of years. By 2019, the DAP programme will have run its course, and the new platform will have been deployed. This includes new national monuments and fieldwork registers, a digital repository for data and reports, and adminsitrative interfaces for local government agencies and fieldwork units. The DAP programme was ambitious, and not all of its ambitions have been fulfilled. This paper will compare the initial goals for DAP as outlined in the author's 2014 paper with the reality of the finished platform. Firstly, an overview of the new digital platform and its concomitant workflow will be presented. The paper will then examine some of the programme's original goals which were not realised, as well as presenting new elements not present in the project's early stages. The paper will conclude by examining the programme's reception among stakeholders in Swedish archaeology, as well as some of the lessons learned during its execution and plans for future development.

The ADED project - a Norwegian infrastructure for excavation data

Christian-Emil Smith Ore, Espen Uleberg, Jakob Kile-Vesik

In archeology, a major issue the last 10-15 years has been to rescue, preserve and give access to the data sets from archeological excavations. The EU infrastructure projects, ARIADNE and now ARIADNE Plus are a driving force in this work. Still there is a huge number of data sets, which has been definitely lost or is not accessible or reusable. For the available datasets there are only weak links between the excavation and the data sets on the one hand and the museum collections (find repositories), site and monument registries and publications on the other. To strengthen the FAIRness (https://libereurope.eu/wp-content/uploads/2017/12/LIBER-FAIR-Data.pdf) of the datasets such links have to be strengthened or at least established. In Norway a new infrastructure project, ADED (Archaeological Digital Excavation Documentation) was launched in 2018 with the objective to create a repository for data sets and establish the aforementioned links. The outcome will be an integrated part of the MUSIT system,

a collaboration between the University Museums. In this infrastructure, the CIDOC-CRM suite will be applied as semantic glue to facilitate cross-project queries based on geography and metadata as well as linking Norwegian excavation data with archaeological information from other countries in Ariadne. So far, most archaeological excavation in Norway have been conducted by the university museums, but in the coming years the counties will conduct more surveys and smaller excavations. Therefore the ADED will include the data flow from fieldwork to permanent repositories at the museums and Riksantikvaren (the site and monument register Askeladden).

Ísleif: a network-based approach to site survey

Adolf Fridriksson, Gisli Palsson

Ariadne did much to establish an infrastructure for archaeological data across the continent. The magnitude of the task can clearly be seen from the extensions to CIDOC-CRM developed to form the so-called Ariadne Reference Model (ARM). Building connectivity beyond excavation datasets requires thoughtful design and implementation of ontologies of the kind ARM provides. This paper presents the emerging use of the ARM to build connections between archaeological and historical data by Fornleifastofnun Íslands, a newcomer to the Ariadne community. The presentation explores the steps necessary to build archaeo-historical connectivity using a mixture of current historical understandings of social formation, archaeological surveys, and spatial analysis. The result is a contextualization of Icelandic site survey data using a network approach based on historically documented intersite relationships. The presentation ends by showing examples of research made possible by historical network approaches to archaeological data, and why Iceland is a highly suitable country for case studies of this kind.

ARIADNEplus for public/community archaeology

Andres Dobat

The presentation will provide a first outline of the plans for the ARIADEplus subproject (Task 18.5 – ARIADNEplus for public/community archaeology). The aim of the task is to pave the way for an inclusion of members of the general public making archaeological discoveries and to demonstrate the added value of ARIADNEplus for non-professional archaeologists. This will be achieved through the incorporation of principles of citizen science and crowd-sourcing. In particular, the task will develop the integration of metal detector finds in the ARIADNEplus infrastructure by facilitating the harvesting of data from the different national user driven recording schemes, which already cooperate under the umbrella of the European Public Finds Recording Network: DIME (DK), MEDEA (Flanders), PAS (England and Wales), PAN (The Netherlands), SuALT (Finland). These schemes all aim at the inclusion of archaeological ob-

jects found by members of the public in the archaeological record and at making them publicly assessable for researchers and the general public alike. Being to some extent based on user contribution, their development over the past decades is closely linked with more general tendencies towards inclusive approaches in heritage management and the paradigm of digital humanities. The presentation will focus on the functionality and the underlying vision behind the newly launched Danish recording scheme for metal detector finds DIME (https://www.metaldetektorfund.dk/) and related initiatives in Europe, and how we envision the integration of the different schemes within ARIADNEplus. Project partners are: o MEDEA (Pieterjan Deckers) o PAS (Michael Lewis) o PAN (Stijn Heeren) o SuALT (Suzie Thomas & Anna Wessman) o DIME (Andres Dobat & Peter Jensen). The presentation will provide a first outline of the plans for the ARIADEplus subproject (Task 18.5 – ARIADNEplus for public/community archaeology). The aim of the task is to pave the way for an inclusion of members of the general public making archaeological discoveries and to demonstrate the added value of ARIADNEplus for non-professional archaeologists. This will be achieved through the incorporation of principles of citizen science and crowd-sourcing. In particular, the task will develop the integration of metal detector finds in the ARIADNEplus infrastructure by facilitating the harvesting of data from the different national user driven recording schemes, which already cooperate under the umbrella of the European Public Finds Recording Network: DIME (DK), MEDEA (Flanders), PAS (England and Wales), PAN (The Netherlands), SuALT (Finland). These schemes all aim at the inclusion of archaeological objects found by members of the public in the archaeological record and at making them publicly assessable for researchers and the general public alike. Being to some extent based on user contribution, their development over the past decades is closely linked with more general tendencies towards inclusive approaches in heritage management and the paradigm of digital humanities. The presentation will focus on the functionality and the underlying vision behind the newly launched Danish recording scheme for metal detector finds DIME (https://www.metaldetektorfund.dk/) and related initiatives in Europe, and how we envision the integration of the different schemes within ARIADNEplus. Project partners are: o MEDEA (Pieterjan Deckers) o PAS (Michael Lewis) o PAN (Stijn Heeren) o SuALT (Suzie Thomas & Anna Wessman) o DIME (Andres Dobat & Peter Jensen).

CENIEH: A relevant source of digital paleoanthropological datasets for ARIADNEplus

Mohamed Sahnouni, Maria Isabel Sarro Moreno, Cecilia Calvo Simal

CENIEH is an acronym for National Research Center on Human Evolution, based in Burgos, Spain. Its mission is twofold: 1) Conducting world-class multidisciplinary research in Paleoanthropology and Quaternary Sciences, focusing on human biological and cultural evolution worldwide; and 2) Providing services to the field of Social and Quaternary Sciences, as well as to the technological and Industrial communities at large. The research is carried out through

three main programs: Geology and Geochronology; Hominid Paleobiology, and Archaeology. To fulfill its mission, the center is equipped with State-of-the-Art laboratories, including: Digital Mapping and remote sensing, sediment analysis, Archaeomagnetism, Cosmogenic, U-Series, Luminescence, Electron Spin Resonance (ESR), Archaeometry, Microscopy, Micro-Computed Tomography, Experimental Archaeology, Use-wear, referential and archaeological lithic collections, and hominid and animal fossil bone collections. As part of ARIADNEplus digital infrastructure, CENIEH has the potential of providing a full range of datasets in Paleoanthropology generated through its research. As examples, these include in situ Gamma dose spectrometry measurement pertaining to ESR and Luminescence dating, data generated from automated analysis of sediment and rock cores such as magnetic susceptibility and quantified color of sediments, micro-computed tomography data, and 3-D scan images and datasets of lithic and fossil bone collections. Thus, as an ARIADNEplus partner, CENIEH will enhance the European digital archaeological infrastructure with valuable paleoanthropological and geochronological datasets covering the prehistoric periods, as well as disciplines and regions that were lacking datasets in the previous ARIADNE.

Prospects and Potential for the National Digital Repository of Archaeological Site Reports

Yuichi Takata, Akihiro Kaneda, Miyu Konuma, Sadakatsu Kunitake

This presentation will introduce the “Japan Cultural Heritage Search”(JCH). The JCH is an electronic online searchable archive which aims to hold every report on excavation or survey of archaeological sites in Japan. Previously, despite their high value as academic resources, such reports (often called 'Gray Literature') have been distributed within a quite restricted range and are rather difficult for public readers to use. Accordingly, by publishing them on the Internet, the Nara National Research Institute for Cultural Properties (NNRICP) aims to create a digital environment easily and readily available to anyone who wishes to use the database for research and study. In our presentation we will discuss the massive public interest in the reports since they have been put online JCH enables the search of cultural property reports published by municipalities and institutions nationwide as well as browsing full-text PDF files. It includes a function to visualize data utilizing natural language processing. The database is operated by NNRICP. We collaborate with 864 organizations including universities and local governments to promote electronic disclosure of reports. Currently, the Agency for Cultural Affairs in Japan is in the process of coordinating the registration of reports as an administrative task of cultural properties. We are working on creating a mechanism whereby the issuing organization registers reports. These activities also aim to interconnect with international portals such as ARIADNE to realize cross research, and therefore language becomes a key constraint on encouraging usage outside Japan.

Other session 23:
Taking your GIS onto the field. "How"-s and "Why"-s of future survey

***Nazarij Buławka**, Institute of Archaeology, University of Warsaw*
***Stefano Campana**, University of Cambirige*
***Julia Chyla**, Antiquity of Southeastern Europe Research Centre University of Warsaw*

Medium Hall B, 8.55 – 15.00, 25 April 2019

Have you ever wondered if it is possible to create field documentation using only your mobile phone? Can you imagine that you have just one tool to measure coordinates, take photos, create 3D models, plan your drone path and fill in the artefact database? Well, it seems that we are on the edge of a technological revolution: in the next few years, we are going to face a breakthrough in the GNSS technologies.

In April 2018, India successfully launched its eighth satellite (IRNSS-1I), Galileo should have reached its full capability soon. The first GPS 3 satellite will be sent to the orbit. This next generation satellite is thought to introduce a fourth GPS signal (L1C). As David A. Turner – Deputy Director Office of OES/SAT - has pointed out, one of the key topics discussed in the modernization of GPS is to "encourage compatibility and interoperability among global and regional systems". There is already a response to this in the smartphone industry as well: The BCM4775X is stated to be the first GNSS chip designed for smartphones to provide dual L1 and L5 frequency. Moreover, Android 7 OS has been equipped with tools to measure the carrier phase, which is a major ingredient in differential GPS. This capability is not available in every type of smartphone yet, but it is possible that future non-professional hardware could have better performance in GNSS.

We are facing changes in the professional hardware as well, as the current operating system used for most PDAs is being withdrawn from the market and replaced by others. GPS signals are going to change from codeless into a modernized civil-coded transmission, which is not going to be usable by all equipment currently used by archaeologists. A new era of modernized GNSS is approaching. We can face it when it is there in the 2020s or we can start preparing for it now. This is the question behind this session in which we will discuss both technical and methodological problems of field surveys which exists today and might occur tomorrow.

This session will consist of short (10-15 minute) case-study papers (10-15 minutes) and a longer, final discussion, in which we would like presenters to address the issue from their research point of view. The main goal of the session is to engage in a broad discussion on this topic involving international experts with the aim of establishing standards and guidelines that

may serve as "good practice" for Mobile GIS usage in archaeology. By "good practice" we aim to discuss topics such as:

- Why is Mobile GIS necessary for archaeology?
- What can be studied via Mobile GIS and how?
- What types of efficient workflows exist for data collection of sites and other landscape elements?
- How best to use mobile GIS on different geographic scales of details: Intra-site and off-site?
- What can archaeologists expect from Mobile GIS' cooperation with other tools, such as geodetic equipment, drones, and sensors?
- What is the ground truth of the collected data (precision, accuracy, and quality of crowdsourcing) and what is needed for the collection of archaeological datasets?
- Security of the archaeological data while using Mobile GIS applications (data loss and theft; access to data by the public; sharing of data);
- The problem of crowd data collection: how to check the quality of the collected data?

After discussing these questions through case studies and arguments we have to answer one last question: What is impeding the use of mobile GIS within archaeological community?

8.55 - 9.00
Opening

9.00 - 9.20
QField and the future of QGIS on mobile devices,
Marco Bernasocchi

9.20 - 9.40
Quantifying and objectifying archaeological survey data : the Archeotracker android app,
F. Hautefeuille, N. Poirier, E. Hautefeuille

9.40 – 10.00
Intensifying extensive survey: a digital workflow for rapidly assessing ancient settlements across large geographical areas 1,
A.Green, A. Alam, L. Green, A. Ranjan, R. Nath Singh, C. Petrie

10.00 – 10.20
Approaching Neolithic and Early Bronze Age "flint-scapes" in Orońsko Commune (Poland) through Mobile GIS,
S. Buławka, K. Kerneder-Gubała, N. Buławka

10.20 – 10.40
Mobile GIS application for field prospection. Case study of archaeological sites in Huarmey Valley, Peru,
J.M. Chyla

COFFEE BREAK

11.00 – 11.20
Enough paperforms - a web and a mobile app for GIS-based field surveys in Bulgaria,
N. Kecheva, T. Branzov, L. Nedyalkov

11.20 – 11.40
Taking not only your GIS onto the field: how to merge our individual documentation types into one archaeological knowledge system,
E. Schönenberger, K. Kruse, P. Wiemann

11.40 – 12.00
Seven years of FAIMS Mobile: Strategies for field recording infrastructures,
S.A. Ross

12.00 – 12.20
Barriers to the Adoption of Digital Systems in Field Research,
A. Sobotkova, S.A. Ross

12.20 – 12.40
Mobile GIS in the field: what people asked for and what they used, a retrospective on seven years of FAIMS,
B. Ballsun-Stanton, A. Sobotkova

LUNCH BREAK

14.00 – 14.20
The Present and the Future of Field-Surveys: are we aware of the digital limitations?
P. Janouchova, A. Sobotkova

14.20 – 14.30
Placing Mobile GIS in the archaeological field survey,
N. Buławka, J.M.Chyla

14.30 – 14.40
Opening the discussion
S. Campana

14.40 – 15.00
Discussion

QField and the future of QGIS on mobile devices

Marco Bernasocchi

Abstract, QGIS is efficient and comfortable in everyday office life. However, data collection often begins on the field. Whether in shiver or sunshine, working outdoors requires a solution that is optimized for mobile devices. QField [1] is the perfect companion of QGIS. The off-the-shelf application allows intuitive viewing and editing of data. With a slick user interface, QField allows using QGIS projects on tablets. QField's map display is powered by the QGIS rendering engine, so the results are identical and come with the full range of styling possibilities available on the desktop. Editing forms on QField respect the QGIS configuration and are adapted for touch interaction. . For situations where network access is unavailable, a QGIS plugin downloads all the data to the device and allows integrating the changes back when returning to the office. Features such as satellite positioning or camera integration make QField a powerful tool for

those who need to edit on the go and would like to avoid standing in the swamp with a laptop or paper charts. For cases where an off-the-shelf solution is not enough, the core components of QField have been extracted into a new framework called QgisQuick. While QField covers the majority of use cases as an off-the-shelf solution, this framework can be used for custom development to meet specific customer requirements and workflows. QField, like QGIS, is an open source project [2]. Everyone is welcome to contribute to make the product even better - whether it is with financial support, enthusiastic programming or visionary ideas. [1] http://www.qfield.org [2] https://github.com/opengisch/QField

Quantifying and objectifying archaeological survey data: the Archeotracker android app

Florent Hautefeuille, Nicolas Poirier, Emile Hautefeuille

The goal of this paper is to show the interest of using a free android application, such as Archeotracker, to optimize pedestrian surveys. Using the phone's GPS allows to systematize the collection of data while improving the overall accuracy of the survey. Archeotracker (googleplay) was developed within the TRACES laboratory (UMR 5608, University of Toulouse, France). Its function is to geotag all the artefacts discovered during pedestrian archaeological surveys. It allows a basic characterization of objects. The registration concerns objects, but also prospectors' paths. In addition, the app allows, through a "master/slave" system, to concentrate all the data of a team on a single phone and to generate a global gpx file directly readable in GIS. This cooperative function also provides a heat map visualization of field data at the end of each surveyed area. The app has been used for 3 years by several programs of the University. Its use offers two categories of benefits. -qualitative: -identification of sites by measuring the relative densities of artifacts in a field -better demarcation of archaeological sites -taking into account "off-site" data to measure anthropogenic pressure on agrarian soils -quantitative: -objectify the prospecting data by taking into account the reality of the artifact concentrations. -accurately measure the survey's conditions (distances between prospectors, collection areas) - measure the individual quality of the prospectors and take into account these disparities in the generated models - allow systematic registration and objective comparisons of data between several parcels of a study area and between several study areas The presentation will be based on examples taken in the context of systematic surveys in the Garonne valley (south-west of France).

Intensifying extensive survey: a digital workflow for rapidly assessing ancient settlements across large geographical areas

Adam Green, Aftab Alam, Lillian Green, Amit Ranjan, Ravindra Nath Singh, Cameron Petrie

Landscape archaeology is data-hungry. Information from hundreds of archaeological sites is needed to address big questions about the location of settlements, their past extents, and how

these variables changes with environmental transformation. This paper will describe a new combination of methods – GPS-enabled tablet-based field data collection and GIS in the field – that were employed to investigate sites across a large area northwest India, where previous archaeological reporting was often out-of-date or incomplete. Northwest India is undergoing rapid agricultural development; a potential threat to many archaeological sites. Faced with these challenges, traditional survey techniques are not enough – new methods for rapidly generating data and reviewing it in the field are essential to uncovering the social dynamics of this unique landscape. Particularly important was a new approach to measuring the size of these sites, many of which were the remains of settlements that were several hectares in size, in a short amount of time. This workflow made it possible to assess past settlement area and the state of preservation at between three and four ancient sites in a single day, dramatically increasing the area that could be investigated in a survey season. As a result, two seasons of fieldwork yielded new, quantitative and comparable archaeological data from 263 archaeological sites, which have the potential to yield new insights into how the Indus Civilization (2600-1900 BC), home to the earliest complex society in South Asia, transformed after climate change appears to have reduced summer rainfall after 2100 BC.

Approaching Neolithic and Early Bronze Age "flint-scapes" in Orońsko Commune (Poland) through Mobile GIS

Sylwia Buławka, Katarzyna Kerneder-Gubała, Nazarij Buławka

The Orońsko Commune is located ca. 100 km south of Warsaw in the Northern Margin of the Holy Cross Mountains in the range of chocolate flint outcrops. The state of research indicates that the region was occupied since the final Paleolithic and is covered by almost three hundreds sites registered in the national field survey program - Archaeological Map of Poland and earlier research. The spatial extent of the sites, their precise chronology, and their function is unknown. Since 2015, a detailed study of spatial organization of stone age communities has been undertaken in the new project ("Exploitation and processing of chocolate flint during Palaeolithic and Mesolithic in the North-Western part of its deposits based on non-invasive archeological and geophysical research and test-trenches". UMO-2015/17/N/HS3/01279 financed by the National Science Center (NCN)). The research showed that Orońsko Commune is a vast landscape with dense scatters of artefacts that are remains of "chocolate" flint mining, its processing and settlement activities of different periods. This "flint-scape" could only be effectively evaluated using efficient survey techniques. This is why, Mobile GIS was the main research tool during field surveys. It enabled to map single artefact distributions and then by studying their dating and function, we were able to indicate the extent of mining, flint processing, and settlement activities.

This paper will present the results of analysis of the Neolithic and Early Bronze Age periods settlement "flint-scape". The main goal of the paper is to reinterpret the archival data on extent of the sites by geostatistical methods focusing on artefact distribution of specific functions.

Mobile GIS application for field prospection. Case study of archaeological sites in Huarmey Valley, Peru

Julia Maria Chyla

During summer 2017, a field survey experiment, whose goal was to test mobile GIS applications was conducted. In order to address problems which occurred and possible solutions, the experiment was repeated during summer 2018 on three, new archaeological sites in Huarmey Valley, Peru. The survey's method was constructed to fit the specifications of a pre-Columbian landscape. The type of data collected in the field was predefined by the author of the presentation. Five students used the mobile GIS application Survey123 to document all artefacts visible on the surface. The field collection of data was conducted in a way that the results were possible to be visualized and analysed as soon as all the data was uploaded into the cloud. The goal of this paper is to present the process of preparing the applications, data collection in the field, results of survey and the presentation of data. The paper is supposed to contribute to the discussion about what and how can be studied via Mobile GIS. On the example of results from the intra-site case study described above, I would like to discuss several questions which appeared during the first experiment such as: is crowd data collection conducted with the help of students a proper way? What were the problems occuring during the collection of archaeological datasets in Huarmey Valley? The paper would also like to reflect upon some questions concerning certain elements of surveys considered as "good practice" in Mobile GIS use in field prospection.

Enough paperforms - a web and a mobile app for GIS-based field surveys in Bulgaria

Nadezhda Kecheva, Todor Branzov, Lyubomir Nedyalkov

Bulgarian archaeologists' long history in conducting systematic intensive field surveys started in 1970s. A major step forward was the establishing of standardised methods for collecting data on the field using mobile GIS devices with GNSS receivers combined with paper forms. Desktop work included filling in attributes in GIS software from these paper forms, a time-consuming process susceptible to mistakes. "Archaeological map of Bulgaria" is a legally established national archaeological information system containing information for archaeological sites on the territory of Bulgaria. It was developed in 1990 as an information system gathering different kinds of site-based data. The most recent, GIS-based, version, being in active development since the end

of 2015, focuses on all types of data gathered through standardised off-site-based field survey methods. The latest system architecture includes redesign of the database into PostGIS, implementation of REST API, development of a web application based on Node.js and OpenLayers. Since 2017 a development of a mobile application for Android and iOS devices has started for facilitation and reliability of standardised data collection on the field helping in a simplified workflow and minimisation of desktop work. The mobile software application is designed specifically according to the process model and the context of terrain research in archaeology. Some, but not all, key points of interest for researchers from both archaeology and CS domain are - the conceptual modelling technics applied in order to describe the process of terrain research; the approach for bundling position and description data; the approach, mechanisms and data structure developed specifically to allow cacheing chunks of data locally on devices which allow autonomous work in places without internet connectivity. Node.js and React Native are used in order to build client-server architecture - advantages that provide this stack are described, also some possible downsides and some UI development decisions are studied. Since both the web and the mobile applications are still in the process of active development and testing, the paper is more focused on their architecture and the change of the conceptual schema of a site-based national archaeological information system to a geographic feature-based and artefact-focused national archaeological geographic information system "Archaeological Map of Bulgaria", a basis for further upgrowth of the system.

Taking not only your GIS onto the field: how to merge our individual documentation types into one archaeological knowledge system

Esther Schönenberger, Kristin Kruse, Philipp Wiemann

Conventional data collection on archaeological sites in departments of archaeology in Switzerland and Liechtenstein happens by photographing, drawing and describing the archaeological features. This data is then checked for quality, inserted into individual databases and linked to related information. Every step is executed by an expert in a specific procedure or software. This ensures good quality of datasets allround. The downsides of this way of handling the data are prolonged waiting times, loss of information and inability to work with complete sets of data. Database and documentation specialists in Switzerland and Liechtenstein now promote a more recent approach to documentation in the field: Future field-data will be integrated into an archaeological knowledge system in the moment of its collection on site. It will be possible to choose between a wide range of documentation techniques from vector based drawing to 3D-photogrammetry depending on the character and complexity of the archaeological findings. This knowledge system will be accessible through both spatial and conventional interfaces

and support analysis of the findings in the database. The process from recording to research needs to be simple, intuitive, on site and fast, supporting GNSS and 5G technologies. Thanks to this reformation of data collection, we get more information and are able to use it sooner and simpler, although this way of restricted crowd data collection will face us with problems of quality control.

Seven years of FAIMS Mobile: Strategies for field recording infrastructures

Shawn Adrian Ross

The nature of research is changing. Driven by the 'reproducibility crisis' and related challenges to research integrity, funders, journals, and other stakeholders are beginning to demand the publication of comprehensive, well provenanced, FAIR ('Findable, Accessible, Interoperable, and Reusable') data. Transparency and reproducibility concerns will require archaeologists to expose their data and processes, rather than simply a finished product. Current ad hoc approaches to field data capture and management will not meet these requirements; without transformation of our knowledge infrastructure, archaeologists will find it increasingly difficult to win grants or publish in top outlets. To meet these challenges, archaeology requires purpose-built, research-specific infrastructure. For such infrastructure to be both fit-for purpose and sustainable in a 'small-science' discipline like ours, it will likely follow four design principles: it will be (1) 'generalised' (but customisable) to allow broad uptake and distribute costs, (2) open-source to improve transparency and allow community control of critical infrastructure, and (3) 'federated', doing one thing well, then interoperating with other tools in a digital archaeology ecosystem. The Field Acquired Information Management Systems (FAIMS) project represents an early (beginning 2012) and innovative example of a platform built according to these principles. FAIMS generates customised, offline-first, GIS-enabled field recording systems with an unparalleled array of research-specific features. Customised for over 50 workflows at more than 30 projects, FAIMS has demonstrated how one can build a platform that caters to the diverse requirement of archaeologists (and researchers in other field disciplines), while also meeting expectations around transparent and reproducible research.

Barriers to the Adoption of Digital Systems in Field Research

Adela Sobotkova, Shawn Ross

This paper reviews the barriers to the adoption of digital tools in the field from the perspective of both a user and an administrator, based on the feedback from over 30 field projects and from 100+ interviews conducted as part of an innovation initiative. Obstacles to the success-

ful adoption of digital field systems (with or without GIS) coalesce around trends outlined by Everett Rogers (2003), such as the lack of expertise, cost of customisation, and the culture of the domain (ie. emergent methods and data in archaeology). The existence of on-site support and willingness to accept the additional complexity of running software systems are critical to the continued use of any platform in the field. Projects that invest the time and resources to the customisation and testing of digital tools before fieldwork, and allocate time and resources to the monitoring of digital data during fieldwork report more happiness with final outcomes, especially data quality and time saving. Investing sufficient time and money in information infrastructure before and during fieldwork is however a feature of early adopters rather than mainstream practice in archaeology. This situation will need to change if archaeologists wish to improve quality of their data, match other social sciences and produce FAIR datasets and transparent workflows. Archaeologists will need to get the right training, invest in and rally around community infrastructure, and overcome other socio-technical barriers around time and priorities to meet the expectations of the emerging open science regime, publish in top journals, and win major grants.

Mobile GIS in the field: what people asked for and what they used, a retrospective on seven years of FAIMS

Brian Ballsun-Stanton, Adela Sobotkova

FAIMS Mobile, the product of Field Acquired Information Management Systems project, based at Macquarie University, Sydney, Australia, (www.fedarch.org) began with extensive community consultation which placed high priority on full-featured mobile GIS capability. We duly built a system with mobile GIS being the single component where most development funds were spent. Six years later, we can ask whether this was money well spent? After ca. 20 deployments of mobile GIS we can say that archaeologists overestimated the amount of GIS they would use during data capture. Basic GIS capability such as automatic synchronisation of multiple devices, loading legacy vector and raster data, saving map settings, connecting to internal or external sensors (GPS, total station), layer management, manual shape creation, editing, and integration with multimedia and structured data comprise the majority of mobile GIS use to date. Other capabilities, such as spatial queries and programmatic creation of geometries (a la Auto-CAD) have never been used in the field. All in all, features that immediately support offline in-field decision-making see the most use. These include visualisation of one's position within study area against various background data, connectivity to external sensors, integration with multimedia and structured data, and prompts and validation that provide immediate feedback and ensure completeness and correct order of in field activities. More complex planning and analytical tasks

remain the prerogative of desktop GIS. This presentation will conclude with the discussion of the planned architecture of next generation mobile-GIS-based archaeological field recording.

The Present and the Future of Field-Surveys: are we aware of the digital limitations?

Petra Janouchova, Adela Sobotkova

FAIMS Mobile, a generalized and customisable OS platform developed by Field Acquired Information Management Systems Project at Macquarie University, Australia, has been customized to fit dozens of survey workflows, most requiring different kind of spatial data capture. This presentation compares two FAIMS modules with different approaches to field-survey. The first module 'TRAP Burial Mounds' serves for point-based documentation and is used for the monitoring of cultural heritage in the Balkans, requiring full manual GIS. The second module, 'TRAP Gridded Survey' serves to record the density of man-made surface material in an distributional approach. While the ideal solution - the creation of mesh representing coverage - was technically possible, the constraints of mobile fieldwork led to the descoping of the spatial in favor of complex structured data collection. Although hardware and software possibilities constantly evolve, field projects with highly complex workflows nonetheless need to prioritize and adapt their field procedures if they want to benefit from a generalized (and more economical) system.

Placing Mobile GIS in the archaeological field survey

Nazarij Buławka, Julia Maria Chyla

In the past, both detailed survey and covering the entire region of study was always "you can't have your cake and eat it". One of the biggest impediments was the possibility to survey both fast and in an accurate way. This situation, however, started to change thanks to improvements of technology for the data collection by Mobile GIS, developments within remote sensing or geophysics. Thanks to that, nowadays many projects tend to find thousands of news sites. Nowadays we can map the archaeological sites and other landscape elements much faster, which influenced the archaeological field prospection. The aim of this introductory paper is to start a discussion on the context of Mobile GIS in current field archaeology. The paper will focus on the changes that happened since the 1990s that affected the quality of field survey.

Standard session 24:
New methods for stratigraphic modeling

Vasiliki Andreaki, Universitat Autònoma de Barcelona
Juan Barceló, Universitat Autonoma de Barcelona

Exhibition Room A, 14.00 – 18.20, 24 April 2019

Various ways have been developed through years showing the necessity to represent visually archaeological stratigraphic sequences. Starting from the classical two-dimensional Harris diagrams to modern three dimensional reconstructions based on photogrammetry and microtopographic data, computers are now the fundamental to process the huge quantity of field data necessary to understand time at the archaeological excavation.

This session has been created to integrate the most recent advances in using computer modelling for data acquisition, processing and presentation of stratigraphic units and sequences. We would like to invite papers presenting different ways to create analytic models of stratigraphic sequences, including:

- data capture and photogrammetry in the field,
- database recording of depositional events,
- extended Harris matrix methods,
- 4D Wheeler diagrams in geoarchaeology
- microtopographic modelling and surface interpolation,
- solid modeling of archaeological excavation
- geomorphology and advanced methods for structural geology
- models of "living floors",
- Directed Acyclic Graphs (DAG) and Bayesian Networks,
- Allen's Algebra and equivalent ontologies for temporal representation,
- Virtual reality systems, teleimmersive systems and cyberarchaeology.
- Ubiquitous computing and portable devices in the field

Especially important is the integration of relative chronology (stratigraphic ordering) and radiometric dates, as modern methods of bayesian chronology ask for stratigraphic data to define boundary events.

We think that stratigraphic modeling, in all its possible incarnations is a domain that needs a new theoretical background to allow the development of new techniques and technologies for understanding the formation processes of archaeological sites.

14.00 – 14.20
Computing Archaeological Stratigraphies. A State-of-the-Art,
Juan Antonio Barceló

14.20 – 14.40
Surface Correlation and the Sequence of Occupational Floors at La Draga, Banyoles (NE Iberia),
Vasiliki Andreaki

14.40 – 15.00
Simultaneous Horizontal and Vertical Stratigraphic Recording Using Daily UAV Flights,
Kristen Jones, Christopher Radford, George Bevan

15.00 – 15.20
The application of 3D density analysis to archaeological data,
Joshua James Emmitt, Sina Masoud-Ansari

15.20 – 15.40
When Harris met Allen in The Matrix: How can the conceptual modelling of stratigraphic relationships facilitate deeper understanding of archaeological space and time?
Keith May, James Stuart Taylor, Steve Roskams

COFFEE BREAK

16.00 – 16.20
Archaeological sequence diagrams, directed graphs and Bayesian chronological models,
Thomas S Dye, Bryony C Moody, Keith May, Caitlin E Buck

16.20 – 16.40
Three-dimensional documentation, reconstruction and visualization of site stratigraphy: A case study of Saruq al-Hadid (Emirate of Dubai, UAE),
Otto Bagi

16.40 – 17.00
Stratigraphy and photogrammetry: the case study of the Basilica Capo Don,
Alessandro Garrisi, Alessio Paonessa, Elia Kas Hanna

17.00 – 17.20
Interactive Visualisation of Stratigraphic Data,
Fabian Riebschlaeger

17.20 – 17.40
Going with the flow - From sediment cores underwater to 3D stratigraphic models in ArcGis to site management,
Niels Bleicher, Tim Wehrle

17.40 – 18.00
Spatial Sequences: The use of 3D GIS for the identification of complex archaeological patterns,
Nicolo' Dell'Unto, Giacomo Landeschi, Andreas Svensson

18.00 – 18.20
Discovering the time of La Draga,
Igor Bogdanović, Vasiliki Andreaki, Joan A. Barceló, Raquel Piqué, Xavier Terradas, Antoni Palomo, Núria Morera, Oriol López

Computing Archaeological Stratigraphies. A State-of-the-Art.

Juan Antonio Barceló

This paper introduces the session on New methods for stratigraphic modeling and surveys current application of computer technology to the recording, visualization and explanation of stratigraphies and the way to build relative chronological methods. We start with advances in classical Harris Matrix methods, their expansion using Allen Algebra and directed graphs, and we give an overview of current methods for integrating stratigraphic and chronometric data for chronostatistical purposes. Based on the limitations of this topological approach we introduce a full metric analysis of archaeological stratigraphy using multidimensional visualization methods of spatial and volumetric interpolation. Although many aspects of 3D/4D models of archaeological layers will be presented, we intend to make more emphasis on explanatory aspects of temporal trajectories as reflected by stratigraphic sequences.

Surface Correlation and the Sequence of Occupational Floors at La Draga, Banyoles (NE Iberia)

Vasiliki Andreaki

The recognition and reconstruction of depositional events in archaeological stratigraphy is one of the main goals of present research at the lacustrine settlement of La Draga on the shoreline of lake Banyoles (NE Iberia). That is directly connected to the definition of stratigraphic boundaries, based on geomorphological data acquisition. The three main excavated sectors represent different preservation conditions directly related to the water level. Their stratigraphic correlation through surface interpolation results in the reconstruction of occupation floors throughout the entire settlement. The digitalization of surfaces and their geometrical characteristics is possible through borehole data corresponding to depth information retrieved from the stratigraphic sections and/or additional cores. This information is visualized in the form of three-dimensional columns, were depositional units are separated by unconformities, defining stratigraphic boundaries. The final visualization of the formation processes is achieved through a volumetric model, where the volume represents the space between two consecutive stratigraphic boundaries and as a result, expresses the time passage from one boundary to another. Additional integration of geomorphological and chronological data is considered necessary and may be complemented at a later stage, in order to pass from a static model to a dynamic one, where natural and anthropic processes interact with each other, conditioning and being conditioned, at the same time, by human action.

Simultaneous Horizontal and Vertical Stratigraphic Recording Using Daily UAV Flights

Kristen Jones, Christopher Radford, George Bevan

The ancient city of Stobi, located in the modern Republic of Macedonia and inhabited from the Hellenistic to Late Antique periods, is an internationally important site. Historically, documentation of stratigraphic units during archaeological excavations there was done manually, being both time consuming and potentially inaccurate. With the development of inexpensive programmable UAVs equipped with high-quality cameras, such as the DJI Phantom 4 Pro used in this study, photogrammetry can now be quickly executed with exceedingly low marginal costs. Using aerial blocks programmed with commercial software (DJI FlightPlanner and Litchi Mission Planner), data was collected daily over the one-month excavation of the Theodosian Palace complex and georeferenced using an engineering-grade Leica Total Station. The resulting 3D models were used for horizontal mapping and calculation of the volume of material removed daily to a demonstrated accuracy of 3 mm, all while eliminating the need for manual documentation in the field. While the data was ideal for horizontal mapping, the geometry of the aerial block, even with the use of cross-strips and semi-global matching, did not provide full coverage of vertical features such as stratigraphic sections or walls. To solve this problem, we have demonstrated the feasibility and benefits of capturing images in a portrait orientation, as well as producing automated oblique imagery flight plans that reproduces the "Maltese-Cross" footprint at each air-station: one nadir image, and four oblique images at each cardinal direction. This method ultimately created a full 3D model of the excavation suitable for both horizontal and vertical documentation.

The application of 3D density analysis to archaeological data

Joshua James Emmitt, Sina Masoud-Ansari

The application of three-dimensional (3D) geographical information systems (GIS) to archaeological data is increasingly common, however these often only involve data visualisation with little analytical applications. With regards to excavated contexts 3D data is usually limited to the depiction of features and deposits. In such cases artefacts may be represented as points, leaving relationships between artefacts up to interpretation and their association to perceived stratigraphic units. An alternative is to use 3D density analysis to explore the relationships between artefacts in excavated contexts, which may then be related to deposits and features. Traditionally point density analyses have been two-dimensional in nature, meaning that clusters of artefacts are made without consideration of the z axis, or, as part of a pre-determined sampling strategy. The use of 3D density analysis means the z axis may be accounted for and sampling is less nec-

essary. This method allows for the relationships between artefacts to be independently observed without the imposition of interpretation at the first level. In this paper we present the theoretical and methodological considerations of 3D density analysis as well as some applications.

When Harris met Allen in The Matrix: How can the conceptual modelling of stratigraphic relationships facilitate deeper understanding of archaeological space and time?

Keith May, James Stuart Taylor, Steve Roskams

Within most archaeological recording systems rooted in the 'European school', the practice of stratigraphic analysis (a la Harris 1979) yields one of the most standardised data outputs of the post-excavation process, a Stratigraphic Matrix, the construction of which is often the product of a range of analytical approaches that are rarely discussed transparently. This paper will reprise work (Tudhope et al. 2011) demonstrating that advances in the conceptual reference modelling of data from units of stratification and associated meta-groupings (phases, finds, samples, etc.), using fundamental principles of temporal reasoning (Allen 1983), can be used to enable semantically enriched deductions about the spatio-temporal relationships which fundamentally link such archaeological data together. The Allen operators have been used in the CIDOC CRM (ISO 21127:2006) to describe not just superposition, but also a set of more complex temporal logical relationships, which are currently only implicitly recorded as part of most archaeological data. If recorded more explicitly as part of archaeological analysis, such spatio-temporal and temporal relationships could enable the development of better spatiotemporal visualisation and inferencing tools for archaeologists, and Bayesian chronological modellers, potentially enabling new linkages between archaeological information across space, time and space-time. This paper will think through the potentials that successful semantic modelling of stratigraphic data and associated groupings and phases might afford, and proposes that such approaches could advance a key archaeological methodological practice which remains largely unchanged since it was first articulated by Harris in 1979?

Archaeological sequence diagrams, directed graphs and Bayesian chronological models

Thomas S Dye, Bryony C Moody, Keith May, Caitlin E Buck

Dye and Buck have developed a graph theoretic approach to representing archaeological sequence diagrams, such as the Harris Matrix. First, they use formal mathematical graph theory to construct "stratigraphic directed graphs". These differ from previous software implementations of the Harris Matrix which employ a mix of directed graphs and other kinds of relations. Second, they have established that a "chronological directed graph" can be constructed alogorithmically

from a stratigraphic directed graph. The chronological directed graph models the stratigraphic relationships needed to construct priors for Bayesian chronological models. As with many attempts at automating the management of archaeological information, however, the work thus far leaves many important questions unanswered. Amongst these are: how should we handle an archaeologist's inferences about once-whole contexts; how many extant excavation records might benefit from these methods; how desirable is it to enforce shared semantics in order to standardise record-keeping and processing; what tools are needed to help archaeologists move from chronological directed graphs of their full stratigraphic record to reduced versions which contain only the nodes to be dated via Bayesian chronological modelling? Such questions and many others are the motivation for the PhD work of Moody, which is sponsored by the UK Arts and Humanities Research Council and Historic England. In this presentation we will outline our graph theoretic approach, illustrate its strengths and weaknesses with examples and discuss our on-going work in this area.

Three-dimensional documentation, reconstruction and visualization of site stratigraphy: A case study of Saruq al-Hadid (Emirate of Dubai, UAE)

Otto Bagi

The unique character of the metallurgical site of Saruq al-Hadid and its setting within the Rub' al Khali desert presented specific methodological challenges to archaeologists both during data acquisition and data analysis. The exceptionally adverse climate and the precarious nature of sand hindered the process of visual recording, while the complex system of aeolian sand deposits and the scarcity of distinct stratigraphic markers further complicated the interpretation of the gathered information. However, the combined implementation of technologies, such as, image-based reconstruction, 3D modelling and 3D visualization helped to enhance considerably the depth and detail of the collected data. These tools allowed to break the boundaries of conventional archaeological documentation by presenting spatial and visual information as one dataset in its natural, three-dimensional form rather than as series of disconnected planar illustrations. This combined model proved to be a useful analytical tool post-fieldwork and helped to gain a deeper understanding of the chronological sequence of the site.

Stratigraphy and photogrammetry: the case study of the Basilica Capo Don

Alessandro Garrisi, Alessio Paonessa, Elia Kas Hanna

Since 2011, on the site of the Basilica Capo Don (Riva Ligure, Italy), a team of young researchers affiliated to the Pontifical Institute of Christian Archeology has used photogrammetry to survey

the stratigraphical units and to realize 3D models for structures discovered on the site. In this paper we would like to disclose the last achievements reached in the field. Moreover, we aim to share with other researchers many important questions emerged with the development of archaeological mapping techniques. We will focus on the reasons why do we switched to photogrammetry from direct mapping and the new open source pipeline to get orthophotomosaics and meshes based on MicMac and Meshlab. We also describe the photo acquisition techniques used to collect images, the different methods we tested to record GCPs and how 3D models in were used (e.g. for sarcophagi). We will show a comparison of different softwares to understand which one could fit better for our purpose and why is the open source the best choice, in spite of its practical limitations. Other important points are the usage of QGIS's plug-ins to represent both planar rasters and the stratigraphical sequence; the comparison between traditional methods of representing the stratigraphic sequence, like 2D Harris' Matrix and hand drawing; how the new methods together can help archaeologists on the field to understand data records and we provide traditional vectorial documentation to the Italian Archaeological, beautiful arts and landscape Superintendence.

Interactive Visualisation of Stratigraphic Data

Fabian Riebschlaeger

Excavations are arguably the most prominent sources for the archaeological record. Most Archaeologists are well aware of the epistemic problems accompanying this practice of data acquisition. The ubiquitous concept of incompleteness, as a result of different formation processes, is particularly inhibiting since even the knowledge of how incomplete the record is uncertain itself. Consequently, approaching this uncertainty with most of the quantitative methods applied in the field of statistics is at best complicated. Therefore, the expertise of an archaeologist is indispensable for the interpretation of archaeological data - even more so, when algorithms are used to extract patterns of interest. However, the steadily growing amount of data recorded throughout an excavation impedes the archaeologist's capabilities to examine all relevant records thoroughly. Computer-based data visualisation is a technology which is particularly well suited to overcome this hindrance since it can actively augment human capacity for data interpretation. The stratigraphy of an archaeological site is an obvious starting point for any understanding of its record, and in the form of Harris diagrams, there already is a well known visual representation of this stratigraphic sequence. The Harris Matrix is limited, though, to those sequential and chronological relationships. Data visualisation together with of modern web technologies can be used to transform it into a tool for interactive, exploratory visualisation and analysis

that also incorporates artefact records and results from algorithmic analyses. In this paper, I want to present the prototype of such a tool and the design decisions made during its creation.

Going with the flow - From sediment cores underwater to 3D stratigraphic models in ArcGis to site management

Niels Bleicher, Tim Wehrle

There… The pile dwellings along the alpine lakes have been named UNESCO World Heritage in 2011. This honor comes with responsibilities and the sites need to be protected. In order to optimize said protection a site management workflow was put into place at the Department of Underwater archaeology and Dendrochronology city of Zürich. This workflow includes a minimal invasive method to acquire sediment core data underwater. Coded stratigraphic sediment descriptions are then automatically turned into 3D Models in ArcGis. The shallow water topography is added via bathymetric measurements using small sonar systems. These models can then be combined with data on water flow directions and current velocities in order to identify areas with highest risk of erosive damage to the monuments. These information help us decide the strategy best fitted for the sites. And back again… The site management approach and new developments in technology have brought us, not only to look ahead but also lead us to rethink and adapt our data capturing. This should lead to a more refined workflow and allow for more automation in the future.

Spatial Sequences: The use of 3D GIS for the identification of complex archaeological patterns.

Nicolo' Dell'Unto, Giacomo Landeschi, Andreas Svensson

The diffusion of new three-dimensional (3D) visualization platforms together with the development of new tools for query and analysis of 3D information has provided archaeologists with the opportunity to define new ways to approach and engage with stratigraphy. Today stratigraphic sequences of archaeological contexts can be represented and visualized in different ways allowing archaeologists to experience different modalities to engage with the material being recorded. For instance, archaeological information, seemingly disjointed in time and/or space, can be simultaneously interpreted and analyzed. This gives new opportunities for both site and landscape interpretations and aids in a synthesis of the archaeological record. Three-dimensional treatment of stratigraphy and spatial information also provides innovative ways to interlink several record clusters including finds distribution and stratigraphic sequencing, forming a more complete interpretational framework. Visualizing and analyzing in three dimensions archaeological records previously conceptualized on a two-dimensional axis, such

as stratigraphic sequence or spatial patterning, may allow now to expand and enhance our present understanding of these fundamental aspects of material culture in the past. By presenting different case studies where 3D GIS was used for recording and analyzing ongoing field archaeological investigation, this paper will discuss how this approach allowed the identification of information impossible to detect with more traditional methods from the perspective of visualization and temporal reasoning.

Discovering the time of La Draga.

Igor Bogdanović, Vasiliki Andreaki, Joan A. Barceló, Raquel Piqué, Xavier Terradas, Antoni Palomo, Núria Morera, Oriol López

The chronological position of the Early Neolithic lacustrine site La Draga (Banyoles, Catalonia) is defined by a series of C14 dates. The unbroken pattern of calibrated intervals suggests that the village was inhabited continuously from 5361-5223 cal BC to 5000-4796 cal BC. Two phases of the dwelling observed in clear stratigraphic relation in the phreatic zone of the site - where the preservation of the construction wood was excellent - are reflected in the graph without any apparent dividing gap. The extension of the site, its duration and low estimate of population suggest dynamic horizontal displacement of events and constructed spaces, with a certain cyclic tendency. Our aim in this paper is to present Bayesian chronological model of the inner time of La Draga and life cycles of its constructed places. For that purpose the data of C14 and dendrochronological analysis are formalized as required by Chronometry Database, following Chronological Inference Chain. The chain relates events on successive levels, from isotopic event (death of single organism) to archaeological event seen as a palimpsest of depositional events. Formalized correlation of archaeological units in the Harris Matrix enhanced by Allen Algebra and directed graphs provides necessary ordering of the data. The integration of these two methods is central for the interpretation of chronological sequence of events which take a place on the shore of Lake Banyoles, and is expected to advance in a ground data model for Bayesian time modeling.

Standard session 25: "Real-time" archaeological data. Hyperreality, temporality and materiality of digital archaeological objects

***Monika Stobiecka**, "Artes Liberales" Department, University of Warsaw*

Medium Hall B, 16.00 – 17.40, 26 April 2019

From data-gathering, through computing and rendering, to simulations, the notion of "real-time" is widely present in digital and cyber archaeology. A term that originated in computer applications has analytical potential for digital archaeological theory.

"Real-time" simulations problematize the questions of reality, hyperreality, representation, subjectivism and objectivism. When digital archaeological objects are being rendered in real-time, they encourage us to investigate the actual character and status of obtained data. What does is mean for an artifact or an archaeological site to be recorded in the real-time? What is the relation between the referent and the referred in this case? How can we examine a disturbing rupture between real-in-reality and real-in-hyperreality?

"Real-time" inspires us to rethink the problem of time, temporalities, and events. Real-time objects, treated as events, have multiple temporalities. While using real-time, we are registering "events". What is an "archaeological event" in this context? What kind of temporalities does it refer to? What is the relation between temporality and materiality of archaeological objects and sites? Assuming that archaeologists are working on vibrant matter (Bennett 2010) and/or performative materialities, we can investigate the relation between real-time technologies and materiality. Is real-time truly a form of registering unstable reality, or rather a form of capturing a temporal moment in time?

Another aspect of "real-time" has to do with objects themselves. Adopting Yuk Hui's (2016) identification of digital objects as composed of data and metadata subjects matter of philosophy, we may pose specific questions in relation to archaeological digital artifacts and sites. We may reflect on their ontological status and consider bridging the gap between two apparently distant phenomena – digital turn and ontological turn.

Treating discussions about "real-time" as an interesting platform, I invite proposals that deal with the theoretical, methodological and practice based problems of reality and hyperreality, time and temporality, matter and materiality, epistemology and ontology of digital archaeological objects.

16.00 – 16.20
Archiving realtime archaeological (para)data or archiving archaeological (para)data realtime?
Isto Huvila

16.20 – 16.40
Beyond regular temporality: Faster than eye,
Michal Piotr Gilewski

16.40 – 17.00
Real-time Performative Negotiations of the Archaeological Unknown within Digitally-born Objects and Landscapes,
William Michael Carter

17.00 – 17.20
Disrupted temporalities of digital archaeological artifacts,
Monika Stobiecka

17.20 – 17.40
General Discussion

Archiving realtime archaeological (para)data or archiving archaeological (para)data realtime?

Isto Huvila

The apparent differences between realtime capturing, reflexive making and not-quite-realtime documentation of archaeological data have multiple implications in the context of archaeological practices and knowledge work. They have consequences to what the data is and how it can contribute to the making of archaeological knowledge but also to what and how we can know about the making of the data. From this perspective a better understanding of the notion of realtime and the nature of realtime archaeological data can be argued to be helpful in framing and unraveling a part of the problem of how to capture enough contextual information about data creation processes, so called paradata. Based on the insights gathered during the work conducted in the context of COST action ARKWORK and research project ARKDIS, this presentation discusses the notion of realtime, and the relation of realtime and non-realtime documentation from the perspective of archiving and describing archaeological data. The enquiry on the issue suggests that while the realtime and non-realtime documentation lead to different information (and consequentially knowledge), documenting the data (metadata) and the process of making/capturing it (paradata), also require radically different methods of documentation. The presentation concludes by exploring Flusser's distinction between traditional (or 'imaginieren') and technical ('einbilden') images as a potential conceptual apparatus to shed light to their differences.

Beyond regular temporality: Faster than eye

Michal Piotr Gilewski

The famous middle-range theory proposed that some dynamic processes that are happening in the present may serve as comparative material to past processes, now observed in a static state of archaeological preservation. This assumption lead to compare various phenomena ranging from lithic debris spatial deposition patterns to demographic growth with modern and ethnographic data. What about processes that do occur in manner that typically is not sensed by human: processes so dynamic that they escape abilities of human perception? In this paper I present, slow motion videography technique as a way to record archaeological experiments, in which processes analogical to past ones are recreated, but I will focus on the phenomena so fast that were cannot have been seen neither in present, nor in the past. In the paper, I would like discuss what role such phenomena, as the ones that did escape the perceivable, human "dimension of real time", can have for archaeological investigation.

Real-time Performative Negotiations of the Archaeological Unknown within Digitally-born Objects and Landscapes

William Michael Carter

This paper will explore the performative real-time nature of doing archaeology, capturing archaeology and making digitally born archeological knowledge. It will discuss the differences and similarities between the realities of physical excavation, digital capture and digitally born heritage objects and landscapes as it relates to the multiple temporalities of an archaeological event. Further, it will draw distance between the notion of digital capture and digitally constructed heritage as being similar in both process and performance in real-time archaeological knowledge construction. Recent research, such as E-CURATORS (Dallas and Batist 2018) or ARKWORK (Huggett, Huvila, Paliou, and Papadopoulos 2018), has actively looked at motivations, negotiations, unconscious and conscious micro-decisions archaeologists make both within the field and later in the laboratory or in the throes of post-excavation writing. These "real-time" decisions empower agency and authority on the objects and landscapes in which archaeology is conducted. When these moments are captured in real-time, as Gant and Reilly (2018) recently demonstrated through the audio and video capture at the trowel's edge during excavation, there is a "hyperreality" which is phenomenologically engaged. Unlike the raw, visceral experience of excavation in the field, digital capture such as photogrammetry, due to

the need to have pristine working environments, becomes a sterile, almost scientific registration of the temporal event at the moment, even though both the digital capture and the excavation are at times performed simultaneously on the same landscape or object. The digital becomes an envelope of a passing reality, far removed from the actionable "archaeological event".

Disrupted temporalities of digital archaeological artifacts

Monika Stobiecka

Artifacts exhibited in museums, as they differ from the old and fragmented pieces found during the excavations, reflect important tensions created by results of archaeological research, heritage/memory politics, and public expectations. I argue, that theoretical reflection on digital archaeological artifacts is of particular importance for considering the future of archaeological museums, narratives they create about the past, and their growing impact on popularization of archaeological knowledge. In this presentation I will propose a working definition of a digital archaeological artifact, taking into account its ontological status and temporal character. Multi-temporal character of digital archaeological objects (understood as fragmented artifacts supplemented with digital aids) creates a perfect opportunity to deepen the reflection on material-digital entanglements that currently dominate archaeological museums. While reflecting on the idea of a digital archaeological artifact, I will investigate the temporal relation that occurs between an original, aging and dynamic matter of an artifact and contemporary digital supplements. My considerations will be placed within recent interest in thing studies, theory of assemblages, entanglements, agency of things, new materialism and "the ontological turn." Displayed on the exhibitions world-widely, digital archaeological artifacts encourage to think about technology and its role in heritage studies, to reevaluate concepts like authenticity, aura, copy, and last but not the least — to think about the place and role of archaeology in building future oriented knowledge of the past.

Standard session 26: Archaeological network research: formal network representation of archaeological theories

***Paula Gheorghiade**, University of Toronto The Archaeology Centre, University of Toronto Material Entanglements In the Ancient Mediterranean and Beyond Project, Johns Hopkins & National Hellenic Research Foundation*
***Tom Brughmans**, University of Oxford*

Large Hall A, 10.20 – 15.40, 24 April 2019

In this session we aim to discuss and encourage the explicit representation of archaeological theories as network data, and the explicit theoretical motivation of network science method selection.

Formal network science methods are increasingly commonly applied in archaeological research to study diverse aspects of past human behaviour. The vast majority of these applications concern the use of exploratory network analysis techniques to study the structure of a network representation of an archaeological dataset, which often leads to a better insight into the structure of the dataset, help identify issues or missing data, and highlight interesting or surprising data patterning.

Less common is the explicitly formulated theoretical motivation of exploratory network analysis tool selection. What tools are appropriate representations of my theorized assumptions? What tools violate my theoretical framework? Equally uncommon is the formal representation of archaeological theories (rather than archaeological data) as network data. What network data pattern do I expect to see as the outcome of a theorized process? What does a theorized past relational phenomenon look like in network terms?

Taking explicitly formulated theories rather than datasets as the starting point of archaeological network research is useful for a number of reasons. It forces the researcher to specify the theory that will enable its formal representation, and possibly improve or modify it through this process. It allows for understanding the behaviour and data predictions of a theory: in exploring the structure of the theorized relationships, the implications for processes taking place on theorized networks, and the evolution of theorized network structure. It facilitates the selection of appropriate network analytical tools that best express the theory or that are appropriate in light of the assumptions inherent in the theory. Finally, it allows for comparisons of data patterns simulated as the outcome of a theorized network process with archaeological observations, to evaluate the plausibility of the theory.

This session welcomes presentations on the following topics:

- archaeological network research: applications, methods or theories;
- network representation of archaeological theories;
- testing archaeological theories with network science;
- using network configurations, motifs and graphlets for representing theories;
- exponential random graph modelling;
- agent-based network modelling;
- spatial network modelling.

10.20 – 10.40
First steps towards ontological geography: experimenting with topographic networks,
Zoran Čučković

10.40 – 11.00
Movescape: towards a formal representation of multiple pathways,
Laure Nuninger, Philip Verhagen, Xavier Rodier, Rachel Opitz, Thérèse Libourel, Clément Laplaige, Catherine Fruchart

11.00 – 11.20
Explicit Knowledge Representation and Cultural Transmission in an Abstract Agent-based Model with Networks, Time and Space,
Frederik Schaff

11.20 – 11.40
Cutting the network, knotting the line: anticipating emergent properties from multimodal networks,
Gisli Palsson

11.40 – 12.00
Evaluation of Probabilistic Graphs or Networks in Archaeology,
Lutz Schubert, Martina Trognitz

12.00 – 12.20
Network analysis of an archaeological research project: A graphical monitoring of the developing interdisciplinary co-authorship of the PaleoAsia project, *Yasuhisa Kondo, Yoko Iwamoto*

12.20 – 12.40
Imposing a free-market present on the Past: Is homo economicus stalking archaeology theory?
Raymond John Rivers, Tim Evans

LUNCH BREAK

14.00 – 14.20
Structure, hierarchy and network dynamics of the complex chiefdom societies of "Germania libera" during the Roman period: The Middle Danube region borderlands,
Marek Vlach, Balázs Komoróczy

14.20 – 14.40
Creating and Analyzing Networks of Interdisciplinary Conceptualizations of 'Change' for the Sagalassos Archaeological Research Project,
Georgia Panagiotidou, Jeroen Poblome, Jan Aerts, Andrew Vande Moere

14.40 – 15.00
Detecting networks among population groups in Early Archaic Sicily,
Emma Nicole Buckingham, Samuel Heroy

15.00 – 15.40
General Discussion

First steps towards ontological geography: experimenting with topographic networks

Zoran Čučković

Human cognition of space is object-based; when navigating through a landscape we rely primarily on objects such as paths, valleys or ridges, and their relationships. Distance is more readily expressed as travel time than as a geographical measure. Such "object oriented" or ontological geography represents a considerable challenge to model. Many geographical objects have no clear limit (hills, plains), and exist in a continuous variety of forms with many unclassifiable intermediaries (e.g. between "valley" and "plain" landforms). These issues can be tackled with network based models, in particular those devised for structural analysis. Already in the 19th century, A. Cayley and J. Maxwell proposed a graph-theoretical model for representing natural topography, known today as surface networks. These are composed of interlocked ridge and valley lines and share some basic principles with watershed modelling. Another graph-theoretical representation of terrain are so-called Reeb graphs. Constructed by connecting contour lines (isohypses), these will have a tree structure where branches are local high-points and roots local low-points ("multi-tree"). In the long run, the ontological approach in geographical modelling (not representation!) should enable us to tackle the difficult issue of cognitive analysis. We can study the relative uniqueness of topographical positions of archaeological sites, which can be related to their nameability. We can also envisage a landscape equivalent of "cognitive cost", used to analyse movement in urban areas. Rather than taking into account the number of turns in a city grid, we can analyse the overall integration of a path with local landforms.

Movescape: towards a formal representation of multiple pathways

Laure Nuninger, Philip Verhagen, Xavier Rodier, Rachel Opitz, Thérèse Libourel, Clément Laplaige,

Catherine Fruchart

Our contribution questions the formal representation of archaeological theories associated to movement. The concepts used in the discussion of movement in archaeology, nourished by detection and/or modelling of ancient routes and pathways, include underlying ideas of scale, social paradigms, environmental context and more, rarely discussed in the literature. Furthermore, network analysis is often applied to the study of ancient mobility because it is logically coherent with the idea of road and transport networks, but its use is not explicitly justified. We propose to first formalize the theories related to mobility using an ontological approach, which serves to identify the practices and materialization of ancient movement. A hollow way, for example, results from movement practices and environmental conditions that creates peculiar landscape features. An ontology of hollow way would take into account all the factors and processes responsible for its current manifestation, and order these in a logical framework. Ultimately, this exercise provides us with a set of accumulated traces, or potential traces, of past mobility. We refer to this set as a path graph: a mathematical construct of nodes and edges that represents the totality of potential mobility in a region. The system of circulation at a point in time then become a network based on the active part of the path graph. In this paper the use of ontologies and the path graph concept will be illustrated through various examples showing how it can be integrated in detection, modelling and formal (network) analysis of ancient movement.

Explicit Knowledge Representation and Cultural Transmission in an Abstract Agent-based Model with Networks, Time and Space.

Frederik Schaff

To understand the historical records in the context of time but also of other dimensions like space, sociality and technology, it is important to formally represent their interdependency within a single 'systems' model. Agent-based modelling is a method that formally allows the representation of such complex systems-of-systems, and, inter alia, to gain an understanding of the consequences of the interaction spanning different dimensions. I present a simple ABM of individual agents that get born, age, get children, and die (population model), take actions in time interacting with others or the environment (time), form relations with others (network model, including heritage network), are situated and move in a geography (space model), learn something about this space, other agents or other meaningful entities (knowledge), take actions based on this internal knowledge model (cognition & rationality), and share their knowledge with others (cultural transmission). The proposed framework is highly flexible. It allows to be extended or reduced (e.g., no space, no networks, etc.), depending on the questions tackled. It follows the design principles of pure agent-based modelling (Author 2016) and provides a first

general formalisation. The model is implemented in LSD, a fast, well documented, open-source, cross-platform and easy to use c++-based ABM framework that is recently extended to provide native GIS support by the author.

Cutting the network, knotting the line: anticipating emergent properties from multimodal networks

Gisli Palsson

Archaeological network analysis has seen a significant surge in interest within the field over the past two decades. It is far from a mature science, however, and the character of the archaeological record tends to yield networks with richly contextualised nodes connected by ties that, in stark contrast, are often based on very limited evidence for connectivity. While it can be difficult to ascertain how and why certain places were connected through material transference, related sources, such as historical records, can be used to build interpretive models of site to site interactions. The author's work uses archaeo-historical lines of evidence to document and analyse networks of interaction between the roughly 6000 farmsteads occupied in late medieval and early modern Iceland. In particular, mapping relations of ownership, resource claims and social obligations alongside archaeological surveys show extensive networks of interdependence between the known farmstead sites occupied at the time. These vibrant networks, documented both spatially and historically, regularly show signs of emergent properties and complex, non-linear methods of handling site-to-site interactions. As these inter-site relations begin to exert their own agency, the networks are cut, and intermediate nodes develop based on familial, social, political and spatial factors. This paper focuses on historically documented emergent properties to propose an integration of assemblage theory principles with formal network analysis. This approach would take network quantification as a starting point, followed by endeavours to anticipate the properties that emerge as people aim to enact and materialise networks of property rights, resource claims and exchange.

Evaluation of Probabilistic Graphs or Networks in Archaeology

Lutz Schubert, Martina Trognitz

Archaeological interpretation lives from analysing relationships and comparing finds. It is well known that such data is best represented as graphs that can link properties and finds with each other, so that e.g. different amphorae from different regions can be compared for commonalities. In the strict mathematical sense, graphs are purely structural and methods from graph theory are not intended to deal with probabilities - archaeological data on the other hand is

full of uncertainties, probabilities, and alternatives caused by a variety of reasons. Even though the properties of a find may be objective in themselves (such as material composition, shape, decoration), its comparative value will vary due to regional differences or simple human variation. This makes graph theory on the one hand perfect for comparison, on the other hand it fails due to the lack of statistics. Principally, we can represent these probabilities and uncertainties by e.g. using weighted edges in the graph. With the right methods this should allow us to do two things: (1) represent the degree of variation in a type of object and thus comparing two finds with a degree of certainty and (2) reason over the impact of variation on clustering. While some methods exist to assign probabilities to weighted graphs, such as - indirectly - the Erdős–Rényi model, Tnew methods for the evaluation and analysis of probabilistic graphs tailored to the archaeological use case are required. The talk aims to explore these methods, test them on two data sets with 'real' archaeological data, and assess the reliability or certainty of the results. One example is based on a weighted graph representing Aegean seals (material, dating, location, depictions) and shall explore how finding groups of seals with similar depictions is affected by considering the different weights. The presented methods might allow to provide a well informed conclusion about the similarity of two subgraphs of the same graph representing a set of artefacts or about the significance of a relationship in a graph representing e.g. potential social connections.

Network analysis of an archaeological research project: A graphical monitoring of the developing interdisciplinary co-authorship of the PaleoAsia project

Yasuhisa Kondo, Yoko Iwamoto

The PaleoAsia project aims to interpret the nature of distinct patterns in the formation of modern human cultures across Asia. To this end, over 50 researchers from diverse backgrounds such as archaeology, cultural anthropology, mathematical biology, and palaeoenvironmental sciences work in collaboration. A previous study (Kondo et al. in CAA 2018) has highlighted that the conceptual meaning of culture is different among researchers from different backgrounds. How can researchers span their conceptual boundaries and work together towards the achievement of a shared research objective? To this end, the progress of interdisciplinary co-authorship was monitored and analysed by means of a network graph in the following manner. To begin with, authors from the proceedings of the first to the fifth conferences were listed, and network graphs of authors (nodes) and co-authoring relationships (edges) were drawn. In total, there were 128 authors, 184 presentations, and 499 co-authoring relationships in total, from the first to the fifth conference. The average number of co-authors per presentation was 1.39 in the first conference, 1.72 in the second conference, 1.46 in the third conference, 2.49 in the fourth con-

ference, and 2.26 in the fifth conference. A remarkable increase in the number co-authors was observed in the fourth conference, held in December 2017. The number of co-authors is high in the archaeology groups and low in the cultural anthropology group. Co-authoring relationships will continuously be monitored to analyse the development of interdisciplinary collaboration, as well as its outcome and impact.

Imposing a free-market present on the Past: Is homo economicus stalking archaeology theory?

Raymond John Rivers, Tim Evans

Theoretical archaeological network modelling often adopts free-market socioeconomic ideas whose C20 language gets translated into historic behaviour with the simplest of lexicons, suggesting that we are imposing the present on the past through the agency of homo economicus. Recent examples include a Ricardian analysis of BA Assyrian trade networks assuming ad valoram iceberg no-arbitrage transaction costs following a Weibull distribution in a framework of Constant Elasticity of Substitution. The paper exploits the data well and is nuanced in its conclusions, but such seeming imposition of free-market agents, rationally maximising utility as consumers and profit as producers, runs counter to recent developments in archaeology. As a result such agent-related network modelling is often treated with suspicion despite further successful applications e.g. in describing historic city state formation in situations from Archaic Greece to Latenian Gaul, adopting an approach originally designed for the organisation of C20 shopping malls. Our intention in this talk is to strip out as much of the contemporary context as possible and bring modelling back to Jaynes' 'epistemic modesty' of MaxEnt. The idea is that although the ontology may be specific to contemporary society the epistemology has much greater generality, while leading essentially (but not exactly) to the same conclusions. The authors cited above are aware of this but we shall be explicit in taking one step back without the need to invoke agents directly, dethroning homo economicus in favour of a flat Bayesian prior, with only a little loss.

Structure, hierarchy and network dynamics of the complex chiefdom societies of "Germania libera" during the Roman period: The Middle Danube region borderlands.

Marek Vlach, Balázs Komoróczy

Since the establishment of a „chiefdom" theoretical concept, as a precursor of the state, there has been substantial research activities and pursuits to discern its featuring principles, structure and dynamics. The embedded sharp contrast of the Roman and „barbarian" (predominantly consisting of the Germanic tribes) worlds, especially along the continental Limes, predestined

multiple forms of political and economic interactions during the first four centuries AD until the Great Migration. Nevertheless, in fundamental aspects unchanged examples of the respective political and social entities survived in the Northern European environment until the Medieval Era and Christianisation. Existing theoretical models usually tends to describe these societies through the structure charts or plain language. The main spatial interest lies within the barbarian landscapes of the Middle Danube region, which represent a specific borderland contact zone of barbarian territories and the Roman Empire. The recreation and reanimation of the featuring theories and their key aspects was based on variety of archaeological proxy data, written sources and other relevant inputs and conceptualization and formalization of acting entities (settlement, retinue etc.) and relations (e.g. lineage). The explicit spatial representation of the study area provides a basis for agent-based model (software NetLogo) with network structure connecting the featuring agent "actors" for testing of existing theoretical models, reflecting vertical (wealth or power aggregation, "ranking") and horizontal (spatial distribution, population mobility) differentiation of connections throughout the social, political and economic space.

Creating and Analyzing Networks of Interdisciplinary Conceptualizations of 'Change' for the Sagalassos Archaeological Research Project

Georgia Panagiotidou, Jeroen Poblome, Jan Aerts, Andrew Vande Moere

Archaeological projects are considered to be interdisciplinary by nature since these often encompass methods, practices, conceptualizations and expertise from other sciences. However, while the exchange on the level of operationalization might be a norm, when theorizing phenomena, effectively sharing and efficiently applying disciplinary conceptualizations remains challenging. This study investigates how to potentially generate new knowledge in an archaeological project by analyzing interdisciplinary concept maps as semantic networks and by creating a boundary visual language between the participating disciplines. The current work synthesizes a common conceptualization of an inherent archaeological topic, the concept of 'Change', by studying a group of scientists from humanities, social sciences and ecology in the context of the Sagalassos Archaeological Research Project, at the University of Leuven. Our work assumes the position of a project level understanding of the topic at hand and therefore lays in-between computationally generated semantic networks and single theory representations. Starting from discipline specific concept maps we create an interdisciplinary semantic network that includes the theoretical backdrops of the collaborating disciplines on the same visualization. The dense, yet highly personalized network that emerges is analyzed through network analysis for its potential to inform the original participants. Namely, we are deploying a mixed-method study that measures the perceived value of the process immediately thereafter as well as its eventual impact on the

project. The goal of this study is to contribute to methods for a more holistic understanding of theory in the field of archaeology, but also more broadly to similarly interdisciplinary work.

Detecting networks among population groups in Early Archaic Sicily

Emma Nicole Buckingham, Samuel Heroy

This paper utilizes Social Network Analysis (SNA), particularly community detection applied to assemblage/ context data, in studying interactions between populations in Early Archaic Sicily. SNA used in several recent studies on Mediterranean societies has generally taken on two forms – descriptive (Malkin 2011) or statistical (Knappett 2013), the latter including network analysis of ethnic and regional interactions during Greek colonization of the West (Donnellan 2016). As Greeks became more entrenched in Italy, their interaction with indigenous groups created a middle ground of mixed settlements linking Mediterranean networks with internal networks previously established through localized trade and interaction. Application of the term "entanglement" to these network-mediated encounters with other social and cultural groups emphasizes objects' role in interactions within colonial and trade systems; reconstruction of networks of people and objects from distinct assemblages can provide insight into the distribution and consumption of objects. This paper models networks through the construction of similarity matrices for two variables (chosen for data availability/ simplicity) – form and production location – for 12,000 objects securely recovered from Early Archaic contexts throughout Sicily. This reveals correspondences between contexts in terms of a collective aggregation of elements, and models potential interactions between sites and identities within settlements that led to the formation of specific assemblages. The paper concludes that SNA demonstrates limited distinction in the material record among sites traditionally considered "Greek" and "indigenous," substantiating recent approaches to Greek colonization (Osborne 2016) that tend to refute a clear ethnic division in Sicily during the earliest Greek diaspora to the West.

Standard session 27: Chasing heritage thieves: digital methods and approaches to contrasting trafficking and looting of cultural property

***Arianna Traviglia**, University Ca' Foscari of Venice*
***Riccardo Giovanelli**, Università degli Studi di Milano VEiL Project Università Ca' Foscari Venezia*

Exhibition Room A, 10.20 – 11:40, 24 April 2019

Looting and trafficking of cultural heritage, especially archaeological, is now a global scale phenomenon, the origins of which are rooted in history. Since the '70s, despite the 1970 UNESCO convention, plundering and illicit trade of cultural property has become an increasing trend with major consequences to internal security, economies and even loss of cultural identity, which exists without distinction at all latitudes, in the most advanced economies of the planet as well as in less wealthy countries. More recently, the phenomenon has been further exacerbated by conflict and turmoil in areas where political stability is compromised. Studies draw a firm connection between increased looting with the political destabilisation of the states.

The last decades have also witnessed several initiatives, promoted by a diverse set of actors engaged in the protection of endangered cultural heritage and halting illicit trade, that rely increasingly on technological and digital advances to combat such illegal activities. This session aims to take stock of ongoing initiatives and bring together emerging digital practices aimed at understanding the complexity of the phenomena of pillage and illicit trade in archaeological objects and evaluate them. We invite participants to discuss approaches and methods that are being adopted (or proposed) to foster remediation and resolution. This includes (but it is not limited to) established practices such as the use of remote sensing to detect looting activities, the role of network analysis to model illicit antiquities trade, the establishment of (local or global) databases of lootable or looted items, together with less explored (but highly promising) methods such as quantitative analysis, predictive modelling, data mining (especially on the dark web where looted properties are often traded), statistical analysis, deep learning, block chain technologies, and even apps and social media.

The session is organised within the framework of the H2020 Netcher project (NETwork and digital platform for Cultural Heritage Enhancing and Rebuilding) that aims at creating a structured network of actors engaged in this fight.

10.20 – 10.40
Towards best practices for monitoring and quantifying archaeological looting with SAR and optical satellite time series,
Deodato Tapete, Francesca Cigna

10.40 – 11.00
Assessing manual, unsupervised, supervised and automatic change detection methods for detection of looting in Apamea, Syria,
Francesca Cigna, Deodato Tapete

11.00 – 11.20
Satellite based extraction of archaeological looting patterns: from visual inspection to automatic procedure. Overview and case studies,
Nicola Masini, Rosa Lasaponara

11.20 – 11.40
JCHC: an editorial and social media project as a collection and dissemination tool in contrasting Crimes against Cultural Heritage,
Serena Epifani, Michela De Bernardin

Towards best practices for monitoring and quantifying archaeological looting with SAR and optical satellite time series

Deodato Tapete, Francesca Cigna

In the last decade, satellite images with very high spatial resolution up to less than 1 metre have been used as an objective source of information to detect the occurrence of archaeological looting. Both archaeologists and heritage bodies are increasingly becoming familiar with these resources acquired from space, to either perform local studies focused on single sites, or undertake more systematic mapping surveys across wide regions. We present an overview of the methods of supervised, unsupervised and (semi-)automatic image processing chains that have been developed so far to exploit time series of either Synthetic Aperture Radar (SAR) or optical images, and provide a comparative assessment of the advantages and limitations of these approaches. We present the results achieved over selected case studies across the Middle East, based on change detection analysis of bespoke time series of COSMO-SkyMed SAR data, and Sentinel-2 and WorldView multi-spectral imagery. The outcomes are discussed to propose recommendations towards best practices for regular monitoring and quantitative assessment of archaeological looting using satellite technologies. This is a research domain still under development but at the same time it is highly regarded across the archaeological community in the hope to overcome the limitations of manual interpretation and counting of looting holes.

Assessing manual, unsupervised, supervised and automatic change detection methods for detection of looting in Apamea, Syria

Francesca Cigna, Deodato Tapete

Apamea is a Hellenistic town in western Syria that has sadly become one of the symbols of cultural heritage in the Middle East devastated by systematic looting. Since 2011, looting holes spread massively across the archaeological site, pockmarking both the ruins and monuments already excavated and the sectors of the site that had not been yet unexcavated by archaeologists. From a scientific point of view, Apamea is an ideal testbed to undertake a comparative assessment of different satellite-based methods for detection, mapping and quantification of looting holes and rates, owing to the distinct shape and clear visibility of the looting features. We tested different methods of supervised and unsupervised classification, as well as automatic change detection, relying on either brightness, texture, morphology, or size of the pits. The tests were undertaken using bespoke high spatial resolution time series of X-band Synthetic Aperture Radar (SAR), very high resolution optical images by commercial satellites, and tens of freely-available optical Sentinel-2 time series at high temporal resolution. Combining the analysis of all these satellite datasets, we were also able to present the first comprehensive account of the spatial and temporal evolution of looting in Apamea since its onset, and provide a proof of concept of how to combine radar and optical satellite observations for multi-sensor looting tracking from space.

Satellite based extraction of archaeological looting patterns: from visual inspection to automatic procedure. Overview and case studies.

Nicola Masini, Rosa Lasaponara

Vandalism and illegal excavations represent some of the main risks that affect archaeological heritage throughout the world. Actions oriented toward quantifying the damage and preventing looting can be supported by satellite technologies that can provide reliable information to: (i) detect and quantify devastation and looting phenomenon, even over large areas, and (ii) set up tools to undertake monitoring for remote areas or sites not accessible due to war or other limiting factors. So far, the identification and quantification of looting has been generally conducted by visual inspection of optical aerial or satellite images. However, recent pioneering investigations based on an object oriented approach for the automatic identification of changes due to illegal excavations have been conducted. Herein we propose an automated approach for the identification of looting in satellite imagery based on local indicator of spatial analysis, unsupervised classification and segmentation. Results obtained from the satellite-based analysis

have been conducted in pilot areas selected in Syria and in Peru. The assessment of the reliability of the results was conducted through field surveys in Peru, and via visual inspection for the Syrian case study. Results from the evaluation procedure showed satisfactory performance from both of the analysed test cases. The outcomes of this study have implications for the protection of archaeological sites not only in the investigated areas, but also in similar environmental conditions across the world.

JCHC: an editorial and social media project as a collection and dissemination tool in contrasting Crimes against Cultural Heritage

Serena Epifani, Michela De Bernardin

A magazine dedicated to crimes against cultural heritage does not exist in Italy. The "Journal of Cultural Heritage Crime" (JCHC) has come to fill this gap as of September 2018. The magazine combines informative articles published on its website and has social media strategy (on Facebook, Twitter, Instagram and LinkedIn). The project aims to raise the public awareness regarding crimes against Cultural Heritage. In order to counter such crimes it strives to reach its goal through public sensitization, active promotion of events (as a sponsor, patron, organizer or media partner) and network building (with professionals and institutions such as the Carabinieri). The communication strategy is planned in each media adopted: on the website, a set number of articles are published every week, flanked by press review both national and international and each SM adopted has its own strategy. The communication pattern adopted saw a rapid boost and an increasing success: statistics confirm a fast growth, both in views (reaching 26,484 views and 14,727 visitors on the website, 2100 followers on Facebook) and in interactions. Engagement data and the interactions shape (with active sharing from public and professionals at a world-wide level and reports of endangered sites) show that the project could indeed be an effective tool in countering crimes against Cultural Heritage. In the near future, the collected reports and data will be stored in an open access database for endangered, stolen, ruined, and recovered artifacts.

Standard session 28: Computational classification in archaeology

Oliver Nakoinz, Institut für Ur- und Frühgeschichte, Christian-Albrechts-Universität zu Kiel
Martin Hinz, Institute of Archaeological Sciences, Bern University

Seminar Room, 10.20 – 15.40, 24 April 2019

To make inferences on archaeological material that goes beyond the individual object we always have to decide what is similar or equal and what is not. This reasoning is at the heart of the archaeological method since its beginning and describes what we understand as meaningful categories such as a type and what we try to achieve with a typology. We group and label objects on the basis of more or, in most cases, less defined criteria. Predominantly this is still done in an "impressionistic" or "intuitive" manner since more "objective" and "standardised" methods, combined with automated recording of the artefacts, have not found a wide reception within archaeology. The reason for this might be that most approaches are considered to be complicated, general or reductionistic.

According to the growing interest in pattern recognition, machine learning, and data mining, classification plays again a significant role in quantitative archaeology. This development could be seen in the classification session at the CAA2018. Now, we focus on two specific aspects of computational classification:

1. Automatic processing of considerable amounts of data. The production of local, regional and supra-regional data sets during the last decades left us with a big amount of data to analyse. Computational classification is an important approach for forwarding the acquired information into the process of archaeological reasoning. The given data, research questions, and theories in different case studies require specific classification methods which will be discussed in this session. Pattern recognition, machine learning and data mining approaches used on large data sets, heterogeneous data or used for supra-regional analysis are topics of this focus.
2. Method validation and reproducibility. Currently, there is not only a huge amount of data but there are also many classification algorithms and approaches available. This requires a much deeper understanding of the theoretical and methodological basics. In this session we will try connecting theory and method, evaluate different methods and estimate range, limitations and methodological constraints of different approaches. Furthermore, we hope to discuss standards of method description and reproducibility. We invite papers on new developments and methodological issues in computational classification.

The aim of the session is to provide a better understanding of classification methods and algorithms and of validation techniques since sound methodological knowledge is required to choose the right approaches among many competing approaches. In particular, a tight connection between method and theory which is essential for a valid interpretation of the results has to be based on this kind of knowledge rather than on methodological fashions.

10.20 – 10.40
An Archaeological Perspective on the Classification of Categorical Data,
Erik Gjesfjeld

10.40 – 11.00
A method for automatic classification of archaeological artefacts using computer vision and machine learning algorithms,
Diego Jiménez-Badillo

11.00 – 11.20
Point and Line to Hyperplane: Set and Graph Theory for Parsing Systemic Contexts and Assemblages,
James Scott Cardinal

11.20 – 11.40
To perceive or to compute? Comparison of impressionistic and computer-aided vessel shape classification based on completely preserved late Neolithic pottery of Central Europe,
Martin Hinz, Caroline Heitz

11.40 – 12.00
How deep or random is your forest? Some thoughts about making the right (algorithm) choice,
Agnes Schneider

12.00 – 12.20
Recovering Commonalities and Highlighting Differences in Aegean Sealings,
Bartosz Bogacz, Nikolas Papadimitriou, Diamantis Panagiotopoulos, Hubert Mara

12.20 – 12.40
A re-evaluation of the concept of type in coroplastic studies based on 3D shape analysis of terracotta figurines from Ayia Irini, Cyprus,
Valentina Vassallo, Sorin Hermon, Andreas Scalas, Michela Mortara, Michela Spagnuolo

LUNCH BREAK

14.00 – 14.20
Comparing sites, based on ceramic finds spectra,
Vincent Mom

14.20 – 14.40
An object-based predictive model for "control places" location in Alpine Environment (Northern Italy),
Luigi Magnini, Armando De Guio, Cinzia Bettineschi

14.40 – 15.00
From the photo to the size groups: Seeking relationships between artefact fragmentation and the use of the living space,
Michaela Prišťáková, Petr Dresler, Vojtěch Nosek

15.00 – 15.20
An Automated Approach to the Classification of Fragmented Faunal Remains using Differential Geometric Methods and Machine Learning,
Peter J Olver, Katrina Yezzi-Woodley, Jeff Calder, Martha Tappen, Pedro Angulo-Umana, Bo Hessburg, Riley O'Neill, Jacob Elafandi, Reid Coil, Chehrzad Shakiban

15.20 – 15.40
General Discussion

An Archaeological Perspective on the Classification of Categorical Data

Erik Gjesfjeld

The emergence of big data across the sciences has renewed interest in the conceptual and methodological tools for classification and clustering. Archeological data, while not often "big" in volume, is often characterized by a substantial degree of variability in the quality of data collected. This disparity in data has become accentuated in recent years with the emergence of digital data repositories and the challenges associated with integrating datasets together. This paper will focus on evaluating the various classification schemes associated with categorical data. Nominal or categorical data is a common source of data for archaeologists but has limitations in its usage with common classification or clustering techniques, such as principal component analysis. The data used in this research will derive from two large digital databases: 1) the Southwest Social Networks Database, curated by Archaeology Southwest, comprising nearly 4.4 million ceramic artifacts, and 2) typology data associated with Jomon pottery in Japan. These databases are representative of many digital archaeological data sets which consist of discrete typological designations and few if any continuous variables. Results of the work aim to highlight the advantages and disadvantages of classification approaches from traditional chi-square approaches to more advanced methods such as support vector machines. The broader outcome of this research is to contribute to the emerging methodological discussion surrounding the classification of categorical data and the influence of different classification schemes on the development of archaeological narratives.

A method for automatic classification of archaeological artefacts using computer vision and machine learning algorithms

Diego Jiménez-Badillo

The project seeks to solve the problem of differentiating cultural heritage objects based on shape characteristics. This is a pervasive challenge in disciplines such as Archaeology and Art History, where researchers routinely face the need to establish or test the validity of artefact typologies through a careful analysis of their formal characteristics, as a means to determining their place of provenance, chronology or position in certain artistic style. The proposal consists in applying a combination of computer vision, machine learning and digital humanities techniques to highlight formal differences and similarities within a set of objects, which can then lead to an automatic recognition of meaningful classes within the collection. After acquiring 3D digital models of the collection under study, the method consists in subjecting every pair of objects

to 3D morphing algorithms. The purpose is creating hundreds of artificial 3D models whose forms lie in-between the shapes of the original pair of real artefacts. This process is repeated for every combination of objects, resulting in hundreds of thousands of models, which represent an "atlas" of all possible shape variations expected for such set. Finally, the geometric characteristics of all these models are classified with deep-learning techniques to highlight the main shape-patterns defining that cultural heritage collection in particular. Based on the findings of this automatic, save-timing method, professionals in cultural heritage would be able to use their time and intellect more rationally, dedicating their best efforts to answer research questions related to the meaning of form variations in their collections.

Point and Line to Hyperplane: Set and Graph Theory for Parsing Systemic Contexts and Assemblages

James Scott Cardinal

Both context and assemblage are methodological constructs for the systemic associations of space and objects for archaeological analysis and interpretation – proxies for the behaviors of interpretive interest and historical trajectories of those behaviors. For empirical and quantitative analyses, however, both assemblage and context rely on identifying systemic linkages of association from observable samples. Applications of computational methods of determining those linkages, either by classification or clustering, are appropriate only inasmuch as they are firmly based on and correctly characterize those empirical data. Machine learning techniques, both supervised and unsupervised, rely on projecting arbitrary n-dimensional data into a system of coordinates. These coordinate systems synthesize the various attributes of interest into a single datum point in that n-dimensional topology, with various distance measures defined to assess the proximity of each point of data to another in that n-dimensional hyperplane. The archaeological question is what properly constitutes those dimensions and measures. Perhaps, though, the answers lie not in the numbers but by considering the topologies and things themselves. This paper presents an archaeological implementation of set and graph theory and their applications for alternative computational approaches to characterizing and associating empirical archaeological data.

To perceive or to compute? Comparison of impressionistic and computer-aided vessel shape classification based on completely preserved late Neolithic pottery of Central Europe

Martin Hinz, Caroline Heitz

Since 2016, in the SNSF-project 'Mobilities, entanglements and transformations in Neolithic societies on the Swiss Plateau (3900-3500 BC)', we have been using a computer-aided classification of vessel shapes to investigate completely preserved Neolithic pottery of Swiss wetland sites and neighbouring regions from the 4th M BC beyond classical typologies and cultural assignments. We follow a holistic approach in which the entire vessel body is understood as a rotational body. One side of the rasterized, filled and equally scaled profile is extracted, and via a simple transfer of the image information into a matrix, the profile line is converted into 400 measuring points. The profile information, enriched with nominal as well as metric values, can be evaluated using various multivariate methods. We opted for a combination of t-sne as ordination and dimension-reducing method and HDBSCAN as cluster algorithm for this analysis. This approach was accompanied by a impressionistic classification by hand. We found that both methods complement each other meaningfully: While computer-aided classification was able to work out more general, cross-cultural trends, which can be interpreted with regard to the function of the vessels and a consumer perspective, impressionistic classification leads to an identification of different styles, which rather open up a producer perspective. The juxtaposition of both methods on the same material can be used to overcome existing stereotypes in the ceramic classification. Furthermore the results also serve to identify yet unresolved shortcomings of the computer-based approach, which will be addressed in the future.

How deep or random is your forest? Some thoughts about making the right (algorithm) choice

Agnes Schneider

Archaeology has always benefited from methods of other disciplines: computer applications and quantitative analysis techniques have been applied by archaeologists since the 1970's to analyze and interpret archaeological data. Some methods have been accepted faster and smoother than others. Developments in Computational Science - more precisely Computer Vision have revolutionised data handling and analysis in disciplines like Physical Geography, Environmental Informatics and Remote Sensing and hold out very promising possibilities especially for data-driven archaeological use which is in need of elaborate methods to be able to handle archaeological big data which is becoming more complex. Nowadays machine learning itself and methods like pattern recognition, feature extraction are still being treated novercal and haven't found a really wide acceptance and understanding in archaeological research. Understanding is an

important codeword: we have to understand what the method we plan to use can give us, if the chosen method is suitable for our research question and how we can refine, "tune" and validate our model. This paper would like to compare several machine learning algorithms (Support Vector Machines, Random Forest, Neuronal Networks, Classification and Regression Trees, Linear Discriminant Analysis and k-Nearest Neighbour) and discuss their advantages and disadvantages. All algorithms will be used on the same dataset (LiDAR data of the region around the Dünsberg, Germany), research question (the detection of burial mounds and enclosures) and in the same scripting language (R) to be able to compare them to each other.

Recovering Commonalities and Highlighting Differences in Aegean Sealings

Bartosz Bogacz, Nikolas Papadimitriou, Diamantis Panagiotopoulos, Hubert Mara

Seals were important in Aegean society and, as functional objects, they would have served three main purposes: securing, marking, and authorizing. Their study provides valuable insights into the Aegean socio-political organization and administration. An important question arising is the determination of authorship and origin of seals. The similarity of sealings is a key factor as it can indicate different seals with the same depiction or the same seal imprinted by different persons. Research on seals relies on qualitative judgments based on manually discovered and observed traits. Digitally verifiable results and visualizations can serve as a foundation for quantitative reasoning and fact-finding. We highlight and expose differences by directly matching common visual patterns of objects of the Corpus der minoischen und mykenischen Siegel (CMS) (https://www.uni-heidelberg.de/fakultaeten/philosophie/zaw/cms/). We study and compute the deformation of shape necessary to match two sigils. The sealings used in our dataset are compromised of 3D structured light scans of plasticine copies. First the local curvature of the 3D data is computed and 2D raster images are rendered using the GigaMesh Software Framework (https://gigamesh.eu). Afterwards feature extractors, based on Bag-of-Visual-Words descriptions and Convolutional Neural Networks (CNNs) are applied. A rigid matching of the extracted features with RANSAC and fine-tune the residual with non-rigid deformation based on Thin-plate Splines (TPS) is estimated. We evaluate our approach by synthesizing artificial deformations and measure the distance to the re-constructed deformation. Results of our 3D-Forensic Analysis and Contextualisation of Aegean Seals and Sealings (ErKon3D) project will be shown.

A re-evaluation of the concept of type in coroplastic studies based on 3D shape analysis of terracotta figurines from Ayia Irini, Cyprus

Valentina Vassallo, Sorin Hermon, Andreas Scalas, Michela Mortara, Michela Spagnuolo

Coroplastic studies refer to the study of terracotta figurines mostly through an art history approach, where types and classes are defined through stylistic and aesthetic considerations. Such an approach is highly subjective and is based on the knowledge of the researcher interacting with the subject material. Moreover, the lack of agreed upon criteria for classification and the lack of quantitative attributes that would define one or another type make any comparative research a futile exercise. The problem becomes even more severe when the objects under investigation are dispersed in various museums in different countries and their initial description has been performed several decades ago within the traditional framework described above. The aim of this research is to propose an alternative method for the investigation of terracotta figurines, but which can be extended to other types of material culture as well, based on the identification and analysis of a set of features objectively describing the objects under investigation. Such features are based on descriptors meaningful for the characterization of the objects' shape, their mode of manufacture and techniques of production and which derive from a 3D geometry analysis and surface characterization. Some of these descriptors are: straightness, circularity, thickness, eccentricity, multiple transversal slices, etc. semi-automatically extracted from the 3D model. The case study consists of a sample of terracotta figurines from Ayia Irini, Cyprus. They are part of a larger assemblage of ca. 2000 statues with various shapes and sizes, excavated at the beginning of the 20th century.

Comparing sites, based on ceramic finds spectra.

Vincent Mom

Secanto is a computer program for comparing shapes of simple archaeological artefacts (vessels, arrow points, axes), resulting in objective and therefore reproducible 'shape distances' between the individual objects, as a measure of their dissimilarity. During the last decade the Secanto ceramics database has grown from about 400 Iron Age vessels from The Netherlands to 5000 vessels from Western Europe: from Denmark to the Iberic peninsula and from the Neolithic period to the late Roman Age period. The database is organized 'by publication', within most publications a further division into individual sites. Often a first step of the analysis of a sites' ceramic spectre consists of comparing the vessels found, an 'intra-site' comparison so to speak, to identify special shapes and to see which are the more common types. But the current database

set-up also enables, on a higher level, comparing sites with each other and, analogous to the shape-distances between individual artefacts, resulting in a dissimilarity measure between these different sites. As an example a number of Iron Age sites from The Netherlands will be compared with each other, and with a number of Iron Age sites from other European countries. How do these distances, based on their ceramic spectra, relate to their geographic distances? And what about time, can time be incorporated as an extra parameter in the distance calculations?

An object-based predictive model for "control places" location in Alpine Environment (Northern Italy)

Luigi Magnini, Armando De Guio, Cinzia Bettineschi

This contribution examines the potential of object-based image analysis (OBIA) for archaeological predictive modeling, by testing a rule-set for "control places" location on two test areas in Alpine environment (Northern Italy). The rule-set was developed on the Western Asiago Plateau (Vicenza province, Veneto) using a 5-meter resolution Digital Elevation Model (DEM) and subsequently re-applied automatically in the Isarco Valley (South Tirol) using a 2.5-meter resolution DEM. Firstly, we considered the physiographic, climatic and morphological characteristics of the selected areas and we applied 3 DEM processing techniques: slope, local dominance and solar radiation. Subsequently, we employed an object-based approach to classification. Slope, local dominance and solar radiation were visualized as a 3-layer RGB image which was segmented with the multiresolution algorithm of eCognition Developer 9.2. Classification was implemented with a rule-set that selected only image-objects with high local dominance and solar radiation, but low slope, which were considered more suitable parameters for human occupation. The classification returned five areas on the Asiago Plateau that were ground controlled, confirming an anthropic exploitation covering a time span from protohistory to the Frist World War for at least four of them. Subsequently, the same model was applied to the Isarco Valley to verify the replicability of the method. The procedure resulted in 36 potential "control places" which find good correspondence with the archaeological sites known in the area. The outcomes of the analysis proved the feasibility of the approach, that can be exported and applied to similar mountainous landscapes for site predictivity analysis.

From the photo to the size groups: Seeking relationships between artefact fragmentation and the use of the living space.

Michaela Prišťáková, Petr Dresler, Vojtěch Nosek

After more than 60 years of archaeological excavation at the early medieval site Pohansko near Břeclav (Czech Republic), a vast number of archaeological artefacts was collected. The most numerous are ceramic shreds, with more than 130,000 records. To better understand the use of the living space and relationships between various types of archaeological objects at the site, we decided to analyse the pottery fragmentation and its relationship to the space in which it was found. One of the most important questions of our research is, whether objects that are not recognizable by common terrain methods can be identified in this way. To process the considerable amount of data, a user-friendly and easily feasible method which does not require very specialised equipment had to be developed. The presentation will aim to discuss the methodology of data acquisition and its issues. Subsequently, the Matlab algorithm for mathematical image processing (originally created for anthropologists), its specification and results will be briefly presented. Values obtained from this algorithm allow us to statistically classify the artefacts into size groups and further using them for various spatial and statistical analyses. Particular emphasis will be placed on the search for relationships between fragmentation of artefacts and our current knowledge of the use of the living space on the site. The research is at the beginning therefore only preliminary results will be presented.

An Automated Approach to the Classification of Fragmented Faunal Remains using Differential Geometric Methods and Machine Learning

Peter J Olver, Katrina Yezzi-Woodley, Jeff Calder, Martha Tappen, Pedro Angulo-Umana, Bo Hessburg, Riley O'Neill, Jacob Elafandi, Reid Coil, Chehrzad Shakiban

Accurately identifying bone fragments and the agents that broke them is essential to site reconstruction and improving our understanding of human evolution and behavior. Here we present a new method of data extraction within archaeology using geometric invariants and machine learning on digital 3D models of experimentally derived bone fragments to classify them by breakage agent and method. Using surface curvature, our preliminary results using hominin and carnivore broken elk bones exhibit exemplary, pairwise, cross-validated, classification rates (>92% in all tests) at the assemblage level using the Kolmorgorov-Smirnov test (75% training and 25% testing) according to skeletal element, actor of breakage and, in the case of hominin broken bones, method of breakage. Here we characterize the surface with far more geometric properties (such as total volume, surface area, higher moments, torsion, and surface curva-

tures), and expand our sample to include other taxa (Bos and Ovis) and modes of breakage (e.g. rockfall). Several methods of machine learning are employed including K-Nearest Neighbors, Decision Trees, Random Forests, and, Neural Networks. Defined by mathematical parameters, these criteria can be automatically extracted from 3D models unlike more traditional, qualitative data that are more subject to inter-observer error. These methods quickly and efficiently capture and exploit a rich amount of shape information used for evaluating hypotheses regarding hominin behavior, surpassing the current state-of-the-art in zooarchaeology and taphonomy. Given the success of the preliminary research, we expect that individual specimens, not simply assemblage level trends, will be classifiable as to breakage agent.

Other session 29:
Our little minions, part 2: small tools with major impact

***Ronald Visser**, Saxion - University of Applied Sciences*
***Florian Thiery**, Römisch- Germanisches Zentralmuseum (Mainz, Germany)*
***Moritz Mennenga**, Lower Saxony Institue of Historical Coastal Research*

Medium Hall A, 16.00 – 17.40, 24 April 2019

In our daily work, small self-made scripts, home-grown small applications and little devices significantly help us to get work done. These little helpers often reduce our workload or optimize our workflows, although they are not often presented to the outside world. Instead, we generally focus on presenting the results of our research and silently use our small tools during our research. This session will focus on these small helpers ("little minions",) and we invite researchers to share their tools so that the scientific community may benefit and – perhaps – create spontaneously special interest groups. This session aims at short presentations – "minion talks" (max. 10 minutes including discussion) – of small software or hardware solutions, not only focusing on field work/excavation technology, associated evaluation or methodical approaches in data driven archaeology. Each "minion talk" should explain the innovative character and mode of operation of the digital tool. The only restriction is, that the software, code or building instructions are open and freely available (e.g. GitHub). Proprietary products cannot be presented (but tools designed for them). We invite "minion talks" that present small tools or hardware inventions related but not limited to the following subjects:

- data processing;
- measuring;
- digital documentation;
- GIS-Plugins;
- hands-on digital inventions (for excavations);
- Linked (Open) Data tools;
- ... etc.

We invite speakers to submit an abstract. But after last years spontaneous success of "Stand-up-Science", there will also be an opportunity to spontaneously participate and demonstrate what you have on your stick or laptop. If you want to participate without an abstract in the spontaneous section of the session, please send an email to us (even shortly before the conference). This is however not obligatory.

Please come and spontaneously introduce your little minion!

16.00 – 16.10
A Linked and Open Bibliography for Aegean Glyptic in the Bronze Age,
Martina Trognitz

16.10 – 16.20
My little text mining minion,
Ronald Visser

16.20 – 16.30
Taming Time Tools: Alligator and Academic Meta Tool,
Allard Mees, Florian Thiery

16.30 – 16.40
Serial, fast and low cost 3D pottery on site documentation,
Fanet Göttlich

16.40 – 16.50
CpyPst3D: a tool for direct exchange of 3D features with attributes between GIS, 3D-modeling environment and CAD,
Bart Vissers

16.50 – 17.40
General Discussion

A Linked and Open Bibliography for Aegean Glyptic in the Bronze Age

Martina Trognitz

Currently I am working with Aegean seals, which are all documented in the „Corpus der Minoischen und Mykenischen Siegel“ (CMS). The CMS is a long term project existing since 1958 which aims at documenting and publishing all known Aegean seals. The major part of this publication is done in 25 printed volumes and nine supplements which represent a fundamental research tool for the Aegean glyptic. Some of these volumes were digitised and are freely available (http://books.ub.uni-heidelberg.de/propylaeum/catalog/series/cms). Amongst these “A Bibliography for Aegean Glyptic in the Bronze Age” by John G. Younger is included (http://dx.doi.org/10.11588/propylaeum.367.518). This bibliography provides an ideal starting point into this research area, by not only providing references but also by grouping them thematically and geographically. The volume was published in 1991 and does not contain references later than 1990. Very recently a small project funded by the German Wikimedia Foundation Based was started in order to create an online interactive and easily extensible bibliography. Its initial content will collect all information available from the published bibliography. Data will be stored in Wikidata which allows anybody to collaborate, correct and extend information. The references will be pulled together via an API and presented to end users in a dedicated web interface (possibly based on Open Knowledge Maps) with filtering and exporting options. The whole project and its source code will be openly documented from its beginning throughout

its process and end. Final results aim to be generic enough to allow creating bibliographies for other subjects.

My little text mining minion

Ronald Visser

The Valletta treaty has led to an increase of archaeological research during the last decades. This has lead to an avarage of 7000 archeological reports per year over the last ten years (data: https://www.narcis.nl/search/coll/publication/Language/NL/meta_repositorygroupid/rce). To synthesize these results the Cultural Heritage Agency has started a program called the Oogst van Malta (The Yield of the Valletta treaty). The subject in one of the projects within this program is agriculture within cities. Due to the large number of reports that we had to analyse within this project, we decided to apply text mining to all reports to select the most useful reports. For this purpose only open source tools were used, with Arch Linux (https://www.archlinux.org/), R (https://www.r-project.org/, including several libraries) and PostgreSQL (https://www.postgresql.org/) being the main tools. The help of these minions saved an enormous amount of time and made the whole process more replicable. The digital workflow will be presented and shared during the session.

Taming Time Tools: Alligator and Academic Meta Tool

Allard Mees, Florian Thiery

Alligator and the Academic Meta Tool (AMT) are two prototypical little minions which in combination allow for establishing relative chronologies according to Allen's interval algebra as Linked Open Data. Starting with a correspondence analyse, this combination of tools achieves temporal reasoning with vague edge information in RDF graphs. The semantical structure of Alligator and AMT is described in ontologies to provide reproducible, interoperable and comprehensible research results. Alligator is developed at the Römisch-Germanisches Zentralmuseum Mainz (RGZM). It consists of an ontology and a web app for transforming correspondence analyses with fixed and floating time intervals into a relative chronology and Resource Description Framework (RDF) representation using Allen's interval algebra. The Academic Meta Tool is developed at the Mainz Centre for Digitality in the Humanities and Cultural Studies (mainzed), the RGZM and the i3mainz - Institute for Spatial Information and Surveying Technology at the Hochschule Mainz University of Applied Sciences. AMT allows for creating ontologies and provides a JavaScript framework for modelling vagueness in graphs, including reasoning, particularly modelled as RDF. This minion talk focuses on a short technical insight into the little minions Alligator and AMT. The tools are demonstrated with an example of Limes dating with Samian.

Serial, fast and low cost 3D pottery on site documentation

Fanet Göttlich

As part of a ceramics study of Iron Age amphorae from the site of Tell el-Burak (southern Lebanon), it was tested how three-dimensional recordings of the ceramic fragments can be included in their documentation and analysis. This pilot project aims at increasing the available data and therefore to improve the analytical procedures by adding 3D data. Compared to the standard drawing method these data are objectively recorded, can be used non-invasively and can be shared worldwide. During the campaign 2018, a trial setup was tested and several studies were conducted on the best recording technique. Subsequently, the parameters for the most successful processing path were tested and determined. The objective was initially based on the results of conventional ceramic documentation. Thereby, the method structure-from-motion was chosen for the three-dimensional documentation because of financial as well as organizational reasons. For optimal resolution and accuracy, many parameters of the method have been evaluated and adapted. The processing workflow has been adapted effectively by using appropriate software and its features. The calculated single 3D model represents the entire sherd, since finally the original find must remain in the country of origin. For foreign campaigns an uncomplicated, effective and cost-effective solution is important. Thus, only a serial and therefore fast and, above all, economic method meets the demands of documentation procedures abroad. This project is made possible by the cooperation of Johannes Gutenberg University Mainz (Dr. Aaron Schmitt) and the center for digital cultural heritage in museums (ZEDIKUM) - Staatliche Museen zu Berlin.

CpyPst3D: a tool for direct exchange of 3D features with attributes between GIS, 3D-modeling environment and CAD

Bart Vissers

3D-analysis and manipulation tools are increasingly available within GIS-software. Building an archaeological (intra site) 3DGIS-model may still involve working within different environments (GIS, modeling software, CAD). A small tool is presented, that directly transfers selected 3D-features and their attribute data between these environments, similar to copy-paste-functionality. This allows a more iterative workflow. The code has been written in C# and maxscript. For each feature in the selection, the 'transmitting' add-in stores vertices, edges, faces in a temporary buffer on disk, together with attribute data. Coordinates are transformed to a local coordinate system. The 'receiving' plug-in then translates the data from the buffer using platform-specific primitives and attaches the attributes. The tool is used as one of several auxiliary scripts for a 3DGIS of the stratigraphy of the Rokin-site in Amsterdam.

Standard session 31:
In pursuit of social space. Detecting activity areas in Palaeolithic contexts

***Gwénaëlle Moreau**, University of Liège (Belgium)*
***Vincenzo Spagnolo**, Università degli Studi di Siena (Italy) - Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente - U.R. Preistoria e Antropologia*
***Nuria Morera Noguer**, Universitat Autònoma de Barcelona (UAB)*
***Andrzej Wiśniewski**, Institute of Archaeology, University of Wroclaw,*
***Irene Ortiz Nieto-Márquez**, Universidad Complutense de Madrid*

Large Hall A, 16.00 – 18.00, 24 April 2019

The label "Palaeolithic site" encompasses a wide range of settlement organizational patterns, which are related to the mobility and economic strategies adopted by hunter-gatherer groups. The evidence of space management by hunter-gatherers constitutes a precious tool for the reconstruction of Palaeolithic settlement dynamics.

Usually, the only structuration elements of space that we can still see are zones with gradient densities of lithics and faunal remains. The introduction of GIS in Archaeology significantly increased our ability of detecting the structured components of space, reducing the subjectivity of the visual approaches, thanks to the parameterizing of data and application of the geostatistical methods.

In the intra-site scale of Palaeolithic sites, the Minimum Spatial Units represent the Activity Areas and their relations with possible features and structures in the site (both evident and latent). Detecting these Spatial Units requires a complex analytical protocol, including a taphonomic premise, as well as the palimpsest dissection (aimed to achieve a high-temporal-resolution) and the elimination of background noise (aimed to obtain a more refined reading of the evidence). In this regard, GIS is confirmed as the best analytical tool, due to its integrated structure and its scientific background in the field of spatial studies. Despite a wide variety of choices, in terms of analytical methods (e.g. KDE, Spatial autocorrelation, K-means, …), we are still far from a common study protocol which can produce effectively comparable results from different sites. However, our analytical methods must be flexible and context-specific, and adapt to differences in preservation, variability and temporal meaning of Palaeolithic sites (e.g. palimpsest-effect, functionalities of sites, …).

In this session, we would like to discuss activity area identification and interpretation processes. Our goal is to set up the basis required for the development of a common model of spatial-functional analysis within Palaeolithic contexts. We warmly invite papers in which integrated and multidisciplinary approaches are applied to gaining new meaningful data on Palaeolithic behaviour. Applications in different contexts, such as open-air, rock-shelter and

cave sites, living floors, short-term or long-term palimpsests, will be welcome. The results must encourage a better integration and comparability of spatial studies in Palaeolithic research.

16.00 – 16.20
A spatial analysis protocol to detect human's activity areas of Middle Palaeolithic open air sites from Northern France,
Gwénaëlle Moreau, Jean-Luc Locht

16.20 – 16.40
Hidden data. The spatial analysis process, from data definition to functional areas identification. Examples from some Italian Middle Palaeolithic sites,
Vincenzo Spagnolo

16.40 – 17.00
GIS spatial analysis of the Middle Palaeolithic site from SW Poland. Integrated approach,
Andrzej Wiśniewski, Marcin Chłoń

17.00 – 17.20
The Gravettian Levels from Arbreda Cave: Understamding the Formation of Residential Contexts of Pre-Late Glacial Maximum Hunter-Gatherers,
Isaac Rufí, Núria Morera, Joaquim Soler, Lluís Lloveras, Narcís Soler

17.20 – 17.40
Palaeo-GIS of chocolate flint mining area in Orońsko, Southern Poland,
Katarzyna Marta Kerneder-Gubała, Nazar Buławka, Sylwia Buławka

17.40 – 18.00
Geomorphometry in Palaeo-GIS applications: What landform analyses can contribute to the study of Palaeolithic landscapes,
Felix Henselowsky, Patrick Cuthbertson

A spatial analysis protocol to detect human's activity areas of Middle Palaeolithic open air sites from Northern France.

Gwénaëlle Moreau, Jean-Luc Locht

Defining the modalities of territory occupation has always been considered as a goal in Palaeolithic studies. To constraint these modalities, it is necessary to compare the management of various sites from a similar chronoclimatic context. Different methods allows us to precise this management and one of them is the spatial organization of human activities, which reflects the relationships between different human behaviors. During a long time, the detection of Neanderthal activities areas was complex and remaining on visual approach. The reason is that the only spatial structures, visible during the excavation of a Middle Palaeolithic site, are a relative density of archeological remains. However with the continuous growth of sites superficies and excavated remains, the bias linked to the visual approach became too important to be neglected. During the last decade, geomatics and more quantitative approaches based on GIS has been developed in order to describe quantitatively and more precisely Neanderthal's activity areas. However, methods used over different archaeological sites are mostly specific to each of them which ultimately develops intersites reproducibility and interpretations caveat. Thus without a reproducible methodology and comparable results, we cannot propose reliable comparison between Neanderthal's living space management from multiple sites. Therefore, during this communication, we propose a new systematic spatial analysis protocol adapted to Neanderthal open air sites in order to accurately detect and describe activities areas and their relationships. First meaningful results has been acquired on well preserved Middle Palaeolithic open air sites from northern France.

Hidden data. The spatial analysis process, from data definition to functional areas identification. Examples from some Italian Middle Palaeolithic sites.

Vincenzo Spagnolo

The spatial organization of a Palaeolithic site is a key to access fundamental information levels for the reconstruction of the Settlement Strategies of the Pleistocene-Early Holocene Hunter-Gatherers. The identification process of this spatiality in the sites is a complex and highly specialized task, that involves contributions from a wide range of disciplines. This implies both a strong multidisciplinary and the necessity of Spatial Archaeology specialists. GIS is a powerful tool but its use must to be aware, to correctly identify the actual structuration of the site. Contextual Archeology and behavioural approach find in Spatial Archeology and in GIS technology the natural terrain to express the multidisciplinary convergence of the research results in the

field of Prehistory. The introduction of an integrated and multidisciplinary approach for the study of some Middle Palaeolithic sites in Central-Southern Italy, returned promising results. The original protocol adopted in this research project is here presented. Schematically, the work-flow includes 4 main steps: 1) the definition data and geodatabase design, 2) the taphonomical analysis of the context, 3) the spatio-functional analysis of the data filtered by "background noise" and, finally, 4) the reconstruction of the activity areas and functional dynamics of the site. As shown in this research, a pivotal role is played by the first steps: the goodness of the results, indeed, is directly related with the "quality" of employed data.

GIS spatial analysis of the Middle Palaeolithic site from SW Poland. Integrated approach

Andrzej Wiśniewski, Marcin Chłoń

A deeper understanding of similarities and differences between archaic and modern humans would not be possible without attempts to reconstruct human behaviors. Currently, this is possible due to the popularization of Geographic Information Systems (GIS) and advanced spatial analysis in archaeology combined with traditional, typological and functional studies of artefacts. With the use of geostatistical methods, GIS enables us to evaluate quantitively spatial phenomenon on a different level of granularity (starting from regional up to the micro scale) The goal of this paper is to present the results of spatial analysis of the open-air site dated back to the beginning of MIS 3, containing remains related to Micoquian culture. Our study was focused on the reconstruction of the site formation processes including cultural as well as the geological stage. Analyses were undertaken with the use of ArcGIS and Past software. Kernel density analysis combined with the layout of vectors of refitted artefacts as well as fabric data (strike and dip of finds) led us to some conclusions. First of all, despite the influence of geological processes, at least three clusters of artefacts have been identified. Size of concentrations and layout of clusters suggest that they were most probably created at a similar time by the small group of people. In the light of records, it seems reasonable to discuss the question regarding position and number of flintknappers involved in the manufacture process. This work has been financially supported by the Polish National Centre of Science (no project 2017/25/B/HS3/00925).

The Gravettian Levels from Arbreda Cave: Understamding the Formation of Residential Contexts of Pre-Late Glacial Maximum Hunter-Gatherers.

Isaac Rufí, Núria Morera, Joaquim Soler, Lluís Lloveras, Narcís Soler

Arbreda Cave is one of the Reclau cave system, located in the municipality of Serinyà (Girona, Catalonia). This archaeological site preserves the largest and most detailed stratigraphy of the

area, providing the most accurate information about the changes that occurred from the Early Upper Pleistocene to the Holocene. This study focuses in the Gravettian levels E and D, dated between c. 26-20 ka 14C BP. Arbreda's E/D levels are chronologically well correlated with other Gravettian contexts of the nearby sites of Reclau Viver and Mollet III caves. However, in contrast to them, in Arbreda Cave there is no evidence of funerary contexts being only documented residential contexts in the site which help us to better understand the lifestyle of the Gravettian hunter-gatherers. Archaeozoological studies have demonstrated that subsistencial activities mostly focused on the hunting of horse, red deer and rabbit. Besides, the taphonomic analysis of faunal remains indicates an extensive bone exploitation – butchery activities, marrow extractions, use of bone as fuel and raw material to make tools. The aim of this paper is to provide new data about the formation dynamics of these two Gravettian levels and to interpret this data in terms of the use of the space by hunter-gatherer groups. To achieve this goal, we have based our research on the results obtained in the the archaeozoological and taphonomic study carried out previously. We have applied different geostatistic methods, such as techniques of density analysis and spatial correlation and autocorrelation.

Palaeo-GIS of chocolate flint mining area in Orońsko, Southern Poland.

Katarzyna Marta Kerneder-Gubała, Nazar Buławka, Sylwia Buławka

Orońsko (Masovian Woyvodeship) is located in north-western part of the chocolate flint outcrops in the Holy Cross Mountains, Southern Poland. Mining fields were discovered here by the Polish prehistorian Stefan Krukowski in the 1920s. They were dated generally from the Final Palaeolithic to the Early Bronze Age. Recent field research, employing surface surveys and excavations, has been conducted by the project "Exploitation and processing of chocolate flint during Palaeolithic and Mesolithic in the North-Western part of its deposits based on non-invasive archaeological and geophysical research and test-trenches" (UMO-2015/17/N/HS3/01279 financed by the National Science Center (NCN)). This project confirmed that the exploitation with the use of mining methods and processing of this raw material took place at least since ca. 13 000 years BP. Palaeolithic mining activity was connected with Arched Backed Piece (Federmesser Group) and Tanged Points Cultures (probably Bromme culture and Swiderian culture that is close to Ahrensburgian culture in Western Europe). Among the sites discovered, mineshafts , processing workshops, as well as living and hunting camps are widespread. These particular kinds of sites form a unique spatial network. It was possible to separate among them individual activity zones related to flint mining and processing, as well as to conduct the analysis of dependencies between sites and surrounding environment with the use of GIS.

Geomorphometry in Palaeo-GIS applications: What landform analyses can contribute to the study of Palaeolithic landscapes

Felix Henselowsky, Patrick Cuthbertson

Palaeolithic applications of Geographic Information Systems (GIS) are unique in the vastness of the spatio-temporal scales at which they operate. This vastness raises unique methodological and interpretive challenges. This paper will illustrate some of these challenges in the context of Digital Elevation Models (DEMs) and hominin dispersal for case studies in Central Asia and Northeast Africa. Terrain analyses and morphometric features of a study area can provide a broad range of information from which palaeo-landscapes can be derived. Two issues in particular are of major importance in geomorphometry: the spatial resolution of a DEM, and the spatial scale of landforms under consideration. A clear identification of various scales is important, as geomorphometry operates on a wide spectrum of scales ranging from a few millimetres up to several hundreds of kilometres, resulting in a wide range of landforms. The spatial extent of a given relief unit is thereby a common approach for landform classification in geomorphometry, where a hierarchy of landforms can be defined. A systematic application of this serves as (semi-) quantitative background to define specific spatial units. By integrating perspectives from geoscience and archaeology, we discuss first the level of scale, where resilient types of landforms can be investigated (to be analysed mostly quantitatively), and secondarily the level of scale, where human behaviour may have been influenced by landforms (to be analysed mostly qualitatively). The resulting analyses aim to provide an example of an integrated approach to the issue of scale within hominin dispersal.

Standard session 32: Multiscalar and Multivariate Approaches to Digital Documentation of Archaeological Sites

Alfonso Ippolito, "Sapienza" University of Rome
Dominique Rissolo, Center of Interdisciplinary Science for Art, Architecture, and Archaeology University of California, San Diego

Seminar Room, 11.00 – 11.40, 26 April 2019

Specific research objectives or priorities as well as unanticipated opportunities and challenges in the field often dictate that each portion of an archaeological site might not be documented at the same level of detail or via the same documentation modality. Either by design or by circumstance, data can vary greatly in terms of scale and, consequently, density or resolution. With the widespread adoption of photogrammetric techniques, new issues of data quantity and quality have come to the fore.

This session explores topics related to massive data acquisition, scalar diversity, and creation of hetergenous models. Digital images or image-derived data are commonly integrated into (and/or compared with) data acquired from laser scanning for the purpose of validation or texturing. However, imaging modalities need not be deployed in tandem to be considered complementary – as different objects, deposits, features, or structures (or components thereof) may call for the use of one technique versus another based on documentation objectives or situational realities. This session hopes to stimulate discussion on the potential benefits and limitations of integrative multiscalar approaches while evaluating the effectiveness and efficiency of practices currently in use.

11.00 – 11.20
Developing a digital documentation toolkit for the recording of coastal archaeology under threat,
Anthony Corns, Robert Shaw, Gary Devlin, Sandra Henry, Edward Pollard, Toby Driver, Louise Barker, Daniel Hunt, James Barry, Kieran Craven, Sarah Davies, Patrick Robson

11.20 – 11.40
Complex Study of Exogenous and Antropogenic Impact within Territory of Volga-Bulgar Fortified Settlements (Tatarstan, Russia),
Iskander Gainullin, Bulat Usmanov, Artur Gafurov, Alexey Kasimov

Developing a digital documentation toolkit for the recording of coastal archaeology under threat

Anthony Corns, Robert Shaw, Gary Devlin, Sandra Henry, Edward Pollard, Toby Driver, Louise Barker, Daniel Hunt, James Barry, Kieran Craven, Sarah Davies, Patrick Robson

Ireland's and Wales' coastline and marine environment contain many archaeological and historical sites which are at risk of being damaged or destroyed by the present and future effects

of climate change. Changes in sea level in combination with projected increase in the severity of coastal storms is expected to intensify coastal erosion and coastal flooding. The EU funded CHERISH Project (Climate, Heritage and Environments of Reefs, Islands and Headlands) of the Irish and Welsh regional seas is researching these threats and brings together a cross-disciplinary, cross-border team of specialists in the development of a field toolkit which will combine multiple complimentary approaches and methods to evaluate current and future risk. This paper focuses on several CHERISH toolkit remote sensing methods, which are currently being developed and employed within the project in both the terrestrial and marine environments to digitally document a range of archaeological sites and the surrounding historic environment, including: terrestrial and marine laser scanning, aerial and marine SfM, photogrammetric modelling of historic aerial imagery and terrestrial and marine geophysics. Critical evaluation of their approach, results and applicability to longer term monitoring will be explored, including: - The ability for field methods to detect coastal change of the historic environment - The development of proxy methods in the detection of climate change on marine archaeology - The evaluation of cost effective metric recording against costly high-end methods - Identifying the full extent of hidden subsurface archaeology features at coastal monuments and archaeological sites, which are at risk

Complex Study of Exogenous and Antropogenic Impact within Territory of Volga-Bulgar Fortified Settlements (Tatarstan, Russia)

Iskander Gainullin, Bulat Usmanov, Artur Gafurov, Alexey Kasimov

The report considers the modern condition of the archaeological monuments of the Republic of Tatarstan as an essential manmade part of the cultural landscape. According to UNESCO directive, the "cultural landscape" is considered not only as a result of cooperation between man and nature, but also as a natural and cultural territorial complex with a structural and functional integrity developing in specific physical and geographical, cultural and historical conditions. The identification and evaluation of monument destruction risks are a priority in the investigation of cultural heritage sites. A new method for assessing the risks of destruction of archeological monuments within the territory of fortified settlements with the use of remote sensing methods, complex field studies and cartographic-geoinformation approaches to data processing is developed. Modern instrumental methods applied in order to collect information on dangerous exogenous processes and anthropogenic impact within the monument territory. The scientific task of our work is creating a system for assessment of cultural heritage object (monument of archaeology) territory state using both archaeological and geoecological research methods.

Standard session 33: Digital Landscapes in Archaeology: From field recording to the reconstruction of human use of space

***Eduardo Herrera Malatesta**, Leiden University*
***Israel Hinojosa-Balino**, CIESAS/Durham University*
***Moisés Hernández Cordero**, IKAnt, Institute for the Study of the Ancient Culture*

Medium Hall A, 8.40 – 12.40, 26 April 2019

Since the early processualist approaches to the post-processual trend and the contemporary integration of disciplines, the study of landscapes in archaeology has been a long and fruitful sub-discipline. Within this development, the impact that Geographical Information Systems and spatial statistics have had on the contemporary advance of landscape research is undeniable. In particular, we have seen the creation of bridges between a wide range of disciplines such as cartography, environmental sciences, history, archaeology, geology, anthropology, computers sciences, among others. Computational methods have brought new avenues for research to the reconstructions of past landscapes, not only for the reconstructions of the ancient past but from contemporary landscapes and their (re)presentations in the context of community archaeology and heritage studies.

With this session, we aim to bring together researchers interested in reflecting on and debating the role of GIS-led research for the future of landscape archaeology, using cutting-edge methods for analysis of distributional patterns, understanding movement, digital reconstructions, etc. Contributions may deal with many aspects of this productive relationship, ranging from the collection of data in the field (small finds and landscape survey) and editing, processing, storing, sharing or visualizing it; to theoretically reflect the possibilities and scope for landscape reconstruction or analysis within GIS-led research.

We have no restrictions on the temporal or spatial contexts of case studies. However, we strongly encourage authors to reflect upon the session's issues using concrete case studies.

8.40 – 9.00
The missing landscape of the Mycenaean Argive Plain,
Victor Klinkenberg, Riia Timonen

9.00 – 9.20
Exploring GIS methods for reconstructing boundaries,
Irmela Herzog

9.20 – 9.40
Using LiDAR as a tool for remote archaeological prospection: the case of Salas and Cobertoria's barrow landscapes (Asturias, Spain),
Fernando Rodríguez Del Cueto, Miguel Carrero Pazos

9.40 – 10.00
Indigenous Landscapes in the Caribbean: Using network analysis and spatial statistics to revisit colonial representations of territory,
Eduardo Herrera Malatesta, Lewis Borck, Maroussia Favre Carlen, Jan Christoph Athenstaedt, Corinne L. Hofman

10.00 – 10.20
(De)constructing the Iron Age and Roman Landscape of Citânia de Sanfins (Portugal) through Geospatial tools. An interpretative model,
Sílvia Maciel, Rebeca Blanco-Rotea, Natália Botica, Manuela Martins

10.20 – 10.40
Prediction of paleolithic sites in KwaZulu-Natal, South Africa using remote sensing, digital landscape analysis and statistical classification,
Christian Sommer, Viola Schmid, Gregor Bader, Manuel Will, Michael Maerker, Nicholas Conard, Volker Hochschild

COFFEE BREAK

11.00 – 11.20
GPS Technology in Field Survey the MYCENAEAN SPERCHEIOS-VALLEY ARCHAEOGEOPHYSICAL PROJECT (MY.SPE.AR. Project 2018-2022),
George Malaperdas, Vayia Panagiotidis, Adrianos Psychas, Christofilis Maggidis, Nikolaos Zacharias

11.20 – 11.40
Cosmological conceptions that transformed the Nile Delta. A hydrological approach from pre-dynastic Egypt to the rise of Islam,
Israel Hinojosa-Balino

11.40 – 12.00
GIS-based approach in cultural landscapes investigations. The case of Dobużek Scarp microregion (E Poland),
Maksym Mackiewicz, Tomasz Jacek Chmielewski, Piotr Demczuk, Mirosław Furmanek, Igor Pieńkos, Jan Reder, Józef Superson, Mateusz Zawadzki, Paweł Zawiślak

12.00 – 12.20
Affordances and Purpose: Modelling Social Behaviour in the Landscape Using GIS,
David Novák

12.20 – 12.40
General Discussion

The missing landscape of the Mycenaean Argive Plain

Victor Klinkenberg, Riia Timonen

The core area of the Mycenaean civilization, the Argive Plain in Greece, is famous for its monumental citadels and burial tombs from the Late Bronze Age. Much less is known about the general population and the ancient landscape, due to a research focus on the citadels and to large-scale sedimentation in the plain, which deeply buried the Mycenaean surfaces. We use GIS to specify how these research- and geomorphological biases influence our knowledge of the Argive Plain and attempt to quantify what is missing. We present a revised landscape model for the region, based on geology, geomorphology and ancient and modern land use. After drawing a parallel with neighbouring regions, where pedestrian surveys were carried out, we suggest that earlier interpretations of the Argive Plain as an urbanized landscape is in need of revision.

Exploring GIS methods for reconstructing boundaries

Irmela Herzog

Boundaries at different scales or in different cultural contexts vary in permeability, fuzziness, and continuity. This paper explores the archaeological GIS toolbox for reconstructing boundaries using historical sources that cover a hilly region east of Cologne, Germany. The sources include two maps dating back to 1575 and 1607 created in the course and after a dispute concerning boundary sections of the Duchy of Berg. Additional historical data refers to religious and other administrative subdivisions of the Duchy of Berg. A linguistic boundary in the study area is said to be reflected by place names. After setting up a GIS layer storing the locations of about 1300 settlements mentioned before 1600 AD, hypotheses concerning place names can be tested easily. A traditional GIS method for delimiting territories is Thiessen polygon generation, variants adjust territory sizes depending on settlement sizes or replace straight-line distances by a least-cost distance measure, accounting for costs of transport and specifically the costs of traversing natural barriers. Alternatively, GIS methods for extracting candidates for natural barriers are proposed. Moreover, voids between different territories may indicate fuzzy boundaries, and based on settlement data, these voids may be detected using GIS methods. The approaches outlined above are explored with respect to their ability to reconstruct several known historical boundaries in the study region covering parts of the Duchy of Berg. Moreover, a new method integrating probable natural boundary sections, voids and known boundaries recorded in later periods is proposed and tested.

Using LiDAR as a tool for remote archaeological prospection: the case of Salas and Cobertoria's barrow landscapes (Asturias, Spain).

Fernando Rodríguez Del Cueto, Miguel Carrero Pazos

This paper explores a specific landscape in the central and southwestern part of Salas council. This territory contains five prehistoric cemeteries with thirty-two barrows, chronologically framed between the Neolithic and the Bronze Age. Our main goal is to compare the information provided by the sites and monuments records from the 90s with a set of data obtained thanks to LiDAR analyses. Specifically, the revised information will be the mound volumes, some sections and their measures; key information for the research of these prehistoric monuments and the spatial role that they played. As a remote survey method, LiDAR is offering a high contrast view of the current state of these elements, in order to reach conclusions about the accuracy of the field walking developed during the nineties and allowing us to update the current state of preservation of some sites. Also, this technique is being revealed as a more efficient method than traditional walking survey, specifically in this area where the vegetation is really abundant and makes impossible the access to some places in the forest. The other dataset that will be presented was obtained during the current excavations of the mound of Cobertoria (2016-2018). In this site, a burial chamber made of stone was built in the 3.500 B.C. However, several phases of construction could be identified in the tumulus, as for example one ring of red clay built prior to the stone structure. A cross-tab analysis of the composition of the clay used in the prehistoric structure and clay samples from the surroundings will led us to establish considerations about the time consumed from the quarry to the site, using LiDAR mapping in order to identify the possible outcrops.

Indigenous Landscapes in the Caribbean: Using network analysis and spatial statistics to revisit colonial representations of territory

Eduardo Herrera Malatesta, Lewis Borck, Maroussia Favre Carlen, Jan Christoph Athenstaedt, Corinne L. Hofman

What we know today of the Indigenous inhabitants of the Caribbean is the result of a process of cultural interpretation and representation originating from the colonial enterprise. For the island of Haytí, later renamed Hispaniola by Columbus, the first Spanish chroniclers define indigenous territories that represented diverse political hierarchies and cultures. This identification has been repeated through the years, reified in textbooks and histories until it represented the "truth" about the indigenous past for the general public in the Dominican Republic, Haiti, and even worldwide. Using regional surveys and extensive excavations throughout the

northern Dominican Republic, the Nexus 1492 project has compiled a database of archaeological information that provides enough data to evaluate the real existence of these territories in terms of material culture and archaeological regional patterns. In this paper, we will confront the Spanish model of the indigenous territories before the arrival of Columbus using three landscape methods to create a model built from different material culture and analyses. The first method uses network analysis to examine relationships revealed through material culture similarities to understand how social relationships might be interacting with the construction of authority. The second uses X-tent analysis to examine hierarchical patterns in archaeological site distribution. The third method evaluates the relationship between environmental variables and archaeological site distribution using Geographically Weighted Regression. These comparing and contrasting methods will allow us to generate an alternative image of the indigenous landscapes before the arrival of Europeans and critically review the Spanish representations.

(De)constructing the Iron Age and Roman Landscape of Citânia de Sanfins (Portugal) through Geospatial tools. An interpretative model.

Sílvia Maciel, Rebeca Blanco-Rotea, Natália Botica, Manuela Martins

The study of landscape is a fundamental step in the structural process of interpreting the life of past communities. It is the stage of diverse and complex dynamics that occurred at several levels such as political, economic, social and symbolic and left their imprint on the landscape. In this paper we present a process of deconstructing the landscape using the infinite possibilities that geospatial tools give us, to better understand those complex dynamics that happened in the Iron Age and Roman landscape of Citânia de Sanfins. And present the construction of an interpretative model based on the preexisting data, especially bibliographic data, and the data obtained by archaeological survey and the usage of the geospatial tools. To do so we established a physiographic unit of the territory that comprehends the natural limits, where the hillfort of Citânia de Sanfins is located. Within this territory we defined two micro units based on the characteristics of the territory, that we were able to study individually applying different sets of analysis, for instance locational, accessibility, mobility and visibility so that in the next step we could study this area at a macro level. This process allowed us to observe the diachronic and synchronic relationships displayed in this territory between the final stage of the Iron Age and the romanization process and establishment, also relate them to political, social, economic and spatial macro logics.

Prediction of paleolithic sites in KwaZulu-Natal, South Africa using remote sensing, digital landscape analysis and statistical classification

Christian Sommer, Viola Schmid, Gregor Bader, Manuel Will, Michael Maerker, Nicholas Conard, Volker Hochschild

South Africa and the province KwaZulu-Natal play an important role in evolution. Modern human archaeological record of the Middle Stone Age is known to be exceptionally rich and detailed, although the total number of sites is very low. Especially rock shelters like the site of Sibudu Cave, formed by fluvial bank erosion and undercutting of hard sandstone, yield long stratigraphic sequences that bear significant archaeological data. They provided protection to H. sapiens and furthermore, anthropogenic deposited sediments were preserved from intense erosional processes, which reshaped the Coastal Belt of KwaZulu-Natal in the Late Pleistocene. Therefore, we developed a method to localize landforms like these as a starting point for systematical archaeological exploration. We present the methodological approach to derive landform, terrain and hydrogeomorphology metrics from a high-resolution Digital Elevation Model (TanDEM-X) and proximate modelling of potential rock shelter sites by the use of different machine learning algorithms. Furthermore, we address the advantages and disadvantages of different classification methods, the influence of vegetation on the results and the limitations of the 2.5-dimensional elevation model. Finally, we present the expected outcomes of our ground truthing campaign in January/February 2019 and the validation of the method.

GPS Technology in Field Survey the MYCENAEAN SPERCHEIOS-VALLEY ARCHAEOGEOPHYSICAL PROJECT (MY.SPE.AR. Project 2018-2022)

George Malaperdas, Vayia Panagiotidis, Adrianos Psychas, Christofilis Maggidis, Nikolaos Zacharias

The goal of the MY.SPE.AR. Project is the systematic archaeogeophysical survey of the Spercheios Valley (total area 683km2), situated in Central Greece focusing on locating, documenting, mapping and analyzing environmental features in combination with the archaeological remains on the Mycenaean sites in the region. This documentation and analysis has begun and will be further implemented by the archaeological team using technologies such as Mobile GPS, UAV photography, satellite imagery analysis, remote sensing, spatial analysis with GIS, and test trenches. In June 2018 a surface survey was conducted, located mainly in the Lamia municipality, of sites documented by toponym from older field reports, Ephorate publications and, with the assistance of the Ministry of Culture. Using DGPS and mobile GPS devices the sites were identified and recorded along with any new sites found, throughout the study area. These coordinates, accompanied by photographs and descriptions were imported to ArcGIS for further

spatial and geomorphological analysis including aspect, slope, hydrology, geoseismic evidence, and the geology of the area. This analysis of different terrains as implemented by the MY.SPE.AR research team in remote locations is possible thanks to the availability of mobile GPS devices, mobile internet network connection and portable photographic devices. The above approach provides spatial and environmental context to the archaeological information regarding patterns and conditions under which these ancient sites developed and the possible interconnections between them. This information marks a significant contribution in the use of GPS technologies for the digital documentation and analysis of archaeological field work in Greece.

Cosmological conceptions that transformed the Nile Delta. A hydrological approach from pre-dynastic Egypt to the rise of Islam.

Israel Hinojosa-Balino

The Nile Delta, a natural landform in its destruction phase, was born about 7500 years ago. Since then, Egyptians, Assyrians, Persians, Greeks, Romans, Arabs, etc., have transformed it into a man-altered coastal plain replete with barrages, dykes, canals, dams, growing population, and urbanism. Different cosmologies with different—conscious and unconscious—ecological, political or economic agendas, have transformed the Nile Delta from a natural landscape to a very rationalised one. In this paper, a cosmologically oriented Geographic Information System (GIS) is presented, focusing on tangible cultural features related to specific ways of understanding the world by the dominant culture. This GIS constitutes the analytical framework to create an approximative animated model to represent the ancient annual flood and its potential impact on urbanism; hydraulics modelling will be used to estimate water levels and flood extents for rivers and watercourses.

GIS-based approach in cultural landscapes investigations. The case of Dobużek Scarp microregion (E Poland).

Maksym Mackiewicz, Tomasz Jacek Chmielewski, Piotr Demczuk, Mirosław Furmanek, Igor Pieńkos, Jan Reder, Józef Superson, Mateusz Zawadzki, Paweł Zawiślak

Dobużek Scarp is an almost two kilometer long segment of the right bank of the Huczwa river's valley that rises as high as 40 meters above its base. This prominent escarpment constitutes an easily defensible position, whereas a loess plateau above it offers favourable conditions for agricultural settlement. Although not inhabited today, the place seems likely to have attracted certain communities in prehistory. Surveys undertaken in 2012 recorded four enclosures dated to the fourth millennium BC. The discovery of these enclosures and of numerous other features

that could be firmly dated back to the period between 4th and 1st millenium BC led to extended project intended to shed more light on cultural and natural factors affecting dynamics of the local prehistoric landscape. Spatial data of different types, scales, and precision were generated at various stages throughout this project. The multifaceted and multiscalar studies slowly reveal the Dobużek Scarp as a prehistoric place of supra-regional importance – a juncture between the Baltic and Pontic areas. Field walking yielded detailed picture of surface finds' dispersion and thereby general map of prehistoric settlement within the range of six kilometers from the scarp. Magnetic prospection of more than 60 hectares gave a basis for more detailed reconstruction of the range and diversity forms of land use on the hypothesized central place. Additional compulsory data were provided by geoarchaeological and archaeological soundings. The analyses were conducted with the use of external spatial data such as archival or modern dedicated maps, ALS, and airborne and satellite imagery. These data were recorded in GIS that now enables various visualizations and analyses of the data collected.

Affordances and Purpose: Modelling Social Behaviour in the Landscape Using GIS.

David Novák

In 1986, J. J. Gibson introduced a term "affordances" into the scholarly communication. He stated that latent potentials may be tracked in the landscape and used to understand human behaviour. By the means of proper theory and methods, it is possible to model these potentials for the past landscapes and use them as a descriptive framework for the archaeological data. On the example of the analysis of medieval and post-medieval elite seats in the Bohemia region (Czech Republic), a specific methodology will be presented as a way to describe possible differences in motivations for foundation and usage of sites. Using high-resolution DEM as a background, various properties of the landscape – like visibility, accessibility, settlement network, water bodies network, landform types, etc. – were modelled and analysed to find the functional potentials of the seats. Subsequently, based on clearly stated hypotheses, the potentials were computationally combined to help to interpret possible purpose of sites for the past society. Combined with distribution analysis, presented method shows a perspective way for the GIS-based studies of the landscape.

Standard session 34: Archaeological Data for Modern Problems. Modern Methods for Archaeological Questions

Stefani Crabtree, Pennsylvania State University
Iza Romanowska, Barcelona Supercomputing Center

Large Hall A, 9.40 – 15.00, 25 April 2019

Challenges faced by modern societies like climate change, epidemics, mass migration, or uneven wealth distribution may seem insurmountable, but they have their analogues in the past. The scale of the challenges may be different, yet the scope of the problems remains the same. Past peoples dealt with anthropogenic change, population shifts, disease, and famine, and the myriad other issues similar to the ones we face today. Some of them were successful in combating these challenges, some of them less so. With the onset of big data, robust computational analysis, scientific approaches to data collection, sampling and modelling, the notion that archaeology is a modern scientific discipline that can contribute useful insights to today's problems has gained momentum. With the technological shift it is no longer regarded as naive to suggest using archaeological and historical data to extend and calibrate our understanding of the present and to try to provide more informed predictions for the future. The question, though, is how do we do that?

In this session we welcome papers from archaeologists whose computational analyses have implications for understanding one of the following broad topics:

- climate change and resilience;
- migration;
- health science;
- wealth distribution;
- cultural identity.

The goal of this session is to encourage researchers to actively use their case studies to approach modern challenges and/or to use their data to bear on influencing public policy. Thus, each of the segments of the session will be followed by an invited discussant – a researcher outside the domain of archaeology who will comment on how data and models from past systems could help with modern challenges.

This session will be punctuated with several breaks for discussion, and the organizers will work as facilitators to bridge questions between practicing archaeologists and economists, climate scientists, public health experts, urban planners, and other scientists whose work could

benefit from dialogue with archaeologists. It is the ultimate goal that this session will lead to constructive collaborations between archaeologists and scientists from other disciplines to solve the largest of today's problems.

9.40 – 10.00
Ecological Marginality and Internal Migration on the Mesa Verde North Escarpment,
Kelsey M Reese

10.00 – 10.20
Promoting human and environmental health by tailoring evidence-based action to local context,
Ross Alan Hammond

10.20 – 10.40
Is Now a Good Time? Bridging Past and Present with Models and Modeling,
John T. Murphy

COFFEE BREAK

11.00 – 11.20
Using the Deep-Time of Archaeology to Understand the Interface of Human and Environmental Health,
Stefani A. Crabtree

11.20 – 11.40
Off they went! What past migrations can teach us about the present and the future of Homo sapiens,
Iza Romanowska

11.40 – 12.00
"Don't put all your eggs in one basket": modelling cropping strategies and climate change in the Indus Civilisation,
Andreas Angourakis, Cameron A. Petrie

12.00 – 12.20
Open Science, Networks, Archaeology and Physics,
Marc Santolini

12.20 – 12.40
General Discussion

LUNCH BREAK

14.00 – 14.20
Programing Human Behavior. Towards a Library of Universal Algorithms,
Florencia Del Castillo Bernal, Juan Antonio Barceló, Xavier Vila

14.20 – 14.40
The climate changes on the Boreal-Atlantic transition in the Tyrol highmountain area as a factor influencing Mesolithic people up-down migrations,
Albert Wydrzycki

14.40 – 15.00
General Discussion

Ecological Marginality and Internal Migration on the Mesa Verde North Escarpment

Kelsey M Reese

Agriculturally-reliant societies are especially vulnerable to changes in climatic patterns and increases in local populations. Increases in population require more food to be produced, while extreme climate volatility results in progressively unreliable annual agricultural yield. In the northern U.S. Southwest, maize agriculture provided 70% of annual calories in the ancestral Pueblo diet from A.D. 880–1300. This paper presents a case study from the Mesa Verde North Escarpment, an ecologically marginal and culturally liminal space occupied from A.D. 600–1300. This paper will present a localized maize paleo-productivity model—an approximation of annual prehistoric maize yields from retrodicted precipitation and temperature records—and a regional demographic reconstruction to trace potential periods of internal migration through the north escarpment in response to climate change. The production and maintenance of trade networks that could supplement poor annual maize yields on the ecologically marginalized north escarpment, and the regional ramification of supporting such a population through hard times will also be explored. The longitudinal scale of this study can inform the point at which populations no longer respond to climatic hardships with trade or small-scale movement. This case study will be used to examine the effects of climate change on local population responses to food shortages, the points at which supportive trade networks break down, the levels of resiliency in local populations when a space is increasingly uninhabitable, and the climatic conditions in which societies determine life is no longer sustainable in the area.

Promoting human and environmental health by tailoring evidence-based action to local context

Ross Alan Hammond

Major health threats now facing developed and developing countries alike, such as the obesity pandemic, are challenging to solve. In many cases, human health and environmental health are deeply interconnected with dynamics strongly shaped by local context. These challenges are not new with similar issues faced in the archaeological record. This talk will introduce the concept of "precision prevention" and provide an overview of new work at the intersection of complex systems science, public health, and environmental science that is helping policymakers to address these challenges by tailoring action to local context using tools from complex systems science. These tools are also being used in archaeology, suggesting synergy between potentially disparate fields of science. Using these complex systems approaches on the archae-

ological record we can calibrate our understanding of modern challenges and potentially aid in prevention of pandemics.

Is Now a Good Time? Bridging Past and Present with Models and Modeling

John T. Murphy

Science conceived as a social and historical process is shaped by contingent factors that include, inter alia: theoretical frameworks within which research takes place; tools, including computational power and software; data available in different forms; a larger social milieu that directs the lines of inquiry that can be pursued (often enforced by funding, etc.); and institutional and professional structures that can impose additional constraints. The rise of computational models and modeling in archaeology can be viewed through this lens, and its trajectory over the past several decades inspected for the ways that these currents have buoyed and swept it. The ways in which it is today contributing to new areas of study or even disciplines (e.g. 'archaeohydrology') provide examples for further inquiry. The use of models and modeling to bring data and insights about archaeological contexts to present-day issues can also be considered in this light: What roles does modeling play in doing this? What can it be doing, given the current states of theory, tools, and data that it exists within right now? Recent case studies in which the author(s) have been involved will be presented in which models and modeling have been applied to archaeological and contemporary settings; these cross urban and regional settings and specifically consider issues of sustainability, resilience, risk, and vulnerability. A recent workshop sponsored by iHOPE and hosted at SESYNC, with an explicit focus on applying lessons from two areas (Maya and Mesopotamia), will be used as an entry to the discussion.

Using the Deep-Time of Archaeology to Understand the Interface of Human and Environmental Health

Stefani A. Crabtree

Our understanding of the dynamics and stability of human systems cannot be uncoupled from their environmental contexts. While most work on coupled natural-human systems focuses on modern systems, there is an enormous amount of anthropological and archaeological knowledge that can deeply inform, enhance and transform our understanding of socio-ecological dynamics and sustainability. Work on past systems where we know the system's trajectory can provide a powerful framework for addressing socio-ecological resilience, stability, and robustness in response to natural and human perturbations and change. In this paper we use the deep time of the archaeological record in conjunction with modern ethnographic work to

address the intersection of environmental health and human health. We highlight work recreating human-centered food webs and assess traditional roles of humans within environments and ecosystems. Using these datasets we demonstrate how modern approaches, such as agent-based modeling and trophic network modeling, can shed light on the complex human-environment-health intersections of the past and offer that these approaches can help calibrate our understanding of our place in the global ecosystem in the present and into the future.

Off they went! What past migrations can teach us about the present and the future of Homo sapiens

Iza Romanowska

You can find humans across the whole Earth: on tiny specks of land in the middle of great oceans, in the searing heat of the world's hottest deserts, surviving arctic winters and the relentless drizzle of Northern Europe. Humans seem to be anywhere and everywhere. And although some of these locations may be more pleasant than others, our species seems to be finely adapted to virtually any biome on Earth. Even though such a wide geographical distribution is virtually unprecedented in the animal kingdom, the mechanisms that led to it are not. In the course of human evolution hominins were subjected to the same climatic fluctuations as well as evolutionary laws as any other species. In this paper we will explore the interaction between climate change, evolution of behavioural plasticity and the process of the dispersal. It will be argued that by using simple abstract agent-based models we are now able to better understand the interactions between the different external forces on the evolution of hominins and their patterns of dispersal. This understanding can be fundamental to our ability to predict and, to some extent, to shape our responses to some of the current challenges such as rapid climate change, mass migrations and societal resilience in the face of natural disasters. However, important issues remain such as different scales of analysis, uneven data record and the challenge of translating models and data across disciplinary boundaries.

"Don't put all your eggs in one basket": modelling cropping strategies and climate change in the Indus Civilisation

Andreas Angourakis, Cameron A. Petrie

The urban phase of the Indus Civilisation (c.2500 to 1900 BC) spanned areas with extremely diverse environments, where two rainfall systems, winter and summer, overlap. The decline of Indus urban is often linked to the regional-to-local consequences of the 4.2 ka BP climate change event, so the Indus Civilisation creates an opportunity to examine how societies can respond

to climate change events that are detrimental to food production. The multi-disciplinary Two-Rains project is looking beyond the coincidence of climate change and the onset of Indus urban decline to understand human adaptation to variable rainfall systems, the local expressions of climate change, human response to it, and the resilience and sustainability of the choices that were made in the face of variable and changing climate. Focussing on NW India, the project has collected data on settlement distribution and material culture, but also evidence of water stress, food production and consumption. As a step towards synthesing data and reaching a robust explanation of the possible connections between climate and societal change, we are developing an agent-based modelling programme to explore if and how the diversity in cropping strategies affects the productivity and resilience of small local producers. We are particularly interested in exploring how these factors operate when farmers were coping with diverse and changing environments, and how it would impact the levels of regional food production required for maintaining urban centres.

Open Science, Networks, Archaeology and Physics

Marc Santolini

In this paper we will cover two topics that we think can contribute to modern-day, quantitative analyses of archaeological data. First, we will give an overview of the open science and citizen science movements. We will show how the use of data crowdsourcing and the design of collaborative platforms has been able to boost data collection and analysis in multiple areas, ranging from health to ecology, to cellular biology and astronomy, through the gathering of a great diversity of actors, from academics to local stakeholders and citizens. As a field where data collection is an intensive but key process, we believe that Archaeology could benefit from such methods. Second, we will present recent advances in the interdisciplinary field of Network Science, with a particular focus on health sciences and team collaboration networks. While archaeologists have been embracing network analysis in their research, here we will show how the spectrum of observed topologies from various interaction networks can lead to crucially different outcomes (e.g., team failure vs. success). We suggest that such an approach is highly adaptable to archaeology, where large-scale historical datasets with both interaction and outcome data could be leveraged for a better understanding and forecasting of our future resilience, moving archaeological studies beyond reporting what has occurred in the past to calibrating our models for the future.

Programing Human Behavior. Towards a Library of Universal Algorithms.

Florencia Del Castillo Bernal, Juan Antonio Barceló, Xavier Vila

Artificial societies and agent-based models are being used in archaeology with increasing success. We can find applications in many different domains from evolution theory and the hominization process to the formation of complex societies. However, much of the effort in programming those simulations of human life is lost because the discoveries and innovations made in one project cannot be "reused" in another simulation. In this paper we suggest a library of re-usable algorithms about different social mechanisms. For example, in simulations of pedestrian movement: if the model includes agents that should walk, you can use some already tested algorithms. We propose a similar approach in the case of prehistory, considering universal "universal" social mechanisms from the point of view of archaeological data: "Hunting", "Gathering", "Cultivating cereals", "Animal breeding", "tool making", etc. To move in this direction, we have investigated the models library in the Netlogo site (thousands of examples) and organized them thematically into a library of scripts implementing different social mechanisms that are useful for archaeologists and social scientists. In the paper, we discuss the theoretical aspects of social mechanisms from the point of view of analytical sociology, and we also discuss the challenges that alternative implementations of the same mechanism may generate.

The climate changes on the Boreal-Atlantic transition in the Tyrol highmountain area as a factor influencing Mesolithic people up-down migrations

Albert Wydrzycki

In the turn of the Boreal/Atlantic period, the climate was more humid and cooler than in Boreal times. During 8.2 ka event, the Mesolithic hunters, who from spring to autumn lived in the Tyrol area at an altitude of about 2000 m a.s.l. and higher had to travel to lower altitudes because the snow lasted longer and the number of hunting prey was decreased. The spatial analysis methodology, which is created in QGIS software can be used to identify at which archaeological sites this phenomenon occurred, specifically by examining the reduction of quantity of seasonal camps and stone tools. The results of this study indicate on very intensive change of settlement strategies in the Mesolithic and more broadly that "migration" is often connected with climate changes.

Other session 35:
Extreme Data Processing in Archaeology

Sebastian Cuy, Deutsches Archäologisches Institut
Benjamin Ducke, Deutsches Archäologisches Institut (DAI)
Reinhard Foertsch, German Archaeological Institute
Marco Block-Berlitz, University of Applied Sciences Dresden (HTW Dresden) Germany

Seminar Room, 14.00 – 15.00, 25 April 2019

Computational tractability (in practical terms: the question of whether it is possible to compute useful results within an acceptable time frame) is a decisive factor in many areas of archaeological data processing. Examples for this include high-resolution geophysical surveying, remote sensing, terrestrial and aerial laser scanning, image processing and image-based 3D reconstruction, high-detail simulation models and cost-distance based GIS analyses.

Obtaining the best possible results from the processing of extremely large volumes of data requires engineering skills, creativity and sound knowledge of optimization techniques: The limits of available resources define the possibilities of data analysis and scientific inquiry more often than would be desirable. Knowing how to push these limits becomes a hallmark of cutting edge research.

The predominant constraints of "practical computability" tend to fall into a relatively small but persistent number of categories:

1. The available resources are insufficient for the tasks at hand.
2. Automated solutions are not available for the entire processing chain.
3. Sensor speeds and resolutions advance faster than (affordable) processing and storage technologies.
4. Some processing tasks are of (presumably) intractable mathematical nature ("NP-hard" problems).

Frequently enough, such issues occur in concert and interact with each other to create technically challenging scenarios. The great efforts that the archaeological community invests into addressing and overcoming these challenges are often underrepresented (if not to say absent) from the forefront of academic discourse and publications. This session aims to make a contribution towards creating stronger awareness of the immense technical skill sets at work behind the scenes of many archaeological research projects and exposing their vital contributions to modern research.

We invite speakers willing to showcase working solutions to the challenges of extreme data processing in archaeology, including "brute force approaches" to hardware and software engineering (such as concurrent/parallel processing pipelines and GPU-based processing), "soft approaches" (employing smart heuristics, sampling strategies and divide-and-conquer

approaches), but also creative and efficient solutions for automating time-consuming manual tasks.

Important notes on session format: This session is meant as an open forum for the immediate benefit of all participants. Contributors should be prepared to give full technical details and insight into their approaches and technical solutions. This includes (where applicable) granting looks into program and/or scripting code, as and if requested by the participants. Contributors are asked to reserve at least one half of their time slot for impromptu technical discussion (with the participation of the audience), detailed showcasing and live demonstration. All accepted contributors are strongly encouraged to contact the session organizers well in advance to discuss the technical and procedural requirements of their contribution.

14.00 – 14.30
Can we process all data we capture on the field? The limits of processing high detail Structure from Motion data on Late Antique urban sites,
Moises Hernandez-Cordero

14.30 – 15.00
What's missing? Comparing large-scale magnetometry results with excavation datasets,
Gábor Mesterházy

Can we process all data we capture on the field? The limits of processing high detail Structure from Motion data on Late Antique urban sites.

Moises Hernandez-Cordero

Recording remains in Archaeology is the primary step to later processing and analysing the data capture. Urban structures on late Antiquity buildings can provide vast amount of data for research and analysis in terms of urbanism, planning, building construction techniques, and social patterns. The aim of this paper is to present the results of the three years building survey on an urban environment (ancient city of Side, Turkey) and the difficulties of combining large quantity of data (10.000 to 12.000 images) with different sensor resolutions (DLRS cameras, drone camera) and weather conditions. Using primarily Structure from Motion technique (SfM) for the workflow, the idea is to show and discuss the limits of this technique using a well-known software (Agisoft Photoscan) and different hardware processing configuration solutions (laptop, workstation, workstation cluster and server cluster) for archaeologists. Besides, it will offer some suggestions to manage the dataset using small scripts on Python. To conclude, the paper will highlight the main hindrances of using this approach with respect to the outcome datasets from the SfM software (point clouds and meshes), the difficulties dealing with huge size dataset on 3D software (Blender), CAD software (AutoCAD, Recap) and GIS software (ArcGIS).

What's missing? Comparing large-scale magnetometry results with excavation datasets

Gábor Mesterházy

Over the past years large-scale geophysical measurements became more and more common as a survey method for different scientific and development-led archaeological projects. The collected large datasets opened new opportunities in archaeological prospection and in archaeology as well. Meanwhile, we have to keep in mind that the limitations and restrictions of the applied method have also became larger due to the bigger extent. In the past 5 years we have integrated magnetometer surveys into the Hungarian cultural resource management as a standard tool, covering more than 20 km2 with magnetometry on different planned motorways, industrial parks and various investment projects. We have started with an Overhauser GSM-19 gradiometer but due to capacity problems we have changed to Sensys push carts. Probe distance was 50 cm for both cases. Usually large-scale preventive excavations had also been made for these projects, creating a unique possibility to compare the two datasets in large areas. The aim of this presentation is to introduce a method, which measures and automatically analyze the physical and cultural properties of archaeological phenomenae by comparing magnetometry, survey interpretation and excavation features. The first step is the structural data exchange from

excavation dataset (AutoCAD) to shape file data format in a semi-automatic way, where the excavation, feature borders and different heights (original surface elevation, excavation surface, inside features) are extracted and separated in a standardised form. During the second step these standardised files are compared with the filtered and gridded (25x25 cm) measurement files and the archaeological interpretation as a black box solution. Physical properties of the features (top-soil depth, feature depth, size, cubic content) are calculated in order to classify the features. The interpretation and the excavated features are overlapped also to measure the accuracy of interpretation (hit percent and extent too). And finally, in different buffer zones around the excavated features the characteristics of the filtered measurement values are collected and compared. The toolbox was created in order to be user-friendly in ArcGIS ModelBuilder, where the users only have to choose the required files and approve or change the predefined settings.

Roundtable 36:
User Experience Design in Archaeology and Cultural Heritage

Francesca Dolcetti, University of York
Sara Perry, University of York
Rachel Opitz, University of Glasgow

Exhibition Room A, 8.40 – 12.40, 25 April 2019

Despite the widespread dissemination of digital tools and applications in both archaeology and heritage, relatively little is known about their real effectiveness and impact on diverse audiences (specialists and lay publics alike). A new iterative design workflow, involving end users and stakeholders from the outset, as well as an accompanying design evaluation methodology, may open new avenues for engagement while, at once, constructively influencing our research objectives and epistemologies.

In this Roundtable session, we seek to bring together a multidisciplinary group looking at different aspects of archaeological knowledge production to discuss theoretical and methodological issues in the field of participatory design and user experience, fostering a critical understanding of how this knowledge is used and its social impact. The aim is to convene researchers and practitioners in a dialogue that is focused on examples of interdisciplinary co-creation and user testing of Augmented, Virtual and Mixed Reality (AR, VR, and MR) and related digitally-mediated experiences for museums, archaeological and cultural heritage sites, and varied teaching and research contexts. We are particularly interested in practical experiences around how to integrate archaeological data, storytelling and digital platforms to create experiences truly tailored to the needs and expectations of users.

The format of this Roundtable is a series of flash position papers (10 minutes maximum) followed by periods of moderated discussion. The session concludes with an open floor discussion and a wrap-up report summarising the discussion and suggesting follow-up activities. Position papers will be submitted in advance to the session chairs and shared with all panelists. The session welcomes participants from different sectors including but not limited to digital humanities, archaeology, museology, design research and Human-Computer Interaction (HCI).

8.40 – 8.50
Ksar es Said: Building Tunisian young people's critical engagement with their heritage,
Paola Di Giuseppantonio Di Franco, Mark Winterbottom, Fabrizio Galeazzi, Michael Gogan

8.50 – 9.00
From heterogeneous data to heterogeneous public: thoughts on transmedia applications for digital heritage research and dissemination,
Damien Vurpillot, Perrine Pittet, Johann Forte, Benoist Pierre

9.00 – 9.10
User Interface Design and Evaluation for Online Professional Search in Dutch Archaeology,
Alex Brandsen

9.10 – 9.30
Discussion

9.30 – 9.40
Unintended Outcomes – VR, Heritage and User Engagement,
William Michael Carter, Rhonda Bathurst, William Ciaran Lim-Carter

9.40 – 9.50
Engaging visitors with 'invisible' heritage: lessons learned on the impact of digital media, immersion, sound and storytelling,
Jenny Wilkinson

9.50 – 10.00
Mixable reality, Collaboration, and Evaluation,
Erik M Champion

10.00 – 10.40
Discussion

COFFEE BREAK

11.00 – 11.10
Design thinking in Cultural Heritage,
Neil Jakeman

11.10 – 11.20
Managing Engagement Design Risk through Creative Constraints,
Claire Boardman

11.20 – 11.30
Creating a unified design system across web, mobile, AR and VR,
Damir Kotorić, Luke Hollis

11.30 – 11.40
Inclusive Digital Engagement for Heritage,
Eleonora Gandolfi, Grant Cox

11.40 – 12.00
Discussion

12.00 – 12.40
General Discussion

Ksar es Said: Building Tunisian young people's critical engagement with their heritage

Paola Di Giuseppantonio Di Franco, Mark Winterbottom, Fabrizio Galeazzi, Michael Gogan

This paper describes the work undertaken as part of the Digital Documentation of Ksar es-Said Project. This project, funded by the British Council, combined education, history, and heritage for the digital preservation of tangible and intangible aspects of heritage associated with the 19th cent. Palace of Said in Tunis. We produced an interactive 3D model of Ksar es-Said and developed learning resources to build Tunisian students' critical engagement with their heritage through enquiry learning activities in the 3D model. We used a user-centred approach, based on pre-assessment, mid-term evaluation and post-assessment design. The selection of effective technologies, and the design of the online platform and its associated contents was a complex, non-linear process. It required formal and informal meetings, focus groups, and interviews to various stakeholder, as well as an important process of mediation between the different stakeholders involved in the co-creation of contents. While the selection of final contents and activities for the platform required us to reduce the complexity of intangible aspects of Tunisian heritage into a small number of 'themes', preliminary assessment of the activities suggests that the learning method proposed is an effective way to actively engage young Tunisian students with the concepts of hybridity and complexity and leaves an open space for teacher-students discussions around constantly changing heritage-values.

From heterogeneous data to heterogeneous public: thoughts on transmedia applications for digital heritage research and dissemination

Damien Vurpillot, Perrine Pittet, Johann Forte, Benoist Pierre

In recent years, we have seen a tenfold increase in volume and complexity of digital data acquired for cultural heritage documentation. Meanwhile, open data and open science have become leading trends in digital humanities. The convergence of those two parameters compels us to deliver, in an interoperable fashion, datasets that are vastly heterogeneous both in content and format and, moreover, in such a way that they fit the expectation of a broad array of researchers and an even broader public audience. Tackling those issues is one of the main goal of the "HeritageS" digital platform supported by the "Intelligence des Patrimoines" research program. This platform is designed to allow research projects from many interdisciplinary fields to share, integrate and valorize cultural and natural heritage datasets related to the Loire Valley. From the valorization perspective, one of our main initiative is the creation of the "Renaissance Transmedia Lab". Its core element is a website which act as a hub to access various interactive experiences linked to research projects about the Renaissance period: augmented web-documentary, serious

game, virtual reality, 3D application. We expect to leverage those transmedia experiences to foster better communication between researchers and the public while keeping the quality of scientific discourse. By presenting the current and upcoming productions, we intend to share our experience with other participants: preparatory work and how we manage with researchers to produce, in cooperation, tailor-made experiences that convey the desired scientific discourse while remaining appealing to the general public.

User Interface Design and Evaluation for Online Professional Search in Dutch Archaeology

Alex Brandsen

This paper will describe preliminary results from the ongoing user study with a small (n=9) representative group of archaeologists, in relation to the AGNES system. AGNES stands for 'Archaeological Grey-literature Named Entity Search'. The search system has a web interface that allows archaeology professionals to search through a large collection of Dutch excavation reports. The purpose of the user study is twofold: (1) to collect user requirements and (2) to evaluate the search system under development. This is achieved by periodic workshops. In the evaluation stage both the UI and the search result quality are evaluated by users. The evaluation is done by screen capturing and the "thinking aloud" method, which asks users to motivate every interaction with the system, and explain their reasoning. This is combined with a more traditional UI feedback questionnaire. All evaluation is done with both controlled use (completion of a given task) as well as free use (completion of a freely chosen task). This empirical evaluation is combined with statistical evaluation of the system by analysing query/click stats as well as click heatmaps, created by user tracking. The iterative, user-led design process combined with intense evaluation and end-user involvement from the start of the project should ensure a more suitable, user-friendly and efficient tool for the target audience.

Unintended Outcomes – VR, Heritage and User Engagement

William Michael Carter, Rhonda Bathurst, William Ciaran Lim-Carter

This paper will discuss the ad hoc deployment of an archaeologically informed Virtual Reality research project, Longhouse VR, as a semi-permanent exhibit at the Museum of Ontario Archaeology (MOA). Originally intended as an exploration of the intersection of technology and archaeology, speaking specifically to the archaeological community, the research project's aims were primarily around the construction of new archaeological knowledge through the 3D making process. The platform for interactivity was an HTC Vive VR headset and gaming engine, allowing for real-time user engagement, immersion and limited interactivity. As it was

never intended for public use, notions of user engagement were secondary to the display and new knowledge creation of the archaeological record. We will explore the means in which the MOA has now physically deployed the Longhouse VR experience and technology, symbolically repatriating museum space from an outdated post-colonial exhibition environment. Further, after almost a year of deployment, over 1800 Indigenous and non-Indigenous users have engaged with Longhouse VR in addition to the post-experience qualitative survey, providing a unique window into the unintended outcomes of non-archaeological user engagement. Benefiting from the substantive user interaction, Longhouse VR is now being remodeled, to better support and address the needs and desires of the public and more importantly, the descendant Indigenous communities. This paper offers a unique opportunity to demonstrate how unintended outcomes can have a direct influence on User Experience Design and the intentionality and communication needed to balance agency, authenticity, authority, and transparency of heritage informed digital media experiences.

Engaging visitors with 'invisible' heritage: lessons learned on the impact of digital media, immersion, sound and storytelling.

Jenny Wilkinson

My PhD investigates the role of digital media in optimising visitor engagement with non-visible outdoor heritage. Building on existing research regarding visitor engagement; this thesis proposes guidance to advise and support heritage practitioners and designers in the design, development and implementation of digital products to interpret heritage. The guidance includes a framework for engagement, defining the stages (process) and the states (experiences and behaviours) of visitor engagement. Visitor engagement is defined in this study as being a transformational experience in which the visitor's emotional and/or cognitive relationship with the heritage is altered. Visitors featured in this study are people who are present at the heritage site, but may not be predominantly interested in experiencing the heritage of the location, consequently the guidance proposes a focus on both place-centred and user-centred design. The heritage site featured in this study is a public park with very little tangible evidence of the historical or cultural relevance of the location. A prototype digital product was created to help visitors understand and appreciate the period in the 19th Century when the park was used as the city's Race Course and annually hosted horse racing. Mixed digital media, including sound, video and audio content were used to deliver location specific storytelling designed to immerse people who were on the park in the carnival atmosphere of the races. Findings from this study demonstrated that using the product had a positive impact in deepening people's understanding of the park and their emotional connection to the location.

Mixable reality, Collaboration, and Evaluation

Erik M Champion

If we are to move past one hit AR wonders like Pokémon Go, scalable yet engaging content, stable tools, appropriate evaluation research, long-term and robust infrastructure, are essential. Formats like WebVR and Web XR show promise for sharing content across desktop and head-mounted displays (without having to download plugins), but there is also a non-technological constraint: our preconceptions about virtual reality. For example, in a 2018 Conversation article "Why virtual reality cannot match the real thing" by Professor of Philosophy Janna Thompson) she argued that virtual reality (and virtual heritage in particular) attempts to provide accurate and equivalent realistic interactive simulations of the existing real world. VR is not only a possible mirror to the current world. As Sir David Attenborough noted about the Natural History Museum's "Hold the World" VR application, it provides a richer understanding of process, people can move and view virtual objects that are otherwise fragile, expensive or remote. And it allows people to share their mashups of reality, mixable reality. Collaborative learning can compel us to work in groups to see the bigger picture... your actions or decisions can be augmented and incorporated into the experience. However, there are few studies on collaborative learning in mixed reality archaeology and heritage. This presentation will discuss two projects, one using two HoloLens HMDs, one a game where two people with different devices must share and control one character, the theories adopted, and the range of possibilities for evaluating user experience in this collaborative mixed reality.

Design thinking in Cultural Heritage

Neil Jakeman

KDL are adopting industry standard project and design processes, believing that correct adaptation of these approaches in an academic setting can address issues of sustainability and archiving in digital research. We are trying to convince project partners of the value of user testing and user interaction design. Historically in DH, there has been a tendency for PIs to concentrate on addressing a very narrow and specialised audience. We feel that even specialist interest group is comprised of multiple audiences who want to engage with research output for different reasons, and through adopting structured processes, we can increase the accessibility of resources without compromising the needs of a particular group. Our approach to this issue is guided by a few fundamental questions that help to direct design: Firstly, who are your audiences? Beyond identifying roles, can we characterise users in a general way by the sorts of outcomes they want from a digital resource? What questions will those users be asking of

your resource? What would be their typical journey? Secondly, what do you want users to feel? What should their impression of a website be? This encompasses both aesthetic and functional requirements. How do we want a resource to resonate with a particular audience? Thirdly, what do we want the user to do? What 'calls to action' are triggered by the resource? Building web resources in specialist domains can be problematic if the experts in that domain perceive that the finer points of research are being oversimplified for general consumption.

Managing Engagement Design Risk through Creative Constraints

Claire Boardman

Non-practitioners often confuse design with art. Whilst each designer develops, through constant application and revision of their craft, a unique and often identifiable style, their work is not to express an inner world but to deliver pre-defined outcome(s). As such and contrary to popular belief, the 'design process' is fundamentally analytical and reductionist in nature; it is a constant cycle of data and information acquisition, evaluation and decision making which ultimately results in a single output – the design. Drawing on current research, this paper exposes the key design decisions made by the Researcher during the creation and employment of a digitally enabled ethnographic intervention consisting of two interrelated engagement designs: one a creative digital process and the other and interactive digital product. Through a reflexive and candid account, the development and success – or otherwise - of each presented design decision is discussed whilst acknowledging that user experience design does not exist in isolation but is nested in the broader processes of interaction and engagement design and therefore the wealth of technology and non-technology based affordances this offers. Further, the inherently iterative and collaborative nature of design practice, the necessity of the early inclusion of users and the importance of adopting a multi-disciplinary 'mind frame' whether working alone or within a wider team are highlighted.

Creating a unified design system across web, mobile, AR and VR

Damir Kotorić, Luke Hollis

A challenge that faces current archaeological data presentation and interpretation is establishing a shared visual vocabulary for user interface components across web browsers, mobile devices, and augmented and virtual reality experiences. https://drive.google.com/open?id=1rXm4s7fX-7OYHXp-ej59LW9afG4sF4786 https://drive.google.com/open?id=1Ql2q1cbSz1neJJt_yyMtYG-VqeY4HAgOf https://drive.google.com/open?id=1snK6blgTe-4ANXYdfee8xzDbLLO9Z0of Working closely with archaeologists, at Archimedes Digital we create cross-platform experiences

for web, mobile, and VR/AR. A critical element that ties together all these diverse experiences is our unified design system. We aim to give users a sense of familiarity that allows them to easily move from one device to the next, and give them the best experience possible no matter the device they're using. https://drive.google.com/open?id=1YxTw7fNBKgb5ApV03UAThf-PLcJOznvc3 https://drive.google.com/open?id=1ZHlJrGosRo892AmvNnzHiSWUO_Fj6bV-https://drive.google.com/open?id=1axrxK57nkmqYp186kAJ0N7ukod8w_UaG Building on the groundwork laid down by design systems like Apple's HIG, Google's Material Design system and Facebook's Oculus VR Design Best Practices, we utilize tools like Figma, and Realtimeboard, in combination with design thinking workshops inspired by Google's design sprints, to help us create this unified design system. We do this with the aim of creating user experiences that feel familiar to users, and with the goal of making archaeology accessible to people around the world.

Inclusive Digital Engagement for Heritage

Eleonora Gandolfi, Grant Cox

Access, participation and representation have been identified as the mechanisms that allow an audience to fully experience a museum or site. Traditionally, access issues were frequently limited by architectural and financial restrictions but with the rise of technology, new barriers need to be taken into account. Consequently, increased attention has been paid to sensory and cognitive interaction, cultural differences (interests, life experiences), aptitudes (the culture and the overall atmosphere of an institution), technology (lack of ICT use to enhance access to cultural offerings) and elitism (e.g. perception of cultural institutions as exclusive places, reserved to educated and sophisticated people; refusal of certain forms of cultural expression, considered to be of little interest or offense; low priority given to cultural participation). In relation to communication of archaeological and heritage content via an online medium, this happens mainly visually, symbolically and textually. Communication, especially textual, is just one of the tools that archaeologists have available to create a bridge between heritage and the public. This proposed case study will critically analyze how digital material, produced for educational and research purposes and for a variety of different audiences, can be adapted to meet the needs of different communities and bridge the gap between physical and digital space. Methodologies such as Action Research and language analysis have been applied in association to IT platform user testing to create a new ideal digital space to collect, access and share heritage information and data.

Other session 37:
3D Publishing and Sustainability: Taking Steps Forward

Elaine Sullivan, University of California Santa Cruz
Heather Richards-Rissetto, University of Lincoln-Nebraska

Large Hall A, 8.40 – 10.40, 26 April 2019

3D technological innovations are being used successfully at varying scales of analysis in archaeology, cross-cutting regions, time periods, and theoretical frameworks. Historic reconstruction modeling, photogrammetry, LiDAR, procedural modeling virtual environments, and serious gaming are all now part of the archaeologist's toolkit. For example, museums are harnessing 3D data capture to record objects in their collections for public engagement and conservation analysis. Archaeological field work is transforming, with fully digital and 3D recording of excavation units as part of the daily workflow on sites all over the globe. Scholars are testing out theories relating to historic architecture, ancient landscapes, visibility, movement, and lighting in virtually (re)constructed "worlds."

While exciting, the adoption of 3D technologies for visualization, documentation, interpretation and analysis of material culture in Archaeology creates many new questions about the dissemination and curation of scholarly products. Can 3D scholarship be published and sustained in a robust and accessible way for the future? How can new platforms and technologies allow for more comprehensive forms of interactive publishing, allowing readers to query and critique the 3D content? What new formats could allow readers access to the decision-making processes of the author, so their interpretations can be peer reviewed? Can we push forward academic journal and monograph publishing to include 3D scholarly content in ways that bring it to the fore, not use it as fancy illustrations to a traditional textual argument? How can archaeologists promote the development of open-source platforms for sharing 3D content and contribute to its future preservation and sustainability? As web-browsers, software and hardware rapidly change, how will 3D information be archived into new formats for future access?

This session will ask archaeologists already working intensely with 3D content to reflect on the future of 3D publishing. Participants will make 10-minute presentations on their own work, showing how they have grappled with the question of disseminating archaeological 3D content in ways that allow for robust interaction by readers, promoting understanding through the integration of 3D with text, audio, imagery, etc. We encourage speakers to define 2-3 current challenges to 3D publication and dissemination of knowledge, and to offer suggestions to facing these challenges collectively as a field. After each group of speakers (3-5), we will break for group discussion and define clear "pain points" for the community. The last part of the session (45-60 min) will be directed to collectively define some next steps forward to concretely

address how to improve 3D publishing and sustainability in order that the exciting content produced by archaeologists today is accessible to current and future generations in meaningful ways. We ask speakers to particularly focus on issues of sustainability related to open-source vs. proprietary software, a major issue as the 3D industry is currently dominated by private sector corporations. We imagine the results from our group effort as taking the form of collaborative grant applications, coordinating professional groups across the traditional subject divides, and the sharing of resources and knowledge in this quickly shifting field.

8.40 – 8.50
3D publishing of culturally sensitive data: the Tokatuhi project,
Joshua James Emmitt, Gerard O'Regan

8.50 – 9.00
Laser scanning and photogrammetry as a way for detailed documentation, and museum and web-site visualization of an Ancient Pueblo community in the canyons of the Mesa Verde region, Colorado, USA,
Radoslaw Palonka, Boleslaw Zych, Anna Wencel, Vincent M. MacMillan

9.00 – 9.10
3D Models: Unwanted, Unknown, Unloved,
Erik M. Champion, Hafizur Rahaman

9.10 – 9.40
Discussion

9.40 – 9.50
Publishing web-based interactive landscape visualizations of archaeological sites,
Elaine Sullivan

9.50 – 10.00
Dig it, and then Dig it again,
Paola Derudas, Nicolò Dell'Unto, Marco Callieri, Giacomo Landeschi

10.00 – 10.10
What do we want and how do we want it? The logistics of archiving 3D datasets,
Kieron Jamie Niven

10.10 – 10.40
Discussion

3D publishing of culturally sensitive data: the Tokatuhi project

Joshua James Emmitt, Gerard O'Regan

Three-dimensional data (3D) is increasingly important in archaeology and has both analytical and visualization applications. The use of 3D data for community engagement is an invaluable resource that helps connect people with their cultural heritage. In particular the visualization of places can help people view places of cultural significance when they are unable to travel there, or places which are inaccessible, particularly for indigenous groups. While the benefits of these applications seem obvious, there are also other aspects which demand consideration, particularly who may view the data and how it is distributed. In this paper we present a case study from New Zealand rock art sites. As part of the Tokatuhi project photogrammetry and terrestrial laser scanning are used to record rock art sites, particularly those under threat from erosion or modern disturbance. These models are uploaded privately to Sketchfab, which are then shared the local Māori community related to the place. In some cases those communities are happy for the models to be made public. Sketchfab is a current display software, but moving into the future issues may arise as to data access, display, and preservation. Here we consider the implications of 3D data when applied to sensitive archaeological sites and future directions for such data.

Laser scanning and photogrammetry as a way for detailed documentation, and museum and web-site visualization of an Ancient Pueblo community in the canyons of the Mesa Verde region, Colorado, USA

Radoslaw Palonka, Boleslaw Zych, Anna Wencel, Vincent M. MacMillan

This paper focuses on the creation and sustainability of an interactive database based on traditional as well as modern techniques of documentation of the community of thirteenth century A.D. Pueblo culture sites located in three canyons of the Mesa Verde region, southwestern Colorado, USA. During several seasons of the project we used laser scanning and photogrammetry for the documentation of Puebloan cliff dwellings and towers located mostly within alcoves on the canyon slopes, and Pueblo, Fremont and Ute rock art panels and murals. The information in our database, aside from the data from the photogrammetry and laser scanning, also includes GIS, BIM (Building Information Modeling), and RTI analysis integrated in a free-ware game engine (mostly with Unreal Engine software). All the information is integrated in an easily accessible, readable and transparent database of digital data that includes maps, site plans, 3D models and visualisations, interactive simulations, text information, and drawing documentation of particular buildings, rock art panels and artifacts. The final aim is

the improvement of the database by way of presenting all the gathered information connected to the Pueblo culture settlement structure in the environmental and topographic context with the prominent landscape features, like mountain peaks and mesa tops. The presentation also includes the challenge we are facing in publishing a large amount of collected data in the form of traditional publications in journals as well as museum displays and Internet web browsers, and later availability to scientists and a wider audience.

3D Models: Unwanted, Unknown, Unloved

Erik M. Champion, Hafizur Rahaman

Given the importance of three-dimensional space and artefacts to archaeology and to heritage studies, one might therefore assume that publications in the area of virtual heritage are heavily reliant on providing scholarly argument based on 3D models. To corroborate this hypothesis, we reviewed virtual heritage proceedings of major digital heritage conferences one could expect to be focused on projects incorporating 3D models. A total number of 264 articles across 14 proceedings were studied, and the results will be tabulated and presented. The lack of accessible 3D models, usable projects, or ways in which the 3D model could be used and critiqued in a scholarly argument is of great concern to us. We suggest that long-term usage and preservation of virtual heritage models are worrying and persistent issues, and their scholastic impact is severely compromised. We suggest there are least three critical issues: we lack accessible, durable and complete infrastructure, which is essential for storage and preservation; we still don't have a shared understanding of how to develop, integrate and demonstrate the research value of 3D heritage models; we also lack robust, long-term publication systems that can integrate and maintain both the 3D models and their relevance and functionality in terms of both community engagement and scholarship. We recommend seven practical steps for ensuring that the scholarship going into the development of 3D virtual heritage models, and arising from 3D virtual heritage models, can be fully implemented.

Publishing web-based interactive landscape visualizations of archaeological sites

Elaine Sullivan

3D visualizations of past landscapes offer scholars the opportunity to address questions of human movement, visibility, and experience in spaces that have changed dramatically since ancient times. While these visualizations are powerful tools for research and education, few have been published in ways that allow for dynamic interaction by the reader or user. In this presentation, the author will show how she is utilizing 3D GIS and WebGL capabilities for a

'born-digital' publication of a temporal landscape model of the Egyptian site of Saqqara. The publication allows the reader to access structured metadata about the site and model reconstructions, as well as control their own movement through the space. Such publication formats have great potential for furthering 3D scholarship in archaeology, as they move beyond 'pretty pictures' and push the model content to the fore. While online interactive publication has great potential, this presentation will also address the challenges of sustainability that these publications create. As part of a collaboration between scholars, technologists, and a series of academic presses based in the US, the author is grappling with questions of archiving and usability for the project in the long-term.

Dig it, and then Dig it again

Paola Derudas, Nicolò Dell'Unto, Marco Callieri, Giacomo Landeschi

It is now quite common to have, even for large excavations, a day-by-day 3D survey of the trenches. This abundance of 3D data has shifted our approach to this media, creating opportunities but also problems. The first issue is the proper archival and management of the data, where the 3D data has to be homogenized, georeferenced, catalogued, enriched by metadata and physically stored. However, simply storing data is useful, but limited. An archival system, then, has to be designed to allow the re-use of that very same data for other scientific purposes. The basic idea is having a common archival system for 3D+2D data and metadata that can be accessed by various "suits" of tools, each focused to a specific use. As an example, we will present an ongoing work that is focused on one of the standard steps in excavation management: the yearly excavation report. The tool uses the 3D and 2D data and metadata in the archive to build an interactive multimedia presentation (text, images, 3D) of the excavation. With a simple authoring tool, it is possible to create a "digital report" that can be transformed in an interactive webpage or in a more classic text+images document. The interaction of this tool with the archive is a virtuous cycle, as the same data used for the study is the base of the report, and the interactive report is a "structured" and "interpreted" index to the archived data.

What do we want and how do we want it? The logistics of archiving 3D datasets.

Kieron Jamie Niven

Resulting from the increase in 3D capture from a range of techniques across the archaeological and heritage sectors, the Archaeology Data Service (ADS) at the University of York has seen an increase in the number of 3D projects being deposited for long-term preservation. This paper will briefly summarise the range and quantity of data recently deposited at ADS before

looking at the specific issues that arise from archiving and disseminating such datasets: namely those connected to the volume of data produced by such projects, the related issues of reuse and long-term access, and lastly the problems of adequately documenting creation processes and the resulting dataset. While the ADS archives 3D data produced from a range of common techniques including laser scanning, structured light scanning, CAD, and CT, this paper will focus largely on projects using photogrammetry and Structure from Motion (SfM) techniques. Using specific examples from collections within the ADS archives, this paper will highlight current approaches to storing, documenting, and disseminating 3D datasets while also exploring possible future problems and solutions.

Roundtable 39: The European Research Council (ERC): funding excellent research in the field of Archaeological Science

Efthymia Priki, European Research Council Executive Agency (ERCEA)

Medium Hall A, 9.20 – 10.40, 25 April 2019

Established in 2007, the European Research Council's mission is to encourage the highest quality research in Europe through competitive funding and to support investigator-driven frontier research across all scientific domains, on the basis of scientific excellence. For more than 10 years now, the ERC has been funding promising and/or top-notch researchers in all fields of science, including archaeology, becoming one of the most prominent funding bodies of frontier research worldwide.

The field of Archaeological Science, in particular, is represented in the ERC panel SH6 – "The Human Past: Archaeology and History", and several ERC-funded archaeological projects have been incorporating computational and quantitative methods to the analysis of archaeological materials.

The aim of this session is to provide information to conference participants about research funded by the European Research Council in the field of Archaeological Science, as well as to bring together in dialogue ERC grantees with conference participants, which potentially will include prospective applicants.

The proposed session will feature a short presentation about the ERC, its funding schemes, and success stories of ERC-funded projects in the field of Archaeological Science, as well as presentations by ERC grantees about their ERC-funded research projects and their experience with the ERC both during the evaluation process and during the implementation phase of their project. The presentations will be followed by an open discussion.

Session-format: Short presentations – 10-15 min. – followed by open discussion.

9.20 – 9.35
The European Research Council (ERC) and its funding schemes,
Efthymia Priki

9.35 – 9.50
"Welcome to the Aegean Bronze Age"Computer-enhanced Open Access in archaeological research,
Ann Brysbaert

9.50 – 10.05
Discussant,
Javier Fernandez-Lopez de Pablo

10.05 – 10.40
Open discussion

The European Research Council (ERC) and its funding schemes

Efthymia Priki

In this short presentation, I will provide practical details on the ERC, its funding schemes, and the evaluation process including general tips for potential applicants. The presentation will also showcase examples of projects in the field of Archaeological Science.

"Welcome to the Aegean Bronze Age" Computer-enhanced Open Access in archaeological research

Ann Brysbaert

Few landscapes have been so intensively modified over time than that of the Argolid (Greece) since at least the Early Bronze Age and certainly in the Mycenaean Late Bronze Age (c. 1600-1100 BCE). The ERC-funded CoG project, SETinSTONE, investigates if and how monumental building activities undertaken there may have impacted on the social, economic and political structures of the Mycenaean polities in this period, and how people responded to changes in these structures. The overall team investigates (1) the minimum levels of human and material resources input in the prolonged building efforts present in this region between c. 1300-1200 BC, and what happened to these resources; (2) what subsistence strategies and other activities people were undertaking in this period, and what resources they had at their disposal. Mobility and access to resources, for agricultural and building activities, were crucial factors in daily life. The subproject of both authors investigates and assesses the usability of past infrastructure and routes to transport resources between the region's major hubs. In line with the ERC request for Open Access in publishing project results, we went one step further in employing devices and open- source software (OSS) that everyone has access to during our walks in this landscape while checking published remains. This paper demonstrates that our research enhances and advocates total Open Access for anyone who is willing to persevere in taking available hard/software to new levels. We believe that such an approach makes this landscape even more accessible to all.

Discussant in Round Table Session S39

Javier Fernandez-Lopez de Pablo

In this session I will discuss my experience with the ERC and provide some examples about the implementation of a range of quantitative and computational methods in the context of the PALEODEM project.

Standard session 40:
Argumentation and the Archaeological Record

Cesar Gonzalez-Perez, Institute of Heritage Sciences (Incipit), Spanish National Research Council
Patricia Martin-Rodilla, CiTIUS University of Santiago de Compostela
Martin Pereira-Fariña, University of Santiago de Compostela

Large Hall A, 16.00 – 17.20, 26 April 2019

Archaeological knowledge is constructed by making arguments based on material evidence. Interpretation, therefore, plays a central role in archaeological practice, and understanding how it works will help us improve our capacity to value other people's conclusions, revise our own, and overall produce better results. For this to happen, two aspects must be developed in conjunction. On the one hand, we need robust models of the archaeological record, which allow us to reason about the corresponding physical artefacts. On the other hand, we need to understand how argumentation takes place, and how new knowledge is constructed from smaller pieces. Thus, ontology and discourse must be treated in relation to one another; if we treat ontological issues without argumentation, we obtain only a static and fossilized view of the world; if we study argumentation without ontology, we obtain only propositions about unknown entities.

Furthermore, a wide array of computational techniques has been used to model, store and process both ontologies and argumentation as separate artefacts, but none exists that can tackle both aspects at the same time.

This session aims to address the joint modelling of the archaeological record and the argumentations applied to it, and the joint processing of the ensuing data.

Major research areas that are welcome in the session include the following:

- What conceptual models or ontologies of the archaeological record exist, and how useful and robust are they?
- What computational conceptual models of the archaeological argumentation processes exist, and how useful and robust are they?
- How can we successfully trace interpretative conclusions to the original evidence, and how can this be supported by computational approaches?
- How can archaeological conceptual models help us to understand and check the integrity of the associated discourse, and vice versa?
- How can archaeological interpretations and argumentations be formally and computationally analysed for a better understanding?

- How do archaeological models or ontologies evolve during multi-agent argumentation? How can this temporal dimension be captured in databases, corpora, or other computer tools?
- How can we build databases, ontologies, or corpora that support interpretative and argumentative processes about the archaeological record?
- What computing techniques, such as data-to-text, data mining or natural language processing, should we use to support multivocal argumentation in archaeology?

16.00 – 16.20
Enabling the comparability of research workflows: a case study,
Iwona Dudek, Jean-Yves Blaise

16.20 – 16.40
Towards a new methodological framework for statistics in archaeology,
Chiara G. M. Girotto, Lutz Schubert

16.40 – 17.00
Cataloging, classification and interpretation. A new database to digitalize the data of the Baths of Albintimilium (Imperia - Italy),
Paolo de Vingo, Sara Graziano, Alessio Paonessa, Giulia Zavattieri

17.00 – 17.20
How Many Dots? Expanding Beyond Single-Sample Characterizations in Chemical Residues,
Jennifer A. Loughmiller-Cardinal

Enabling the comparability of research workflows: a case study

Iwona Dudek, Jean-Yves Blaise

As a result of the massive introduction of computer-assisted research workflows in and around the analysis of heritage items, we are today witnessing a blooming of highly specialized, and sometimes obscure for outsiders, data processing chains. Operations conducted on this or that site include a vast range of digitization activities and an equally vast array of post-processing roadmaps. The amount, diversity, and sometimes complexity of these operations is definitely a challenging aspect of the heritage science community's move towards "more" digital data acquisition and processing. It hinders that community's ability to identify and share, beyond results, methods and argumentation [1]. In particular, it jeopardizes its capacity to preserve and explain research processes on the long term, and therefore to ensure their reproducibility (obviously a key methodological issue if processes should fall within a "scientific" approach). This paper presents the MEMORIA research, aimed at experimenting a practical solution for the formali-

zation and intersubjective description of research workflows[2]. The initiative bases on the idea that, beyond metadata describing outputs themselves, the scientific community concerned is awaiting for means to ensure their verifiability, reproducibility and comparability [3][4]. The paper focuses on two aspects: - A real-case experimentation on a series of investigations we have conducted on the historical centre of Krakow (Poland) over the last 15 years. - A feedback on difficulties to foresee at a methodological level, for instance in terms of grain (what exactly should be recorded? Each and every click inside a given computer software? Certainly not...)

Towards a new methodological framework for statistics in archaeology

Chiara G. M. Girotto, Lutz Schubert

Statistics in prehistory often encodes not only the researcher's perception of the past by the choice of factors of interest but also the idea of human behaviour as a linear dynamic by applying homogeneous estimators, parametric functions, and non-Bayesian probability approaches. Their applicability, assumptions, and the theoretical foundation of the equations are rarely addressed or even tested. Hypotheses are often embodying the cognitive and symbolic nature of current archaeological behavioural research but fail to acknowledge that they need to be based on a relation of quantities. Assumptions in prehistory can never be measured directly or objectively, they represent probability variation. Therefore it is more important how stable a sequence of events is than how probable it is objectively. Furthermore, the dynamics of nonlinear systems as well as entropy highlight the inability to recover all influencing factors. Consequently statistics is applied on a rudimentary basis and assumptions of universality need to be applied. Often they reaffirm the researchers' conceptual model of societies and algorithms design a past of parametric normality. In this talk we aim to reassess our fundamental stance towards statistics and its application in archaeology. We will try to lay out a basic framework that allows us to trace conceptual models of the data, the researcher, and the process, and to assess these traces comparatively. Further, we want to emphasise the possibilities and advantages of not only a clear hypothesis but also the ability to evaluate theories based on their factors of interest alleged in the literature.

Cataloging, classification and interpretation. A new database to digitalize the data of the Baths of Albintimilium (Imperia - Italy)

Paolo de Vingo, Sara Graziano, Alessio Paonessa, Giulia Zavattieri

Since 2016 the chair of Christian and Medieval Archeology of Turin, is working to catalog, classify, digitalize and explaining by interpretation the finds collected in the thermal baths

of Albintimilium. Finds come from all the Mediterranean, since II a.C till VII d.C., and they are mostly ceramics. The context showed difficult challenges to face: excavation method was stratigraphical, but based on a different system than Harris's one. Excavation's documentation reveal a detailed and innovative method for that time. Nevertheless, it is now outdated, thus the contest is paradoxical, being contemporary interpreted and absent. It is necessary to deal with this reality, the stratification of classification's methods and conceptual models related to each class material, such as historical, processual and postprocessual. It has been decided to apply a pluriversal approach, that keep together and compare different interpretational paradigms, in a multivocal coexistence. In the practice, it has been decided to operate as following: start with a new different ontology grounded on a didactic team work in three moments: the collection of the previous studies, a first general classification and a deeper analysis with specific specialized study; make it compatible and transferable to the institutional database deployed by the Italian Cultural Agency; model the ontology and the vocabulary over a data schema built upon open source softwares and open data formats to scale then quickly to a remote storage system.

How Many Dots? Expanding Beyond Single-Sample Characterizations in Chemical Residues

Jennifer A. Loughmiller-Cardinal

Organic residues analysis has traditionally focused on identifying specific substances from particular artifacts or contexts. Often, at least in Americanist archaeology, the target samples have been elite goods from elite contexts such as burials. With advances in rapid and non-destructive sampling technologies such those involving all kinds of light spectroscopy (Raman spectroscopy, Fourier transform-infrared [FT-IR], ultraviolet-visible [UV-Vis]) we can now begin to widen both the breadth and scope of chemical analyses. Although the single context residues have been broadly informative and methodologically productive, such single-point data are an insufficient empirical basis for the broad interpretive inferences that have resulted. Current and pending methods allow for multiple simultaneous spectra to be analyzed, non- or minimally- destructively, in a small fraction of the time required by previous techniques. This new capacity allows consideration of projects for broad-scale analysis of ancient residues and for establishing a substantial dataset of baseline spectral signatures for substances of research interest.

Standard session 41: From Micro to Macro: computer-based approaches for the analysis of big data in the study of artefacts and societies

Marta Lorenzon, University of Helsinki
Agnieszka Kaliszewska, Systems Research Institute, PAS

Small Hall, 10.20 – 12.40, 24 April 2019

We see steady progress in computational modelling and its application to the detection of patterns in complex datasets. This approach finds application in archaeology, such as in modeling of the settlement patterns, and in the analysis of material culture (e.g. pottery typology). Nevertheless, these applications are still relatively new in the field of archaeology, although their potential to improve our analysis of past societies, in both micro and macro scale, is undeniable.

Archaeological research often deals with large amounts of data of different types. Such datasets are often too complex to be analysed in a traditional way. However, the application of formal computer-based modelling approaches can uncover underlying patterns in large and diverse datasets. These models allow us to combine a multitude of factors that impact the archaeological record (e.g. climate, topography and resources in the case of settlement location), or various characteristics of material culture objects (e.g. shape, material, colour).

Most methodologies, whether they are dealing with the micro or the macro scale, combine the use of model-based approaches with tools such as CAD (2D and 3D), GIS and/or Space Syntax, methods of image recognition, and clustering or classification. The application of such methodologies allows for new lines of investigation, testing of new theories, and the combination of data on multilayered registers passing from the micro (artefact) to the macro (society behaviour and spatial pattern of occupation) scale. Thus, the utility of formal-based computer-generated models becomes of paramount importance, providing a new venue for archaeologists to discuss hypotheses before empirical testing and the development such technologies may help to bridge different approaches and help establish the field of formal methods in archaeology.

In this session we invite contributions using a model-based approach to analyse the archaeological built environment and its material culture, creating a deeper and multilayered understanding of past societies. We also seek case studies showcasing innovative approaches to qualitative and quantitative computer modelling in archaeology, presenting new techniques and expanding the use of computer-based modeling, or providing new forms of investigation of material culture.

10.20 – 10.40
From Local to Global: Nested Interaction and Community in Late Bronze Age Crete,
Paula Gheorghiade, Henry Price

10.40 – 11.00
Handling large pottery assemblages through the application of clustering to 2D profiles,
Agnieszka Kaliszewska, Monika Syga

11.00 – 11.20
From the artefacts to material culture, Statistical modelling using R,
Lizzie Scholtus

11.20 – 11.40
Modeling the Ptolemaic Cultural Export: A Quantitative Evaluation of the Spread of the Isiac Cults in the West Coast of Hellenistic Asia Minor,
Tomas Glomb, Adam Mertel

11.40 – 12.00
Computing Similarity Networks of Maya Glyphs from 3D-Data,
Hubert Mara, Bartosz Bogacz, Felix Feldmann, Christian Prager

12.00 – 12.20
From Point to Pattern. Integration of Spatial Data Analysis Methods for Settlement Pattern Investigation,
Rafał Bieńkowski, Marta Lorenzon, Agnieszka Kaliszewska, Krzysztof Leśniewski, Robert Kłopotek

12.20 – 12.40
General Discussion

From Local to Global: Nested Interaction and Community in Late Bronze Age Crete

Paula Gheorghiade, Henry Price

The exploration of archaeological questions through computer-based approaches often focuses on one of two things: spatial or material data. On one hand, rich archaeological datasets are ideal for interrogating various social practices such as consumption, crafting, mobility and interaction locally at the settlement level (through assemblages) and comparatively between several communities. Such methodologies often consider the micro-scale socio-material networks by examining various facets of object networks for example through similarity, dissimilarity approaches in visualizing and drawing out patterns from the data. On the other, approaches interrogating settlement patterns, variability and landscape transformation often utilize point based spatial data for modeling and analyzing archaeological questions. Rarely are these two combined. This paper takes such an approach in exploring the possibility of combining empirically observed socio-material networks derived from a large archaeological data set of 13,700+ ceramic vessels from the Late Bronze Age (LBA) with modeling spatial interaction between 150+ settlements across Crete and the Eastern Mediterranean. We explore a two-factor threshold model in two parts: one for modelling interaction between pan-Cretan sites dynamically by including parameters that consider distance and landscape in testing hypotheses regarding the growth and centrality of sites across a 250 year period; and two, nesting our pan-Cretan network within the larger landscape of the east and west Mediterranean. The results of modelling are tested against our archaeological dataset with the goal of considering whether such exploration is fruitful in supporting our hypotheses regarding LBA interaction in this part of the world.

Handling large pottery assemblages through the application of clustering to 2D profiles

Agnieszka Kaliszewska, Monika Syga

This contribution presents a novel approach to the investigation of ancient ceramics, through the analysis of the shape of rotationally symmetric vessels. We propose a method of investigating the shapes of ceramic, wheel-made vessels and semi-automatic generation of typologies, through a combination of widely available shape descriptors. For the major part of the archaeological excavation, pottery is the most abundant type of finds. The investigation of the vessels' shape, aside from decoration and production techniques, is often vital in establishing relative chronology, the function of the excavated areas, and the connections between sites and regions. This aspect of the analysis suffers often from the large amount of data, very subtle changes in forms, as well as often inconsistent terminology between sites or regions. To tackle these issues we have created a method of describing the shape of vessels in a formal way by using mathemati-

cal representations of vessels' profiles. This allows us the comparison of pottery fragments and generating typologies, through the application of shape descriptors. The typology generation process can be calibrated to include the expert's knowledge about the investigated assemblage. We believe that the presented method will facilitate the study of large assemblages of pottery fragments from a given site, allow a quick initial comparison between sites or study the variability of shapes within a given site, region or period.

From the artefacts to material culture, Statistical modelling using R

Lizzie Scholtus

By using small finds as cultural markers, this analysis aims to highlight recurrent typological assemblages in eastern Gaul between the 3rd century BC and the 4th century AD. The idea behind this study is, therefore, to combine the information intrinsic to objects (typology, chronology, localisation) to quantitative data based on artefacts inventories and online databases. This method relies on a classical approach in archaeology, which is to determine cultural groups based on artefacts and their geographical distribution. However, this study adopts a new prism by modelling the data and developing statistical analysis tools to process large quantities of variables (over 15000 objects for now). This allows us to establish types distribution graphs, a sort of typological « barcode », for each site or area. These are then compared to each other, using clustering techniques and distance diagrams. This method therefore takes into account all artefacts considered as cultural markers, with no limitation regarding discovery contexts. The cultural groups thus defined are differentiated by characteristic typological assemblages. The presence or absence of a certain type is no longer a determining factor. Moreover, it is easily possible with this method to add or remove a type of object in order to see if it affects the making of those cultural groups. This modelling is created on the open-source software R for its ability to treat efficiently an extensive dataset as well as its flexible framework.

Modeling the Ptolemaic Cultural Export: A Quantitative Evaluation of the Spread of the Isiac Cults in the West Coast of Hellenistic Asia Minor

Tomas Glomb, Adam Mertel

During the reign of the first six Ptolemaic kings in Egypt (ca 305-145 BCE), the Isiac cults (i.e. cults related to Egyptian gods Isis and Sarapis) spread first to ports of the ancient Mediterranean and subsequently further into the mainland. This case study focuses on the process of the spread of the Isiac cults in the west coast of Hellenistic Asia Minor where a significant amount of related archaeological evidence is located. During the early Ptolemaic era the west coast of Asia

Minor was deeply involved in Ptolemaic political activities. Some of the cities within this region played the role of allies of the Ptolemaic dynasty while other cities were under direct control of Ptolemaic officials or were garrisoned by Ptolemaic troops. However, there is no evidence suggesting that the Ptolemies systematically promoted the Isiac cults in their possessions in Asia Minor. In order to inspect this process of cultural transmission in detail, this study proposes a mathematical model which based on geographical, political and economic datasets determines which factors were responsible for the dissemination of the Isiac cults in the Hellenistic Asia Minor and which of these factors had more impact than others. The spread of the Isiac cults is within this methodological frame conceptualized as a cultural transmission happening on a transportation network. A successful transmission is then reflected by local archaeological evidence. This case study follows the methodological know-how gathered in the project "Generative Historiography of Religions" realized at Masaryk University (http://gehir.phil.muni.cz/).

Computing Similarity Networks of Maya Glyphs from 3D-Data

Hubert Mara, Bartosz Bogacz, Felix Feldmann, Christian Prager

Motivated by the demands for compilation of a text-database and digital dictionary of Classic Mayan (http://mayawoerterbuch.de), we are developing an approach to compute and visualize similarity of 3D-digitized Maya hieroglyphs. The glyphs are typically arranged within a squared block consisting of three or four signs arbitrarily deformed and attached to a larger main sign. These signs vary in shape and design considerably, preventing an easy and complete decipherment. Instead of photographs and manual drawings we compute visualizations of 3D-measurement data using the GigaMesh Software Framework (https://gigamesh.eu) to maximize readability. Those images serve as input for a machine learning pipeline. Maya glyphs and parts thereof are segmented with projection profiles and a random walker approach based on the curvature of the 3D surface. The retrieved sub-glyphs are (i) firstly clustered into a set of common sizes and (ii) secondly clustered hierarchically based on a Histogram of Gradients similarity descriptor. Distances and connections derived from the clusters are visualized in a force-directed network. The results correspond very well to the hitherto manual established sign classifications within the traditional research and enable a critical discussion about glyph similarity. The resultant quantitative measure of similarity will support the objective compilation, indexing and sorting of about 1.000 known signs based on their morphology. Future work will integrate more recent methods like convolutional neural networks, which is challenging task due to the relative few and short texts distributed over time and geographical area.

From Point to Pattern. Integration of Spatial Data Analysis Methods for Settlement Pattern Investigation

Rafał Bieńkowski, Marta Lorenzon, Agnieszka Kaliszewska, Krzysztof Leśniewski, Robert Kłopotek

This contribution aims at presenting two methods of Spatial Data Analysis utilised for the identification of possible location of archaeological sites. We investigate the possible application of multicriteria optimization (MC) and Agent Based Modelling integrated with GIS (ABM) in order to analyse the quality of results and determine their best application during archaeological survey. The two methodologies differ significantly from the type of of data used to their final outputs, but we argue that the integration of these two methods presents an efficient practice for archaeological survey and settlement pattern analysis. Our case study presents the application of these two methods on the same dataset. Firstly, we compare the two methods on Near Eastern sedentary society (e.g., Iron Age Jordan) with a defined agriculture-based economy. Then we combine the outputs to further characterise the long lasting settlement patterns. The comparison between the two methods highlights the need of an integrated approach in planning fieldwork as these diverse methods result complementary in their scope and aims. The multicriteria based approach determines possible site locations in a partially static manner, under the provided criteria and in a given moment in time, whereas ABM-GIS based approach works in a dynamic way, taking into account the relationship between social groups over time. The main purpose of this comparison is to support archaeologists in the analysis of distribution and location of potential sites, and hence creating a more efficient and oriented surveying strategy.

Standard session 42:
New technologies in woodland archaeology: problems and limitations

***Kamil Niedziółka**, Cardinal Stefan Wyszyński University in Warsaw*
***Pawel Konczewski**, Uniwersytet Przyrodniczy we Wrocławiu, Katedra Antropologii*
***Michał Jakubczak**, Institute of Archaeology and Ethnology Polish Academy of Sciences*

Medium Hall A, 11.00 – 12.40, 25 April 2019

A vast part of Europe is covered with woods (esp. Central, Eastern and Northern Europe), however, research within woodlands has often been neglected by archaeologists, mainly due to limited accessibility to these areas and the difficult conditions encountered during field investigations. Nevertheless, many forested areas offer unique opportunities to explore well-preserved remains of earlier human activities, traces of which have not been erased or transformed by modern agriculture, industrialisation or urbanisation. For some chronological horizons, there are regions that preserve complete accumulations of deserted cultural landscapes (economic, domestic and funerary) despite the succession of forestation processes. Unfortunately, the presence of dense vegetation has until recently meant that the application of standard archaeological techniques in forested environments, such as surface surveys and excavations, was problematic. However, the development of new technologies can significantly support archaeological investigations in wooded landscapes (e.g. the introduction of ALS data, GPS tools, GIS software, modern geophysics, photogrammetry etc.).

Alas, these new approaches are not without their own problems. For example the frequent lack of GSM/GPS signal caused by the wood cover makes it difficult to properly locate and georeference surface surveys, excavations and other investigations. The woodlands also restrict the deployment of drones and the preparation of photogrammetric plans. Furthermore, the application of geophysics is much more difficult, both from the point of view of conducting field work and the subsequent interpretation of survey data. Of course, these are just a few examples of problems related to woodland archaeology, the full list is much longer.

In this session, we will address topics ranging from non-invasive remote sensing to more invasive ways of archaeological investigations, performed with the use of high-tech methods of documentation and geodetic measurements. We would like to focus especially on specific problems and limitations related to utilisation of concrete modern technologies in woodlands as well as possible solutions. Interdisciplinary approaches are also welcome.

11.00 – 11.20
Airborne laser scanning in Białowieża Primeval Forest,
Michał Jakubczak, Michał Szubski, Janusz Budziszewski, Kamil Niedziółka

11.20 – 11.40
Between traditional and innovative. Case study of deserted forest village Neuhaus,
Radosław Biel, Paweł Konczewski

11.40 – 12.00
Mapping legacies of historic charcoal production on the landscape scale,
Anna Schneider, Alexander Bonhage, Alexandra Raab, Florian Hirsch, Thomas Raab

12.00 – 12.20
Geophysical survey in tropical forest: Results of research carried out at the pre-Columbian centre of Nakum (Guatemala),
Piotr Wojciech Szczepanik, Patrycja Obrempalska-Majdak, Jarosław Źrałka, Wiesław Koszkul

12.20 – 12.40
Terrestial Laser Scaning in the Rainforest: 3D documentation of the site and archaeological excavations of the ancient Maya centre of Nakum, Guatemala,
Bolesław Zych, Wiesław Koszkul, Jarosław Źrałka, Bogumił Pilarski

Airborne laser scanning in Białowieża Primeval Forest.

Michał Jakubczak, Michał Szubski, Janusz Budziszewski, Kamil Niedziółka

Białowieża Forest is one of largest forested areas in Europe. In total, it occupies nearly 1,500 km2, of which 42% is in our country and the rest is located in Belarus. This area is almost entirely considered as protected, including strict reserve in the form of the Bialowieża National Park. Such situation conducive to maintaining the remnants of an older settlement, but forest cover made the area almost inaccessible for archaeologists. Change of this state provide technology development of airborne laser scanning (ALS). Launched at the end of 2016 project "Cultural and natural heritage of Białowieża Forest" is aimed at a comprehensive, interdisciplinary examination of the archaeological resources of the forest with the background of nature sciences. During the project, three different point clouds were used, with a nominal density of 4, 6 and 12 points per square meter . The clouds also differed in the size of the laser beam footprint, form 50 centimetres for two first point clouds and about 12 centimetres in case of the last one. As research has shown, changing the scanning parameters has a large impact on the ability to detect archaeological sites, but also on the quality of analysis and the conclusions. As the research shows, the cloud of points has to be adapted to the needs of the research and data with a density of 4 points per meter and 50 cm of footprint are sufficient for detection, but in analysis more sophisticated small forms of terrain, better quality is needed.

Between traditional and innovative. Case study of deserted forest village Neuhaus.

Radosław Biel, Paweł Konczewski

The medieval deserted village of Neuhaus located in the Lower Silesian Wilderness is one of the many woodland sites in the area. Despite the presence of people since the beginning of the Holocene, this region is presently the largest continuous forest of Poland and one of the largest in Central Europe. The current state resembles the one from before Late Middle Ages' colonization when over 80% of the area was forested. Undoubtedly, the beforementioned circumstances are the source of problems common to sites with dense vegetation. Instructed by our colleagues from the University of West Bohemia we have conducted a research based on their experiences. Due to the fact that Neuhaus spans over many kilometres on both banks of the Czerna River, on the basis of historical records a couple of main points of interest were designated to undergo a series of different examinations. The most important one was a surface survey correlated with highly detailed topographical maps from the 19th century, during which the structures preserved in terrain were mapped with the use of a total station. Some of the methods used included LiDAR, GPR, magnetic and metal detecting surveys. In 2018 we have also conducted an excavation and were able to add its results to the GIS database that stores all the gathered data. We would like to briefly present our workflow and, in the interest of future research, demonstrate the methods that in our opinion gave the best results as well as the most ineffective ones.

Mapping legacies of historic charcoal production on the landscape scale

Anna Schneider, Alexander Bonhage, Alexandra Raab, Florian Hirsch, Thomas Raab

The remains of historic charcoal hearths (RCHs) occur in many forest areas as characteristic small-scale relief features, and are valuable archives of land use history. The increasing availability of high-resolution ALS data has given rise to many recent studies mapping such land use legacy features, which have revealed impressively high numbers and spatial densities of RCHs in many regions of the world. Nevertheless, the limitations of mapping from remotely-sensed data still need to be considered to allow for meaningful interpretations of RCH spatial distribution patterns and conclusions on past forest use. We present an assessment of the possibilities and limitations of RCH mapping from ALS data on the landscape scale, comparing mapping results from study areas in the Northeastern German Lowlands, the German lower mountain ranges and the lower mountain ranges in the northeastern USA. RCHs were mapped using automated detection and manual digitization, and mapping results were validated against archaeological excavations and detailed field surveys. The results allow for a detailed analysis of mapping accuracy in relation to DEM resolution and feature size, but furthermore show up relations of mapping success to RCH age and preservation and to geomorphology and subsequent forest use. Results

from a GIS analysis of RCH spatial distribution in relation to historic charcoal-consuming industries affirm that RCHs are a widespread and underestimated legacy of past woodland use in many regions, but also underline the relevance of considering variable mapping accuracy in landscape-scale analyses of archaeological relief features mapped from ALS data.

Geophysical survey in tropical forest: Results of research carried out at the pre-Columbian centre of Nakum (Guatemala)

Piotr Wojciech Szczepanik, Patrycja Obrempalska-Majdak, Jarosław Źrałka, Wiesław Koszkul

This paper aims at presenting results of geophysical survey carried out at the Maya centre of Nakum located in northeastern Guatemala. Between 2012 and 2016 several different geophysical surveys were conducted. They involved such methods as electrical resistivity (with the use of different probe systems) and application of ground penetrating radar. Surveys were carried out both on vast plazas as well as on top of platforms and pyramidal structures. They showed various anomalies some of which were verified archaeologically, bringing the discovery of several underground features. In our paper we would like to show both advantages, as well as shortcomings for archeological use of geophysical methods in the tropical jungle.

Terrestial Laser Scaning in the Rainforest: 3D documentation of the site and archaeological excavations of the ancient Maya centre of Nakum, Guatemala

Bolesław Zych, Wiesław Koszkul, Jarosław Źrałka, Bogumił Pilarski

This paper is focused on the presentation of the data which were obtained by Terrestrial Laser Scanning from the Maya center of Nakum, located in north-eastern part of Guatemala. The ruins of Nakum and its surroundings are covered by low and high vegetation which makes it difficult to analyze all surface features and modifications by aerial photography. One of the goal was merging 3D data with information from archaeological excavation and creating database. Point Cloud from Terrestrial Laser Scanning (TLS) was classified and Digital Elevation Model (DEM) with vegetation class was build. It allows us to conduct a very detailed analyze of area and its structures. Those data were integrated and compared to ESRI raster from examined area. The second way of use TLS data was to create interactive 3D map, which is based on triangulated point cloud and contains all digitalized tunnels, excavation unites with georeference, 3D models, photos, drawings and other important research data. It builds accurate database for the inventory and spatial planning, taking into account terrain shape, architectural objects and vegetation density. These data were combined with GIS and free-ware game engine software to create a database with easy open access, interactive publishing, and to build various interactive simulations in real time (flood, sun). Most of used software were open source (Meshlab, Blender, Unreal Engine) or accessible for research purposes (Arcgis).

Standard session 44: Analysing Shape in the Digital Age: Current Considerations in Archaeological Application of Geometric Morphometrics

***Christian Hoggard**, Department of Archaeology and Heritage Studies, Aarhus University, Denmark.*
***Sarah Stark**, University of Southampton*
***Georg Roth**, Institut für Prähistorische Archäologie Freie Universität Berlin*
***Katrien Janin**, University of Cambridge*

Small Hall, 14.00 – 15.40, 26 April 2019

Ordering and analysing objects according to their morphology has been at the heart of archaeology since its very construction as a discipline. And over the last thirty years a new methodology for the quantitative analysis of digitised shapes, Geometric Morphometrics (GMM), has become increasingly popular, leading to case studies around the world. GMM characterises and analyses morphological data directly, resulting in representations of shape (differences) as numeric variables open to combinations with other forms of data, including spatial or chronological frameworks. Additionally, powerful visualisations that partition shape differences into independent components (by PCA for example) allow for hitherto impossible separate interpretations of these differences. Yet curiously, despite positive feedback in its application, GMM still has not reached the attention in archaeology its potential achievements deserve.

This session illustrates the various aspects which GMM offers for the archaeological study of physical object forms, while aiming to highlight current issues in the field of archaeological shape analysis. It aims to provide a forum for debate on how archaeologists apply GMM technologies for research in the physical shape of objects, and how GMM can be further integrated into archaeological analyses.

We are particularly interested in presentations which discuss:

- The current state-of-knowledge of GMM in the discipline;
- Methodological developments (including software, frameworks and recording);
- The innovative application of GMM to object classes beyond lithic, osteological and zooarchaeological data;
- The consideration of GMM with alternative data types and frameworks (including Bayesian modelling);
- Theoretical considerations e.g. bridging the gap between statistical GMM and archaeological significance.

Note: in the interest of transparency, and in aiding discussion and learning, we encourage authors to distribute scripts used in their presentations prior and immediately following the session. Following the conference participants will be invited to collaborate on a review article on GMM for the CAA Journal.

13.40 – 14.00
Unsupervised techniques for shape analysis of Iberian ceramics based on Geometric Morphometrics,
Pablo Navarro, Celia Cintas, Manuel Lucena, Jose Manuel Fuertes, Claudio Delrieux, Manuel Molinos

14.00 – 14.20
What can GMM do for you?
Katrien Gwennola Janin

14.20 – 14.40
Geometric morphometrics, visual perception of similarity, gestalt principles and creating groups,
Rachel Opitz

14.40 – 15.00
Bridging morphology and technology: a case study on EUP blade technique in NE Japan,
Atsushi Noguchi

15.00 – 15.20
Differentiating between cutting actions on bone using geometric morphometric and Bayesian analysis of complete 3D cut mark surfaces,
Erik R. Otarola-Castillo

15.20 – 15.40
Rethinking the cultural taxonomy of the European Final Palaeolithic through two-dimensional elliptic Fourier analysis (EFA),
Christian Steven Hoggard, Felix Riede

Unsupervised techniques for shape analysis of Iberian ceramics based on Geometric Morphometrics

Pablo Navarro, Celia Cintas, Manuel Lucena, Jose Manuel Fuertes, Claudio Delrieux, Manuel Molinos Mail

The morphological analysis of ceramic pieces allows to establish the chronology, functionality and origin of the samples. The conformation of a typology of ceramic materials is made by analysing several aspects, such as shape, functionality, the context in which they were found, etc. Traditional studies are based on an intuitive recognition by the domain expert, which uses idealised shapes for creating the classification criterion. Other analysis collect linear measures such as height, width, thickness or ratios between them (maximum width / maximum length) to describe artefacts. The lack of a standardised protocol means that the classifications are partial and the analysis can not be easily compared or replicated by other researchers. Geometric Morphometrics provides a set of techniques that allow to quantitatively analyse the size, shape and variation between objects. In archaeology these techniques have been used for the analysis of rock representations, study of projectile tips, and ceramic vessels. The approach presented in this paper shows the typification in an unsupervised way using automated computer methods, based on concepts of Geometric Morphometrics and Principal Component Analysis. In addition, a Clustering study is carried out to determine the geometric space made up by a set of Iberian pottery from the upper Valley of Guadalquivir (S. VI B.C. - I A.C.).

What can GMM do for you?

Katrien Gwennola Janin

When coming across Geometric morphometrics (GMM) for the first time, it can appear to be a daunting and complicated technique. Questions ranging from 'will it be beneficial to my investigation?' to 'where on earth do I start?' are common, yet unfortunately answers are not that readily available. The proposed talk aims to provide people new to GMM with an overview of what GMM is, what it can and cannot do you for you, and how to take your first tentative steps into the world of shape analysis through the use of GMM.

Geometric morphometrics, visual perception of similarity, gestalt principles and creating groups

Rachel Opitz

How do we define shape, how do we know when two objects have similar shapes, and how do we as humans use this information? Li et al. (2013) define shape as referring to the spatial regularity of an object. Their research suggests that humans use shape to identify, remember and recognize objects, and to infer the functions and uses of an object. The gestalt principle of similarity, states that things which share visual characteristics such as shape, size, color, texture, value or orientation (with shape dominant within these) will be seen as belonging together. Bringing these ideas together, we can argue that one use of shape by humans is making groups of similar things with similar purposes. How do we know that two objects have similar shapes? Geometric morphometrics methods that rely on the statistical characterisation of shape approach this problem through measurements, geometric morphometrics methods that use landmarks rely on a mix of perceived and measured properties, while as humans we rely primarily on perceived shape. This paper considers the practice of grouping objects on the basis of their measured and perceived morphology. It argues that the motivation for the creation of groups of similar objects will favour the use of either measured or perceived shape similarity. Based on this, the implications for the application of different approaches to the characterisation of shape as applied in archaeology are considered.

Bridging morphology and technology: a case study on EUP blade technique in NE Japan

Atsushi Noguchi

Both archaeological materials especially of reffited reduction sequence and reconstructive experiment are key for understanding of lithic technology. 3D measurement and morphometric analysis would be key methodologies for comparing and conjoining these different criteria of research material. While well-controlled experiment yield replicas of archaeological material with observed technique upon original, morphometric analysis examine and confirm accuracy of results in comparison with morphology and technology of each other quantitatively. In this paper, authors present a case study on Early Upper Palaeolithic blade technique in northeastern Palaeo-Honshu Island in Japanese Archipelago. Unidirectional semi-rotated laminar reduction sequence observed in both Kazenashidai 1 and Matsugidai 3 sites (ca. 36ka) are replicated by a present performer with certain technique reconstructed by careful observation of riffited material. Multiple 3D measurement attribute is analyzed for quantitative verification on technical controls to understand the technical basis for obtaining objective morphology of blade as

support for pointed tool, while geometric morphometrics is employed for revealing demanded shape for tool kit. Correlation between technical controllability and common difference of demanded shape of blade/ tool will also be examined for understanding technological scalability.

Differentiating between cutting actions on bone using geometric morphometric and Bayesian analysis of complete 3D cut mark surfaces

Erik R. Otarola-Castillo

Cut marks and other bone surface modifications (BSM) on archaeological faunal assemblages provide critical evidence about human evolution and hominin subsistence behavior. However, aspects of BSM identification and classification are contentious. There is little consensus regarding the most accurate methods to identify human-made BSM, and how to differentiate them from marks created by other taphonomic agents. This has been particularly problematic when identifying the earliest instances of hominin butchery. Most BSM studies rely on morphological characteristics to identify butchery marks and understand their patterning. This approach extends to the analysis of cut marks, one of the most evolutionarily significant human-made BSM. Recent studies have employed 3D scanning technologies that generate detailed morphological information to interpret marks found in the fossil record. Although 3D methods open promising new avenues for investigation, most studies rely on cross-sectional slices of 3D scans as proxies for overall BSM shape. Such analyses, unfortunately, fail to take advantage of complete 3D surface morphology. Here, we demonstrate that geometric morphometric analyses of complete 3D BSM surfaces, in conjunction with Bayesian statistics, can discriminate with 88% success between marks created by different butchery behaviors. Our results help strengthen statistical confidence in cut mark identification and offer a novel method to distinguish subtle differences between cut marks in the fossil record. This study provides a nascent digital library from which to make quantitative comparisons to archaeological examples, particularly controversial specimens that are key to understanding the earliest date of hominin butchery.

Rethinking the cultural taxonomy of the European Final Palaeolithic through two-dimensional elliptic Fourier analysis (EFA)

Christian Steven Hoggard, Felix Riede

A fundamental precondition to understanding the nature of population and social learning structures throughout the Palaeolithic is the unambiguous definition of comparative analytical units. However, in the creation of such taxa for the European Final Palaeolithic there is significant ambiguity in the appropriateness of current units for a number of research-historical

reasons. Furthermore, rigorous high-resolution frameworks which test the robustness of groups and artefact types for this period are lacking. Here we use elliptic Fourier analysis (EFA) on a large sample (n = 2200) of Final Palaeolithic formal projectile point types (backed points and tanged points), in order to assess whether perceived 'ethnogeographic' variability can be captured quantitatively and across regions and research traditions. We then present agglomerative hierarchical clustering (using the principal component scores) of these point types to discuss the appropriateness and robustness of current analytical units.

Standard session 45:
Virtual Reality and 3D modeling: Where are we now?

Mantha Zarmakoupi, University of Pennsylvania

Exhibition room B, 14.00 – 15.40, 26 April 2019

Over the past 20 years virtual reality and 3D modeling technologies have expanded the range of research tools used in the study of the history of architecture. They have enabled researchers to explore multifaceted themes of design and restoration, as well as sensory experience of historic buildings and spaces in virtual space. The excess of 3D and virtual reality representations asks for methodological approaches that will further facilitate their instrumental integration in research. This session invites papers that tackle the use of 3D modeling representations and virtual reality simulations, especially in the fields of ancient Greek and Roman art and architecture, that attempt on the one hand to challenge their limitations and, on the other, to address the ways in which they can be used to develop research questions. Papers can address the challenges that virtual Reality and 3D modeling technologies pose for research today by focusing on specific case studies or addressing broader methodological questions.

14.00 – 14.20
Similarity analysis of African Red Slip Ware (ARS) with modern 3D and 2D processing techniques,
Philipp Atorf, Carina Justus, Ashish Karmacharya, Louise Rokohl, Frank Boochs

14.20 – 14.40
Facing the Challenges: Academic Credit & 3D Archaeological Scholarship,
Costas Papadopoulos

14.40 – 15.00
3D documentation of ceramic vessels with the use of modern measurement technologies,
Edyta Puniach, Paweł Ćwiąkała, Mateusz Boruchowski, Witold Niewiem, Kamila Nocoń

15.00 – 15.20
Mongolian deer stones: a perspective of documenting by photogrammetry,
Daria Hookk, Alexey Kovalev, Nikita Pikov

15.20 – 15.40
Digital authenticity: aesthetics of glitch and an interactive user experience design through digital heritage,
Zeynep Özge Özdemir, Serdar Aydin

Similarity analysis of African Red Slip Ware (ARS) with modern 3D and 2D processing techniques

Philipp Atorf, Carina Justus, Ashish Karmacharya, Louise Rokohl, Frank Boochs

African Red Slip Ware (ARS) is a relief-decorated ceramic produced mainly between the 3rd to 5th century AD in North Africa. The characteristic appliqué motifs provide us some insights into understanding the late antique worlds of ideas and their change. As mass-produced image carriers and everyday objects, ARS bowls, plates and vessels found a wide distribution. 3D geometry and archaeological interpretation allows to identify correspondences between different appliqué motifs in order to determine common manufacturing strategies or even a common workshop. For this purpose, a digital true-to-original replica of each relief-decorated ARS of the RGZM collection is created using structured light scanning and photogrammetry. Due to the manufacturing process appliqués are deformed in different ways, depending on the geometry of the vessel. These deformations must be eliminated as far as possible prior to a similarity analysis; therefore, different types of transformations have to be applied. Restituted appliqués can be processed in different ways in order to estimate a potential similarity. We apply 2.5D, 3D, and image processing techniques in order to calculate transformations and supporting spatial features helping to support correspondence hypotheses. In addition, we will use semantic technologies helping to split the object into unique spatial entities and to model the archaeological content. The latter will be based on visualisation and manual interpretations through experts.

Facing the Challenges: Academic Credit & 3D Archaeological Scholarship

Costas Papadopoulos

In the last three decades 3D modelling and visualisation has been seen as an essential research practice in archaeology, ranging from schematic (re)constructions of buildings to photorealistic renderings, spatiotemporal simulations of ancient structures (Dawson et al., 2007, Paliou et al. 2011; Papadopoulos & Earl 2013; Oetelaar, 2016), and interactive virtual worlds (Sequiera and Morgado, 2013). Concerns over the photorealistic and deceiving nature of 3D (re)constructions and lengthy discussions about transparency and ambiguity (Miller and Richards, 1995; James, 1997; Goodrick and Gillings, 2000; Eiteljorg, 2000; Clark, 2010; Watterson 2015) have led to proof-of-concept implementations (e.g. London Charter, Seville Principles, Epoch's Interpretation Management) to demonstrate intellectual rigour in 3D models and explicate decision-making in the process of their creation. Despite the abundance of work in the field, and the potential of 3D visualisation projects to form new understandings and interpretations, 3D modelling has never been established as scholarship in its own right. 3D models and their inherent interactive

nature have to be turned into static, often black and white publications in high impact factor journals in order to get academic credit and count towards tenure and promotion. This paper will explore 3D scholarship and academic credit, discuss the challenges that 3D visualisation scholars face, and propose ways to move towards more sustainable 3D scholarship.

3D documentation of ceramic vessels with the use of modern measurement technologies

Edyta Puniach, Paweł Ćwiąkała, Mateusz Boruchowski, Witold Niewiem, Kamila Nocoń

Digital photogrammetry is quickly becoming a standard documentation tool in archaeology. Photogrammetric techniques are used to document both the findings of an archaeological site and the whole excavation. This paper is focused on a method of recording and documenting the surface of small objects by means of automatic photography device called FocusSphere. It is an original, inexpensive device prototype developed for the purpose of such a documentation. Resolution of 3D models obtained using FocusSphere is up to 0,1 mm depending on a non-metric camera and a lens which were used. Design and principle of operation of the device are presented in the paper. However, the main goal of the study was the assessment of FocusSphere suitability for the documentation of ancient ceramic vessels belonging to the Cypriot and Greek cultural circle. The research work was carried out in two stages. The first stage was to determine repeatability and accuracy of FocusSphere (ability to achieve repetition of the same position and ability to achieve desired position). For this purpose, precise measuring instrument (laser tracker) was used. The documentation of selected ceramic vessels differing in shape and surface characteristics was carried out in the second stage of the research. In order to assess the accuracy of the 3D models obtained by photogrammetric method the reference data were collected. They were cross sections of vessels measured by means of metrological device (measuring arm) guaranteeing the measurement accuracy at the sub-millimeter level. The results obtained were also compared with classic archaeological drawings. The methods of development of data collected by two different techniques (FocusSphere, measuring arm) along with indication of their advantages and disadvantages were finally discussed.

Mongolian deer stones: a perspective of documenting by photogrammetry

Daria Hookk, Alexey Kovalev, Nikita Pikov

The ritual complex of Khar Chuluut 1 in Bayan-Olgii aimag of Mongolia belongs to Chemurchek (Qiemuerqieke) cultural phenomenon (26–18 c. BC). The site was excavated in 2015 and a 'treasure' of 79 engraved and not-engraved stone plaques was found. The closest analogies of these engraved plaques, supporting the hypothesis of Western European origin of Che-

murchek phenomenon, are engraved anthropomorphic plaques from megalithic monuments of the Iberian Peninsula (31–27 c. BC.), as well as statues-menhirs of Sion-Aosta type (29–27 c. BC). Similar anthropomorphic engravings on pebbles and slate plates, according to the authors, were distributed in the Sayan-Altai region as result of expansion of cultural traditions of Chemurchek people. The problem consists in the state of preservation of the ritual place with broken engraved stone walls spread around the site, and the number of engraved plaques, which are damaged during transportation to a museum. The opportunity to make the digital copies of them by photogrammetry allows scholars to continue investigations after the field works and recreate the ritual complex using digital technologies. Thus we get chance to became familiar with images: anthropomorphic figures, idols and devils, animals and other signs, as well as compare engravings on pebbles and slate plates.

Digital authenticity: aesthetics of glitch and an interactive user experience design through digital heritage

Zeynep Özge Özdemir, Serdar Aydin

This paper discusses glitches that occur as part of polygon mesh processing in 3D photogrammetry. The production of 3D geometries in photogrammetry is relevant to the object(s) being photographed or device-related parameters, e.g. camera lens and shutter speed. In this context, there are several determinants regarding the modelling of 3D mesh geometries, including transparency and brightness of objects and subtlety between repetitive elements. Data transformation from 2D images to 3D objects frequently changes the message and the glitch appears as part of the process. We present the results of a two-day workshop attended by four participants. We experimented the generation and the dissemination of glitches as both scholarly and creative products. The workshop showed how glitches (digital errors) could be exploited to rather catalyse communication between the machine and the audience. During the workshop, photographs were converted into 3D sculptures with 'errors' or as we define 'glitches' that appear like holes or dislocation of pixel's colour values. Such internal errors were taken as potentially representative of a gap in knowledge where users must project their own conceptual understanding to complete it. Decentralisation of the artefact from its materiality, by tolerating glitches of the digital transcoding processes, led us to evolution of means for stimulating the subjective performance of users whereby emotions and intertextual narratives can be represented.

Standard session 46:
Spatial Analysis of 3D Archaeological Information: Method and Theory

Gary Nobles, University of Groningen
Joerg Raether, Archaeological Museum Hamburg

Exhibition Room B, 16.00 – 17.00, 24 April 2019

Archaeologists and Heritage professionals continue to capture 3D data through photographic and optical methods. While the methods of data collection are well documented, the theoretical and practical aspects of using these relatively new datasets within archaeological practice are in the initial stages. Point cloud processing, web visualisation, spatial thinking, volumetric analysis are a few of the related themes to this broadening topic. This session aims to bring together researchers working with a variety of 3D spatial data. The key aim of this session is to move the discussion beyond purely data capture towards the analytical applications which have been, and continue to be, developed. Papers can take various forms: narratives considering the current and future archaeological requirements for 3D data; analytical applications applied to 3D data with archaeological contextualisation; theoretical conceptual papers which question how we understand the 3D spaces we record; technological developments and innovation applied to 3D archaeological data; or purely 3D spatial analytical applications. The session will conclude with a general discussion indicate the hurdles, technological or theoretical, which limit the use of these kinds of datasets.

16.00 – 16.20
Proportions vs dimensions: shedding a different light on the analysis of 3D datasets,
Jean-Yves Blaise, Iwona Dudek, Gamze Saygi

16.20 – 16.40
Enter the TechnoScape: thinking through our future toolkit,
Gary Nobles

16.40 – 17.00
Skeletons. We've all got one. What next?
George Alexis Pantos

Proportions vs dimensions: shedding a different light on the analysis of 3D datasets

Jean-Yves Blaise, Iwona Dudek, Gamze Saygi

In the last decades, many methods (e.g., digital photogrammetry, laser scanning, computer vision, etc.) have been introduced that result in a renewed capacity of academics to produce large 3D datasets. Naturally research objectives, technological suites, levels of geometric accuracy required, or scales of objects under scrutiny do strongly vary - hence a wide range of "outputs" corresponding to various data interpretation strategies. But with that renewed capacity methodological questions emerge: does the "massive amount" of 3D data a survey results in really corresponds to the analytical need? Ultimately, is the added-value of "going massive" undeniable? We argue that this capacity to "go massive" can also open opportunities to investigate new analytical filters. We base on two observations: - more 3D data does not imply abandoning our capacity to reduce, to sum up, to spot significant features - flexible, low cost survey suites can give us a chance to revisit fundamental metrics in the history of architecture : ratios, proportions, rather than exhaustive dimensioning. We investigate how a low-res 3D point cloud can be re-read with the aim of identifying simple ratios and geometric relations, in other words of extracting from it meaningful architectural features. The paper underlines the cognitive potential of reading proportions in the history of architecture (both at design and analysis levels) and focuses on an experimentation conducted on thirty "comparable" edifices. The approach exemplifies a shift from a one-shot, exhaustive documentation of one edifice to a workflow dedicated at decoding and visualising relations inside a collection.

Enter the TechnoScape: thinking through our future toolkit.

Gary Nobles

Forte (2010) has argued that we are at risk of following technological determinism, this has become apparent within the scope of recent attempts at 3D GIS which on the technical level are 3D environments encapsulating 2D data. Such 2.5D GIS' are therefore masquerading under the 3D label. Other non-geographical software – like 3D modelling – have also been presented as a 3D GIS solution even though they are lacking in the GIS fundamentals. It is clear that there is a developing diversity in the world of 2.5D and 3D data management and analysis, but what types of software do we have at our disposal and what are the pros and cons of the various directions that we could be taking? This paper looks at the trends which are developing in the realm of 3D GIS and related technologies and brings them into digestible categories from GIS to Geodesign, HBIM to the concept of Smart City infrastructures. It questions the suitability

of the new wave of technologies and asks which if any are suitable for archaeological purposes from both the theoretical and methodological perspectives.

Skeletons. We've all got one. What next?

George Alexis Pantos

That photogrammetry is a useful, and accurate tool for documenting human remains encountered on archaeological excavations is now quite well accepted. 3D records of graves can add greater context for bio-archaeologists working on material after the excavation as well as a tool for discussion by excavators. Work by commercial units (e.g. see CAA 2018) exemplify many of the practical and potential financial benefits to this recording method and a code of ethics for publishing and sharing this sensitive data is well underway. However, substantial methodological and technological challenges still remain – especially for smaller projects as technology, and our expectations of technology continue to change. What's more, there are relatively few projects exploring what new information this 3D data might offer that could not achieve what traditional modes of documentation (e.g. standard photography and plans). How else might our 3D field records help us? How ought we be striving to document inhumations in the field? How much detail is enough? Where should we take things next as we develop our future systems? And how do we cope with the inevitable data variability? This talk has no answers, but by drawing on burials documented on sites that span different times, recording challenges and research aims it hope to raise discussion and explore some of the issues and opportunities that we may face.

Poster session

***Łukasz Miszk**, Jagiellonian University*
***Wawrzyniec Miścicki**, Jagiellonian University*
***Wojciech Ostrowski**, Warsaw University of Technology*

Poster Space, 15.00 – 16.00, 25 April 2019

Light to measure, light to record: 3D recording of a Roman sundial via Structured Light Scanner,
Arianna Traviglia, Filippo Bergamasco, Mara Pistellato

'Meeting the minoans' – an assessment of visitors' experience on a bronze age archaeological site in Crete,
Thérèse Claeys

3D visualization of the medieval bishop's palace in Milicz as a method of presenting research hypotheses,
Małgorzata Markiewicz, Justyna Kolenda

Pilot study: problems and solutions in applying deep convolutional neural networks in zooarchaeology,
Ilkka Matti Veikko Sipilä

Yesterday once more: A novel approach in the preservation of ancient buildings in Boketu town,
Cui Hexun, Li Pengzhen

The Q Continuum: open source GIS tools for paperless field survey,
Joe Roe

Bone language: Fuzzy mathematics + GIS tells the story of the dead miner,
Cui Hexun, Li Pengzhen, Zhang Quanchao

Automating Archaeological Documentation with Robotics Tools,
Juergen Landauer

Old excavations on the landscape: Using legacy data to inform new interpretations,
Joshua James Emmitt

Where am I in the Forest? - Application of SLAM/LiDAR Technology to Measurement and Geophysical Survey of Archaeological Sites in Forest,
Akihiro Kaneda, Hiroshi Yamaguchi

The Regional Archaeological Infrastructure SPATZ in Switzerland and Liechtenstein – Lessons from the Past, Visions for the Future,
Philipp Wiemann, Kristin Kruse

Kerameikos.org: Linked Open Data for Greek Pottery,
Renee Gondek, Ethan Gruber, Tyler Jo Smith

Virtual and augmented reality in presentation of the La Tène culture in Bohemia,
Betka Danielisová, Jiří Unger

Architecture and soil stratigraphy of relict charcoal hearths in Europe and the USA,
Florian Hirsch, Anna Schneider, Alexander Bonhage, Thomas Raab, Alexandra Raab, Will Ouimet, Patrick Drohan

Advanced Documentation Methods for Black-Figure Styles with Combined CT and Optical 3D-Data,
Paul Victor Bayer, Andras Marton, Hubert Mara, Stephan Karl

From analogue to digitalized papers and reports: -Status and benefits of transforming past knowledge for future research,
Magne Samdal

Open source tools for tidy photographic and 3D data management between the field and the archive,
George Alexis Pantos, Joe Roe

What's the point, what's the number? - The use of mobile devices in the field prospections conducted on multicultural sites in southern Poland,
Jan Bulas, Michał Kasiński, Magdalena Okońska

Photogrammetry and laser scanning of Ancient Pueblo architecture and rock art sites in the canyons of the Mesa Verde region, Colorado, USA,
Radosław Palonka, Vincent M. MacMillan, Bolesław Zych, Anna Słupianek, Katarzyna Ciomek, Paweł Micyk

Spatial archaeology in Lagoa Uri de Cima archaeological site (Salgueiro/Brazil): a study of intrasite distribution of the lithic vestiges,
Lucas Bonald Pedrosa de Souza, Demétrio da Silva Mützenberg

An ontological approach to focus group research at the boundaries of the archaeological semiosphere,
Costis Dallas, Ingrida Kelpšienė, Rimvydas Laužikas, Suzie Thomas, Isto Huvila

Virtually Terraforming Iron Age Ireland: A 3D Reconstruction of the Structures at Dun Ailinne (Co. Kildare),
Zenobie Susanne Garrett

Reconstructing the past of Ancient Pueblo culture: Results of geophysical surveys by Sand Canyon-Castle Rock Community Archaeological Project in Colorado, USA (2011-2018),
Radoslaw Palonka, Piotr Szczepanik, Patrycja Obrempalska-Majdak

"The volume of light" - how to estimate the capacity of ancient oil lamps using 3D models?
Martina Polig, Małgorzata Kajzer, Sorin Hermon

Machine Learning for Ground-Penetrating Radar,
Katie Simon, Christopher C. Angel

Cleaning new data: Lessons learned while preparing datasets for publication,
Matthew Barrett, Joshua James Emmitt

Interpreting Archaeological Sites by Combining GIS and Other Kinds of Surveys,
Wojciech Ejsmond, Julia Maria Chyla, Olivier P. Rochecouste

Traceability of archaeological data, from excavation to publication
Olivier Marlet, Xavier Rodier

**Rescuing the cultural heritage of Nea Paphos using geophysics:
the case of Omirou street and Glyky Nero locations**
Efstathios Raptou, Nikola Babucic, Ewdoksia Papuci-Władyka, Martina Seifert

A virtual look into a museum depot: enhancing small collections through digital approaches
Irene Sarcinelli, Elisa Sartori

**3D-Documentation and excavation of a huge reversible water wheel
from a medieval mine in Bad Schlema, Germany**
Thomas Reuter

Title Application of Photogrammetry and VR in Archaeology – from Field Survey to Virtual Museum
Giorgi Datunashvili, Mikheil Elashvili, G. Kirkitadze, N. Vacheishvili

After the Strafexpedition: A digital heritage perspective on the Winterstellung trenching system,
Armando De Guio, Luigi Magnini, Giulia Rovera, Andrea Marra

Light to measure, light to record: 3D recording of a Roman sundial via Structured Light Scanner

Arianna Traviglia, Filippo Bergamasco, Mara Pistellato

The precise orientation of the centuriation of Aquileia (Italy), once one of the biggest cadastre ever deployed in Italy up to the beginning of the 2nd century BC, has been suggested to be 22 degrees 30" W from the N based on the indications provided by the so-called sun-dial of Euporus. The instrument, a horizontal plane sun-dial, was discovered in the area of the Aquileian Circus. The longer side of the horizontal plane was aligned with the orientation of the city and angle between the side orientation and the Meridian represented in the sundial is supposed to indicate the orientation chosen for the ancient city. In order to ascertain with precision the amplitude of the angle, the sun-dial was thus captured with a 3D scan. The recording was performed using a Structured Light 3D Scanner composed by a DLP LED projector and a single 3-Mpixels camera. Such device enables the full 3D acquisition by projecting a sequence of light patterns that are synchronously acquired by the camera. The team used a novel robust phase shift technique to associate a unique code to each observed camera pixel and then compute a 3D range-map via camera-projector triangulation. Considering the dimensions of the scanned object (1mx2m), multiple overlapping range-maps were acquired. To precisely align each range, an additional DSLR camera was positioned to capture the entire scene from above and was used to record the scanner position and orientation for each range. Finally, the scanner poses were used to align all the range-maps and reconstruct a single high-resolution watertight surface. The scan enabled to remeasure the correct angle formed by the Meridian with the orientation of the Cardo and transpose the results to the study of the Aquileian cadastre. In addition, by simulating the progression of the shadow projected by the gnomon on the sundial plane and studying its changes according to latitude, with a reverse engineering approach, we have ascertained that the sundial was not designed for Aquileia's latitude but for one further south, in central Italy.

'Meeting the minoans' – an assessment of visitors' experience on a bronze age archaeological site in Crete

Thérèse Claeys

Since the 1970s, the island of Crete has been experiencing an ever-growing increase in tourist flows to the extent that tourism industry has become its most important economic activity. Although most tourists visit the island's seaside and less its cultural and natural landmarks, many of them, however, include a visit to the archaeological site of Knossos in their program, as it is touted as one of the island's premier attractions. Moreover, Knossos keeps dominating public

perceptions of the Cretan and especially 'Minoan' past. This poster explores the impact of the extended reconstruction work conducted at Knossos on its visitors and the degree of satisfaction it provides through comparison with the experience provided to visitors on another highlight of the Minoan civilization, namely the archaeological site of Malia. This experience is assessed by a combination of visitor-sourced qualitative and quantitative analyses. The ultimate goal of this on-going project is to eventually assess whether and how digital technologies can improve the visitors' experience on Minoan archaeological sites and increase their attractive power without generating their "disneyfication". To address this challenge, the study will first reflect on the effectiveness of geo-temporal tracking methods not only for quantifying visitors' movement but also for informing management decisions in the planning of visitors' circulatory patterns. Secondly, the opportunities disclosed by augmented reality, as a trendy technological advance though not experimented yet on Minoan sites, will be discussed in the framework of this poster.

3D visualization of the medieval bishop's palace in Milicz as a method of presenting research hypotheses.

Małgorzata Markiewicz, Justyna Kolenda

Over the last decades a very intensive development of digital media, such as computer visualization techniques, has been observed. The willingness to protect the cultural heritage – especially historical monuments which are in ruins and exposed to further destruction – as well as the need to spread knowledge about such monuments in the society made the 3D-visualizations particularly useful. In the subject literature there are many proposals for the reconstruction of the form of this palace. We chose the most recent hypothesis, based on architectural and archaeological research. The 3D model allows us to verify spatial solutions that could not exist due to technical reasons. The bishop's palace in Milicz was probably built in the late thirteenth century. Completely devastated relics inspired us to make a visualization of the earliest phase of this object. The work was conducted as part of the project titled Regni custodia et clavis – Santok and clavis regni Poloniae – Milicz as an example of two borderline strongholds. Visualization of the bishop's palace in Milicz was implemented by the Institute of Archaeology and Ethnology of the Polish Academy of Sciences. The virtual reconstruction of the palace was made as a result of analysis and interpretation of source materials according to the guidelines of the London Charter. The purpose of the visualization is to introduce Milicz's local community and tourists to the history of the building, as also to urge the local authorities to make efforts to preserve and revitalize the bishop palace.

Pilot study: problems and solutions in applying deep convolutional neural networks in zooarchaeology

Ilkka Matti Veikko Sipilä

In theory, successful utilisation of object categorization and computer vision in archaeology would have an enormous impact on the discipline. For instance, identification of all artefact classes would become more objective and quicker, researchers would be able to process larger samples, and coupling machine vision with robotics would speed up environmental sample processing. Zooarchaeology especially would benefit from a standardised methodology, as zooarchaeology is sometimes criticised for lack of quality control and assessment (Wolverton, 2013), as well as for inter-analyst variation (Gobalet, 2001) that can result in complex biases in meta-analyses (Lau and Whitcher Kansa, 2018). However, in the case of deep neural networks, achieving a level of accuracy and consistency beyond human ability is ultimately dependent on large, good quality training data. The problem then arises, how do we collect large datasets for use by a neural network capable of zooarchaeological identification, if using zooarchaeological assemblages identified by many specialists leads to complex bias? In this research, the present author highlights some of the issues that arise when blindly using data that depends on information derived from outside sources by employing deep convolutional neural network (CNN) on bear skulls. It is argued that image data downloaded from popular search engines and crowdsourcing campaigns for use in such models will not provide suitable data for an accurate model. Rather, the researcher should know the provenance of all image data being used, which leads to higher costs in the model's training phase.

Yesterday once more: A novel approach in the preservation of ancient buildings in Boketu town

Cui Hexun, Li Pengzhen

In this paper, the authors study on the ancient town with ethnic customs and exotic features in Inner Mongolia Autonomous Region of China. Considering Boketu is a typical mountain town. The houses and buildings are mostly scattered on the hillside and some buildings are close to each other, traditional methods cannot effectively measure the ancient buildings in Boketu town. To address this issue, first, handheld RTK measurement method is adopted to obtain the basic geographic data of the ancient urban area, and VRS is used to control the measurement accuracy. After obtaining the layout map of the ancient urban area, UAV is used to collect the top view of the ancient buildings, and three-dimensional camera is used to take pictures of the ancient buildings. When encountering the damaged structures with special decoration or peeling and

weathering, Artec 3D scanning is adopted to carry out accurate scanning on a small range. Finally, extensive collection of relevant historical photos, written materials and descriptions of people. Using ArcGIS (ESRI) to build a database and conduct 3D analysis. So as to provide guidance and reference for carry out all-round ancient buildings of Boketu.

The Q Continuum: open source GIS tools for paperless field survey

Joe Roe

"Paperless" field documentation has been on the digital archaeologist's agenda for over twenty years. A range of approaches have been proposed, from the straightforward application of off-the-shelf software (e.g. Filemaker, GeoODK), to full archaeological information systems (e.g. ARK, FAIMS). Despite this, we haveyet to converge on a standard toolset. There appears to be a central tension between generic software, which tends to be easy to use but may lack flexibility, and systems specifically designed for archaeologists, which are full-featured but can be difficult to deploy. In this poster I outline "yet another" system for paperless recording in archaeological survey, but one which occupies a middle ground between these two approaches. It consists of a stack of open source GIS software: PostGIS, QGIS, and the newly-available mobile app QField. Running on Android devices in the field, QField natively supports the core components of survey documentation: navigation, geolocation, custom forms, photography, and planning. It seamlessly integrates with QGIS, already widely used by archaeologists, for data processing out of the field. PostGIS is used for a central database for collaboration and dissemination via webGIS. The advantage of this system is that it is flexible enough to support a full archaeological workflow, but uses easily-deployed tools that are actively maintained by a wider community of GIS developers. There are caveats, particularly in the reliance on QField, which is still in beta, but it is hoped that this approach will contribute to the eventual standardisation of digital documentation in the field archaeology.

Bone language: Fuzzy mathematics + GIS tells the story of the dead miner

Cui Hexun, Li Pengzhen, Zhang Quanchao

During the Japanese occupation of northeast China, they oppressed the people, deprived them of personal freedom and forced them to undertake heavy manual labor, especially the work of miners. Resulting in the deaths of millions of Chinese laborers, according to rough statistics, more than 80,000 Chinese miners have been killed or maimed, forming six large mass graves. Due to the large number of the dead and the casual burial, the research on the miners' remains

encountered many problems. Therefore, cluster analysis is used for sort out human skeletons. By introducing the discriminant function and establishing the factor analysis model, the problem of recognition and arrangement of scattered bones is effectively solved. The study found 70 different types of trauma: 32chop trauma, 9bruises trauma,3scratches trauma,5bone indentations,14penetrated fracture,5 collapsed fracture,1 linear fracture,1 saw-cut. In order to identify and analyze the bone trauma in miners remains, and help us explore the nature and formation mechanism of the trauma. The author also use mathematical method for the first time to make a possible hypothesis for the real causes of the injured miners. Combined with fuzzy analysis of mathematical statistics, gives a fuzzy model of the miners' remains. The membership degree is determined by probability and the weight is determined by fuzzy equation method. The database was established by fuzzy mathematics for the first time, and the scenes of the dead miners' remains were played back through GIS technology, which provided important reference for the further development of the follow-up work.

Automating Archaeological Documentation with Robotics Tools

Juergen Landauer

Photogrammetry has been adopted by archaeologists for documentation of artefacts for quite a while with good results. Even researchers with limited experience are able to produce good results by obeying simple rules such as “ensure sufficient overlap between images” or by using software tools such as Pix4D or Scann3D which incorporate such rules. However, these rules are mere simplifications of the underlying photogrammetry algorithms. Whereas they work well with rather planar structures and objects without protruding or partially occluded features, they are bound to provide less-than-optimal results with a large set of real world archaeological objects. Here, we propose a new approach derived from recent progress in robotics and computer vision (more specifically solutions to the so-called Next-Best-View problem) which lets the computer decide which image to take next based on previous images. By intertwining image capturing and processing a more accurate 3D documentation can be achieved. We demonstrate that this method is useful for both entire sites (demonstrated with a Roman Villa Rustica) and smaller scale objects (e.g. Minoan pottery). Capturing the latter currently still requires some manual assistance, whereas site recordings are fully automatic (with drones).

Old excavations on the landscape: Using legacy data to inform new interpretations

Joshua James Emmitt

Digital archaeology is a relatively recent advancement in archaeological practice. Modern digital recording methods allow for the accurate measurement of many artefacts over a short amount of time, however, much archaeological data remains in analogue form. The level to which analogue data may be digitized and incorporated with modern geographical information systems data (GIS) is dependent on the level at which it was initially recorded. In many cases only two-dimensional reconstructions are possible, but others provide an opportunity to create three-dimensional (3D) reconstructions of archaeological sites, perhaps demonstrating a desire to record data at a level that was perhaps technologically ahead of the time. While the level of recording may be detailed, careful consideration must be made of the integrity of the data and the interpretations that may be made from them. Once this is done reconstructions are used in reassessment of the original interpretations of the sites and the landscapes they are situated within. In this paper case studies from the Fayum north shore, Egypt, and the Aboriginal burial ground at Roonka, Australia are discussed. Through the use of 3D GIS new interpretations of these places have been possible, particularly with regards to the impact of post-depositional processes in these environments. In the Fayum the site of Kom W is shown as a product of erosion as opposed to being a unique place on the landscape, and the distribution of burials and artefacts at Roonka shows a complex depositional history for the site.

Where am I in the Forest?-Application of SLAM/LiDAR Technology to Measurement and Geophysical Survey of Archaeological Sites in Forest.

Akihiro Kaneda, Hiroshi Yamaguchi

In this presentation, we will present experiments and practical examples of multiple SLAM and LiDAR methods of position localization method to support topographic measurement and geophysical survey technologies in forest area in Japan, and compare the results. Japan is covered with forests covering the majority of the country land. There are many archaeological sites grasping inside it. Archaeologists have always confronted problems to measurement and geophysical survey in it. One of the problems is difficult and troublesome to get localization of survey position in a forest and urban area. In many cases, we can't often measure by GPS or total station by the trees or buildings. However, it is important to get information which is a basis on research and conservation about these past human activities. For these aims are used terrestrial LiDAR and SfM. Through refining and combination these techniques, we will promptly and

accurately determine the position and promote the improvement of the quality of topography measurement and geophysical survey. This poster introduces the GPS localization used SLAM technology. LiDAR (KAARTA Stencil) or camera are installed at the top of the GPR antenna and it's positioning coordinates integrated to the GPR signal.

The Regional Archaeological Infrastructure SPATZ in Switzerland and Liechtenstein – Lessons from the Past, Visions for the Future

Philipp Wiemann, Kristin Kruse

This poster presents the SPATZ infrastructure, a regional archaeological documentation, management and research platform. Used on a daily basis in four major state and national archaeological services in Switzerland and Liechtenstein, it combines and integrates a database solution, a digital image management system and a spatial database. SPATZ is supporting various tasks like documenting rescue excavations, managing archaeological sites and recording artefacts. Therefore, a complex data structure and several data interfaces were developed to facilitate a highly integrated archaeological resource management platform. Semi automatized workflows allow importing image metadata from the image management systems via XML and transferring data from CAD projects into the spatial database. As a "living system" used in recent excavations as well as in heritage management actions, the quality of the data is continuously improved. The layout of SPATZ is based on modularity that allows the replacement of any underlying software module without jeopardising the infrastructure as a whole. Even though the SPATZ project can be considered a success and a true benefit for state archaeology in the participating cantons and countries, it is currently being challenged by the growing demands of the research community. For example, true interoperability of data is only given among the SPATZ partner institutions. To overcome this handicap a project has started to extend the SPATZ infrastructure with a software module that can provide data from SPATZ following the FAIR data principles and complying with international data standards. The challenge of this endeavour is to define and to publish static data from a constantly updated archaeological resource management system without removing data from the repository. The project itself and some first results will be presented in this poster.

Kerameikos.org: Linked Open Data for Greek Pottery

Renee Gondek, Ethan Gruber, Tyler Jo Smith

Kerameikos.org is a collaborative project dedicated to defining the intellectual concepts of Greek pottery (artists, vase shapes, techniques, etc.) following the tenets of Linked Open Data. In-

spired by Nomisma.org for its success in uniting numismatics around a common data standard, Kerameikos.org was founded in late 2013, and the online prototype was first presented at CAA 2014 in Paris. With a recent Digital Humanities Advancement Grant from the U.S. National Endowment for the Humanities, Kerameikos.org is now able to move forward with the creation of all concepts necessary to fully express Archaic and Classical Greek pottery. Additionally, we will aggregate Greek vases from a variety of open data collections, such as the British Museum and the Harvard Art Museums, in order to demonstrate a variety of geographic and statistical visualizations that were not previously possible in other ceramics databases. Kerameikos.org will support broad reuse of pottery data through the art museum community-driven linked.art specification, focusing on Linked Open *Usable* Data espoused by information specialists at the Getty Museum: APIs based on JSON-LD and CIDOC-CRM. This poster will demonstrate current progress in the Kerameikos.org project beginning with the award of the NEH grant in September 2018.

Virtual and augmented reality in presentation of the La Tène culture in Bohemia.

Betka Danielisová, Jiří Unger

Poster aims to introduce recent project of the Institute of Archaeology in Prague which presents several models in virtual space from the La Tène period in the Czech Republic for the purpose of exhibition "The Celts" (National Museum, Prague). 3D visualisations of various occupational horizons of the oppidum of Závist as well as the viereckschanze of Mšecké Žehrovice have been undertaken basing on authentic data from excavations and contemporary analogies. In order to make the models more dynamic and in accordance with modern exhibition standards various La Tène artefacts were captured using 3D scanning and 3D photogrammetry. In addition to the classical presentation frames such as films, virtual and augmented reality models have been also produced. A new level in computer visualisations has been achieved by populating the otherwise static models by digitised real characters from the living history groups.

Architecture and soil stratigraphy of relict charcoal hearths in Europe and the USA

Florian Hirsch, Anna Schneider, Alexander Bonhage, Thomas Raab, Alexandra Raab, Will Ouimet, Patrick Drohan

Relict charcoal hearths (RCH) are a widespread feature in forested areas in Europe and the USA. Before the usage of hard coal, charcoal from RCHs was the main energy source and chemical reagent for the production of iron from ore. Depending on region and age, RCHs have diameters

up to 30 m, and due to their size and shape they are nowadays often identified by GIS-analysis of widely available LiDAR data. We study the architecture and soil stratigraphy of RCHs in several type regions in the USA and Germany where high densities of RCHs are known (Connecticut, New Hampshire, Pennsylvania and Brandenburg, Bavaria) and propose a morphological classification scheme. Whereas RCHs on flatland mostly have a circular shape which is often surrounded by an about half a meter-wide ditch, RCHs on slopes are mostly elliptical and often have a different architecture than on flatland sites. While the RCH platforms in flatland are only about 30 cm higher than the surrounding area, the platform of RCHs on slopes has often a height of up to one meter in downslope direction. Therefore, RCHs on slopes are much easier to identify during GIS mapping than RCHs on flatland. Remarkably the size, shape and architecture between our studied RCHs in the USA and Germany are often very similar which could indicate common roots of collier's knowledge and technology that can be explained by immigration of European craftsmen to New England in the 18th and 19th century.

Advanced Documentation Methods for Black-Figure Styles with Combined CT and Optical 3D-Data

Paul Victor Bayer, Andras Marton, Hubert Mara, Stephan Karl

Profile-drawings and tracings are essential elements of object documentation in archaeological pottery studies. Within the study of Greek pottery unwrappings of painted surfaces have a long tradition and a still well-deserved high significance. They show the depiction at once enabling archaeologists to analyze and interpret the complete image. This is especially true in our case i.e. Corinthian pottery, where poor preservation of the painting tends to flake off resulting in unclear photographs. Additional traces of flaked off painting layers can be recovered using additional illumination settings. Creating manually profile-drawings and unwrappings is time-consuming and tactile tools like lead wires or profile combs are not feasible for the fragile surfaces. To digitally document the vessels as complete as possible we combine 3D data derived by photogrammetry (Structure from Motion, SfM) and computed tomography (CT) allowing to fuse the high resolution texture from SfM with the high accuracy in geometry for surfaces and inclusions of CT. The main steps are the color transfer using existing tools like MeshLab and the GigaMesh Software Framework (https://gigamesh.eu). The latter is used to compute a high-contrast texture map highlighting smallest details in the surface i.e. the fine incisions of the Black figure style. Further processing steps with GigaMesh are computing multiple profile lines, which are exported as XML-based Scalable Vector Graphics (SVG) and high-resolution unwrappings as optimal basis for tracing the manufacturing details.

From analogue to digitalized papers and reports: -Status and benefits of transforming past knowledge for future research.

Magne Samdal

The current status with scanning and publishing of archaeological papers and reports will be shown, and also our plans for future actions in digitizing our archives for a more open access and thus gain better conditions for use and reuse of our data in analysis and research. Papers and reports are now available in the Research Archive at the University of Oslo, DUO (https://www.duo.uio.no/), which is an open access -site with possibilities for search and download. It also gives a permanent link to share in other systems. The poster will also give an example of the application of this archive in our databases and how it can be presented through an interactive web-platform using ESRI's Storymap-online.

Open source tools for tidy photographic and 3D data management between the field and the archive

George Alexis Pantos, Joe Roe

Taming messy data is a tedious but essential task for all archaeologists. Photographic data can be particularly troublesome. Even modest field projects accumulate large volumes of images, which come with their own formats and metadata standards that don't fit easily into existing data management systems. The advent of photogrammetry as a common part of field recording compounds this complexity. Progress has been made in the production and maintenance of long-term archives (OAIS, CIDOC CRM, ADS, tDAR, etc.) However, with large research projects, it can take years or decades before data is ready to "deposit" into an archive. This poster asks: what do we do in the meantime? What is the best way to keep photographic archives tidy, short of a permanent, static archive and the associated overheads? How can we maintain an authoritative database, but retain the flexibility and accessibility needed for ongoing research with multiple collaborators? Our approach to this problem uses server–client architecture to maintain a single, consistent research database. We combine existing open source software packages (Piwigo, 3DHOP, PostgreSQL) with custom extensions to provide a simple, web-based frontend for intuitive navigation of photographic and 3D data. Critically, the underlying filesystem is independent of this platform, so the data remains fully accessible to software preferred by specialists. Key metadata is also stored at the file level, meaning data can be cleanly separated from the software used to view it and remain 'archive ready'. We suggest that our approach may help other projects facing similar challenges.

What's the point, what's the number? - The use of mobile devices in the field prospections conducted on multicultural sites in southern Poland.

Jan Bulas, Michał Kasiński, Magdalena Okońska

Within last decade mobile devices, especially smartphones, started to play a more relevant role in our everyday life, providing solutions and help with many of common problems and tasks. Archaeology is obviously not an exception. The poster's aim is to present, how the use of described devices can be implemented during the field-walking survey process. It will be based on the example of such procedure carried out on selected multi-cultural sites located in southern Poland. It will concentrate on how different mobile phone applications, when free online data are provided can be used on different stages of the research process including planning, survey organisation, documentation process and post-processing of obtained data and what possible gains and risks are related to each of those stages. Another significant aspect that will be discussed, will be how the use of popular mobile devices and applications allowed to involve students in the scientific process as well as what where both educational gains and challenges linked with it.

Photogrammetry and laser scanning of Ancient Pueblo architecture and rock art sites in the canyons of the Mesa Verde region, Colorado, USA

Radosław Palonka, Vincent M. MacMillan, Bolesław Zych, Anna Słupianek, Katarzyna Ciomek, Paweł Micyk

Our poster focuses on modern techniques of documentation, such as photogrammetry and laser scanning of Ancient Pueblo culture sites with stone architecture and rock art located in several canyons of the central Mesa Verde region, southwestern Colorado, USA. The research was conducted over the course of several seasons by the Sand Canyon-Castle Rock Community Archaeological Project led by the Institute of Archaeology, Jagiellonian University in Kraków. The petroglyphs and paintings from the project research area include Ancient Pueblo and Fremont rock art depicting shamans and warriors, geometric motifs which are connected with astronomical observations as well as historic Indian petroglyphs, mainly created by the Navajos and Ute, illustrating clan symbols, fighting warriors and hunting scenes with buffalo and deer. The registered data has been used to generate accurate 2D documentation and 3D models. The 3D models that were generated have also been used to interpret some details by varying the position of the light (for example with the use of RTI software). Another element is the virtual 3D models that we used in a game engine and Digital Elevation Model that encompasses the sites and the associated environment.

Spatial archaeology in Lagoa Uri de Cima archaeological site (Salgueiro/ Brazil): a study of intrasite distribution of the lithic vestiges

Lucas Bonald Pedrosa de Souza, Demétrio da Silva Mützenberg

This paper deals with the intrasite spatial analysis of the lithic material, found predominantly at two stratigraphic levels (1B, 1.4 m deep, 1B-2, 1.8 m deep) of the Lagoa Uri de Cima Archaeological Site (in the county of Salgueiro/Pernambuco/Brazil). This analysis aims to obtain archaeological data for the region and thus to understand how the populations that inhabited there, used that space. The research starts from the questioning, if the human occupation were in the immediate surroundings or in the center of the dry lake, to carry out its activities. For this purpose, the concepts of Spatial Archeology and related areas were used as a theoretical basis, and a methodology followed by the use of a Low Cost Unmanned Aerial Vehicle (UAV) to create a Digital Terrain Model, in order to observe the drainage networks that made up the lake, besides an analysis of kernel density spots, all this integrated to a GIS, created for the spatial analysis of there. It was also observed the presence of junctions and refittings of the lithic material, in order to know if the chipping processes had been carried out in situ. By analyzing the density spots and the low number of joints of the lithic material, it is possible to say that the site was used for a random chipping, but its materiality must have been intensively used in the group activities, due the great amount of tools to the detriment of other classes close to the center of the dry lake.

An ontological approach to focus group research at the boundaries of the archaeological semiosphere

Costis Dallas, Ingrida Kelpšienė, Rimvydas Laužikas, Suzie Thomas, Isto Huvila

This poster presents transnational focus groups research on archaeological activity at the boundaries of professional and academic archaeology. Conducted within ARKWORK – Archaeological practices and knowledge work in the digital environment COST action, the project includes studies on: (a) Archaeological communities on Facebook, based on scoping interviews and a focus group discussion with Facebook site administrators; (b) Metal detectorists engaging with archaeological heritage, based on pre-interviews and focus group discussion with metal detecting hobbyists; (c) Role of archaeology in country image making, based on in-depth individual conversations with academics, policy makers and experts, and a focus group discussion with domestic and foreign visitors; (d) Museum visitor photography, based on photo elicitation focus groups with site visitors who have posted photographs on Instagram; (e) Archaeology and the nation, based on Facebook communities focusing on national cultural heritage; (f) Archaeolog-

ical site visitor experience, based on exit interviews with archaeological site visitors, followed by focus group discussion with archaeological tour operators; (g) Contract archaeology, based on scoping interviews and a focus group discussion with representatives of European contract archaeology companies; and, (h) Urban archaeology, based on a focus group discussion with city archaeologists. Building upon a conceptual model on the structure of the field of archaeology-related boundary practices based on Yuri Lotman's semiosphere theory (Lauzikas et al 2018), and drawing from process ontologies of archaeological practice, the poster elaborates a common methodological approach for these studies addressing questions of research design, code system preparation, qualitative data analysis, and theory building.

Virtually Terraforming Iron Age Ireland: A 3D Reconstruction of the Structures at Dun Ailinne (Co. Kildare)

Zenobie Susanne Garrett

The site of Dún Ailinne (Knockaulin) in County Kildare is one of four major ceremonial sites of the Irish Iron Age. The site sits on a large, isolated hill in an otherwise flat landscape on which a large earthen bank and ditch encloses approximately 13 ha of land at the top. Excavations in the 1960s-1970s, as well as ongoing excavations today have uncovered evidence that several large timber structures once stood on the site. The stunning vistas that dominate the hilltop experience today have inspired archaeologists, including myself, to consider the importance of vision in the experience of ceremony at the site. While archaeologists have postulated that gaps in the timber structures would have controlled not just access but also views, these studies have largely focused on the location of the structures, without the visible impact of the structures themselves. This paper builds upon this work by presenting the results of a 3D reconstruction built in AR for the site and exploring the structures visibility and invisibility both within the site itself and in the larger landscape. In so doing, this paper seeks to understand the impact these structures would have had on local performance and activity. Additionally, the use of AR is explored as a potential for radically altering the public's (literal) view of the site and experiencing the archaeology in a more hands on and engaging fashion.

Reconstructing the past of Ancient Pueblo culture: Results of geophysical surveys by Sand Canyon-Castle Rock Community Archaeological Project in Colorado, USA (2011-2018)

Radoslaw Palonka, Piotr Szczepanik, Patrycja Obrempalska-Majdak

This poster focuses on geophysical survey results from the Sand Canyon-Castle Rock Community Archaeological Project. This project by Jagiellonian University in Kraków focuses on

research concerning the social and cultural changes in the thirteenth century A.D. Pueblo culture settlements located in several canyons of the Mesa Verde region, Colorado, USA, mostly placed within cliff alcoves and the canyon slopes. Along with the Castle Rock Pueblo - the largest site - they created a micro-regional community of allied sites. Part of the project is devoted to geophysical surveys around some sites where geophysics were applicable, and during the seasons from 2011 to 2018 geophysical research was conducted in around ten archaeological sites. The common method used there was electrical resistivity (with some addition of GPR) which gave us satisfying results revealing many of the unknown archaeological buildings, especially those located on the canyon slopes. We would like to present some of them to show how much new information about this settlement community these non-invasive methods provided for us.

The volume of light" - how to estimate the capacity of ancient oil lamps using 3D models?

Martina Polig, Małgorzata Kajzer, Sorin Hermon

The application of photogrammetry in material studies give the opportunity not only to create precise documentation but also to answer for miscellaneous research problems. In this case, group of clay oil lamps found in the Agora of Nea Paphos, Cyprus was chosen, to analyse and compare the volume of various examples representing different types, technology of production, provenance and chronology. The group of objects contains examples preserved both partly and completely which creates different possibilities and methodological problems. After the documentation of the various lamps in 3D through photogrammetry, their 3D scaled 3D models are used to calculate their volume. Both broken and complete examples of the same typology are of equal importance in this process. The broken examples are used to understand the internal geometry and the wall-thickness, which is crucial to determine the volume for each type. The complete pieces on the other hand serve to understand the complete shape and calculate the capacity with the complementing information about the interior and wall-thickness from the broken pieces. The results are the basis to calculate the range of time a particular lamp could be used, depending on the type and quality of the oil and wick used. In this way 3D methods allow us to ask a question that is quite difficult to answer through traditional means in an accurate and fast way.

Machine Learning for Ground-Penetrating Radar

Katie Simon, Christopher C. Angel

This poster reports on current efforts to develop a self-contained image classifier for ground-penetrating radargrams through the use of various machine learning methodologies and recent

advances in convolutional neural networks. This investigation presents a unique application of machine learning for archaeo-geophysics in which the richer density of data present in radargram profiles is directly classified rather than averaged/binned and interpolated amplitudes of time slices. The challenges involved in implementing tools like TensorFlow for Poets, Theano, and PyTorch as well as achievements with TensorFlow (via Keras) using a LeNet architecture, will be discussed along with how such automation methods for radargram processing can facilitate machine-guided interpretation and new forms of rapid GPR data visualization.

Cleaning new data: Lessons learned while preparing datasets for publication

Matthew Barrett, Joshua James Emmitt

Data integrity is essential when publishing open data. There is a push in archaeology from the community and funders to publish the datasets that are made and used in archaeological fieldwork and interpretations. For the purposes of data integrity, "clean" data – that is, data with identified and documented issues – are often the desired product for publication, accompanied by documentation explaining how to use those data. However, doing this is often no trivial task, with large amounts of time and effort required to prepare data for publication. In this paper, we discuss the cleaning and preparation of two datasets for publication, and how issues were identified and solved, even when the original data acquisition protocol was designed to produce "clean" data. The URU Fayum Project (Egypt) generated field data from 2002-2012. Over the course of the project, numerous people were involved and a range of different collection and recording strategies employed, as well as different machines and levels of recording. During the cleaning of these data, numerous issues were discovered that had to be solved, including the handling of duplicate data, "incorrect" data, and inconsistences with the level of recording. Another project, the Ahuahu Project (New Zealand) has been generating data since 2012 and despite attempts to minimise problems with data, both similar and new issues were encountered. The ultimate aim is to publish the clean datasets openly in the next few years.

Interpreting Archaeological Sites by Combining GIS and Other Kinds of Surveys

Wojciech Ejsmond, Julia Maria Chyla, Olivier P. Rochecouste

Analysis of artefacts is one of the basic ways for the functional and chronological interpretation of an archaeological site. It can be supplemented with geophysical prospection, which can provide information about a sites' horizontal structures. Thus, the combination of these methods can offer researchers a more general overview of an archaeological site. Throughout multiple archaeological surveys at Gebelein (Upper Egypt), mobile GIS applications on GNSS tools

provided new opportunities for detailed documentation. The area was heavily looted and partly destroyed by contemporary expansion of agricultural lands and modern settlements. Therefore, every piece of information was priceless. The combination of pottery and bioarchaeological surveys (collecting faunal remains at a site) with mobile GIS and geophysical prospection, as well as archival data analysis, opened new possibilities to gather more data on structure and dating, and to help with interpreting archaeological sites at Gebelein. This method offers good results in terms of data acquisition and proves to be an inexpensive solution for complex non-invasive research. The application of this method towards analysing three different cemeteries at Gebelein will be discussed as part of this presentation.

Traceability of archaeological data, from excavation to publication

Olivier Marlet, Xavier Rodier

The development of the linked open data over the last few years has seen the emergence of recommendations to provide reliable data: metadata, sustainability, interoperability. These precepts, such as the Five Stars of Linked Open Data or the FAIR principles (Findable, Accessible, Interoperable, Re-usable), help to publish data according to specific rules that promote their utilization in the LOD. However, these principles do not focus on assessing the scientific quality of the published data. While metadata can document the source, this is not sufficient to ensure that the information is reliable. Several solutions exist that have been implemented by the Laboratory "Archaeology and Territories" (CITERES-LAT). Within a dataset, metadata is used to document the conditions under which the data is acquired. In archaeology, the recording is very often done on paper on the field before being computerized. During this computerization, the data are selected, sometimes reinterpreted and modified to respect the database structuring constraints. Thus, the availability of field recording scans is essential to ensure the traceability of information. In the ArSol database, each record is associated with the scan of the primary record performed in the field, allowing the researcher to access information that may not be computerized in the database. In a publication, giving the reader the opportunity to consult the excavation data in an online database helps to justify a hypothesis. The logicist publication formalism according to Jean-Claude Gardin's principles allows each proposition to be justified by the evidence on which it is based. The reader can thus trace back from the conclusions of the publication to the observation data available through an online database. In this case, it is the administration of evidence that is ensured. The ArSol online database has also been structured for this purpose: each record (stratigraphic unit, feature, burial, wall, artifact, chronological sequence, etc.) is accessible via a specific URL that can be used as a reference to evidence in the argumentation

for an online publication. This is the case of Rigny's online logicist publication, which is based on the field recording of the excavation made available online in the ArSol database.

Rescuing the cultural heritage of Nea Paphos using geophysics: the case of Omirou street and Glyky Nero locations

Efstathios Raptou, Nikola Babucic, Ewdoksia Papuci-Władyka, Martina Seifert

Continuous urban expansion of Paphos with ever larger building programs has made almost impossible the protection of archaeological sites by the Department of Antiquities only through salvage excavations. Thus, the implementation of new technologies in the service of archaeology is becoming imperative. The lack of the necessary infrastructures by the Department of Antiquities for this purpose is covered by the valuable collaborators as the Paphos Agora Project of the Jagiellonian University of Kraków and the University of Hamburg. Recently, an appeal has been made by the Department of Antiquities of Cyprus to these institutions to make geophysical surveys in two important areas inside modern Paphos, limited sections of which have been previously excavated in the frame of a preventive control before delivering building permits in two locations. The first is located in the Omirou street, east from the theatre and here buildings of Medieval periods where possible dwellings existed with workshops and other structures. However, the most important discovery was the location in the deepest levels of the excavated area of huge stone blocks which are believed to be the foundations of the fortifications of Nea Paphos which dates back to the Hellenistic period. In the second place - the Glyky Nero, the most important discovery was the existence of a cemetery of dogs, the first to be located on the island. The excavation has also revealed new burial customs for Hellenistic and Roman Cyprus. So both places are of extreme archaeological importance.

A virtual look into a museum depot: enhancing small collections through digital approaches

Irene Sarcinelli, Elisa Sartori

The idea for the project originated from a review of the range of artifacts accessible to visitors of the archaeological collection at the Villa Sulis Ceramic Museum (Castelnovo del Friuli, Italy). Only 138 of the over 5000 post-medieval pottery sherds recovered on local sites are displayed at present; this initiative aims to broaden the range of exhibits on show, and set an example for other small historical, artistic or archaeological collections. The main purpose of the project is to enable the local community to enjoy a piece of its cultural heritage that would otherwise not be accessible, and encourage the public to engage with it through the use of digital technologies. 3D models of a selection of ceramic finds, currently preserved in a closed depot, will be

produced using photogrammetric techniques; these models will then become part of a virtual exhibition, accessible from a specially equipped area of the museum, and through QR codes scanned from personal devices. Visitor experience will be integrated with interactive educational activities for children and adults (including virtual games and AR experiences), as well as traditional workshops. To disseminate new knowledge and foster young people's interest in the archeological collections, a series of video lessons and storytelling sessions will be held via social networks and a dedicated website.

3D-Documentation and excavation of a huge reversible water wheel from a medieval mine in Bad Schlema, Germany

Thomas Reuter

Since 10 years, medieval mining and the documentation of its legacies is a main topic at the Archaeological Heritage Office of Saxony. The region of the Ore Mountains - in the south of the federal state of Saxony and Northern Bohemia - was the focus in two previous EU-funded binational projects. During the realisation of safety measures in abandoned mining shafts and tunnels by the Upper Mining Authority of Saxony, in 2016 large parts of a huge reversible water wheel were discovered. The wheel probably dates into the late 15th century and originally had a diameter of 12m, which makes it the oldest and the biggest one that has been found in Saxony so far. The excavation and documentation of the wheel had to be carried out while the ongoing work of the "Bergsicherung" continued, so a close cooperation between the two institutions was necessary. This led to the development of an efficient workflow, to document this unique find as accurate as possible. Not only Total Stations, but also structure-from-motion and mobile 3d scanners were used, as the data had to be recorded during a challenging underground excavation in partly very confined areas. An interesting challenge was the gradual documentation and excavation of the shaft (length 8m, weight 4t). The poster will present and analyse the difficulties as well as the solutions in managing and post-processing huge datasets generated by various recording devices. Finally, by combining several data sources a detailed reconstruction of the paddle wheel could be made.

Application of Photogrammetry and VR in Archaeology – from Field Survey to Virtual Museum

Giorgi Datunashvili, Mikheil Elashvili, G. Kirkitadze, N. Vacheishvili

First phase of our work is focused on documentation of archaeological artefacts. During the recent years rapid development of photogrammetry and 3D modelling allows precession of obtained 3D models to be quite close with laser scanner results. The same time photogrammetric shooting can be performed in "field" conditions, making the process essential part of Archaeological excavations. Selection of lenses and proper illumination, let it be applied for micro and macro scale archeological objects, widening scale of the objects to be scanned. Second phase of presented works focuses on management and processing of the obtained 3D models. The raw data obtained using photogrammetry requires retopology, UV recreation and optimization, corrected and enriched with additional information. Optimized 3D models retain the high quality with sensible decrees in the size, allowing to store and display large amount of artefacts. Third Phase is visualizing and handling the results. Processed 3D models are universal and suitable for variety of real time rendering engines. Most simple (and effective) solution of data dissemination is 3D pdf format. In Adobe Reader we can visualize and handle the 3D object, with basic analysis tools. Large amount of 3D archaeological material, their visualization using the widely used engines coupled with the multiparameter attribute database leads us to the concept of Virtual Museum, designed in a virtual space with totally unbounded abilities, some of which are shown in current study. Same time providing online access to the archaeological material, tools for their analysis and handling, multiparameter query search over the database.

After the Strafexpedition: A digital heritage perspective on the Winterstellung trenching system

Armando De Guio, Luigi Magnini, Giulia Rovera, Andrea Marra

Since the end of the Great War, the material remains of the conflict have undergone a progressive destruction, first as a source of metals for resale and later as collector items. In the last decades, Conflict Archaeology contributed to promote investigations with a scientific approach. Landscape retains traces of natural and man-made changes caused by the conflict as well as of the depositional and post-depositional events underlying the formation of the archaeological record. Residuality plays a fundamental role in the study of the formation processes, as the short chronological gap allows us to analyze the archaeological structures in a phase of incipient formation (mainly affected by natural processes) or primary obliteration (mainly related to anthropic processes). In this contribution, we will present the results of a comprehensive

study along the northern Italian front, on the Asiago Plateau. The area played a key role in the early years of the conflict, with crossed assaults of the Italian and Austro-Hungarian armies and the subsequent creation of the Winterstellung trenching system. Methodologically, the study was carried out with different degrees of impact on the investigated (infra)structures using: 1) non-invasive, advanced remote sensing techniques such as: 3D modeling; GIS and DEM analyses; (semi)automatic recognition (GeOBIA); 2) targeted field and UAV surveys to verify the reliability of the remotely sensed investigations and the preservation of the structures; 3) micro-invasive excavations (half-sections, small trenches) to identify the causes that determined the highly heterogenous degree of residuality during the pre- sin- & post-depositional processes.

Tuesday

08.00 - 16.00 › **Registration**
10.00 - 16.00 › **Workshops**
17.00 - 21.00 › **Icebreaker Party**

Wednesday

07.30 - 17.00 › **Registration**
09.00 - 10.00 › **Welcome Adresses & Keynote**
10.20 - 18.20 › **Sessions**

Thursday

07.30 - 17.00 › **Registration**
08.40 - 15.00 › **Sessions**
15.00 - 16.00 › **Poster session**
16.00 - 18.00 › **Annual General Meeting**
20.00 - 23.00 › **Conference Dinner**

Friday

07.30 - 17.00 › **Registration**
08.40 - 18.40 › **Sessions**

Saturday

09.50 - 18.00 › **Excursions**

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