

2018 IEEE INTERNATIONAL CONFERENCE ON
**METROLOGY FOR ARCHAEOLOGY
AND CULTURAL HERITAGE**



METROARCHAEO
2018



CASSINO, ITALY - OCTOBER 22-24, 2018

PROCEEDINGS

MetroArcheo

CASSINO 2018



© 2018. Personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution to servers or lists, or to use any copyrighted component of this work in other works must be obtained from the IEEE.

IEEE Catalogue Number: CFP18073-ART
ISBN: 978-1-5386-5276-3

© 2018 IEEE

**2018 IEEE International Workshop on Metrology for Archaeology and Cultural Heritage
(MetroArchaeo 2018) Proceedings**

© 2018. Personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution to servers or lists, or to use any copyrighted component of this work in other works must be obtained from the IEEE.

Copyright and Reprint Permission: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law, for private use of patrons, those articles in this volume that carry a code at the bottom of the first page, provided that the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For reprint or republication permission, email to IEEE Copyrights Manager at pubspermissions@ieee.org.

All rights reserved. Copyright © 2018 by the Institute of Electrical and Electronics Engineers, Inc.

IEEE Catalog Number: CFP18O73-ART

ISBN: 978-1-5386-5276-3

CONFERENCE PROGRAM

Monday, October 22

Special Session on Non-invasive systems and techniques for "on site" monitoring and diagnosis - PART I

Room: Aula Magna, Cassino University Campus

Chairs: Emanuele Piuzzi, Sapienza, University of Rome, Italy
Livio D'Alvia, Sapienza, University of Rome, Italy

- 1 Effect of Applied Pressure on Patch Resonator - Based Measurements of Moisture Level for Cultural Heritage Materials**
Livio D'Alvia, Sapienza, University of Rome, Italy
Erika Pittella, Sapienza, University of Rome, Italy
Stefano Pisa, Sapienza, University of Rome, Italy
Emanuele Piuzzi, Sapienza, University of Rome, Italy
Zaccaria Del Prete, Sapienza, University of Rome, Italy
- 6 Multidisciplinary approach for the study of the Ptolemaic coffin of Ankhkhy from the Egyptian collection of MANN in Naples**
Alessia Volino, Università degli Studi Suor Orsola Benincasa, Italy
Maria Rosaria Barone Lumaga, Università degli Studi di Napoli Federico II, Italy
Paola Cennamo, Università degli Studi Suor Orsola Benincasa, Italy
Giancarlo Fatigati, Università degli Studi Suor Orsola Benincasa, Italy
Giorgio Trojsi, Università degli Studi Suor Orsola Benincasa, Italy
- 12 Acoustic Characterization of Outcropping Stratigraphic Units**
Andrea Azelio Mencaglia, Institute of Applied Physics "Nello Carrara", Italy
Ilaria Cacciari, Institute of Applied Physics "Nello Carrara", Italy
Giorgio Franco Pocobelli, Cooperativa Archeologia, Italy
Salvatore Siano, Institute of Applied Physics "Nello Carrara", Italy
- 17 Non-destructive Diagnostics of Architectonic Elements in San Giuseppe Calasanzio's Church in Cagliari: a Test-case for Micro-geophysical Methods within the Framework of Holistic/integrated Protocols for Artefact Knowledge.**
Luca Piroddi, University of Cagliari, Italy
Giulio Vignoli, University of Cagliari, Italy
Antonio Trogu, University of Cagliari, Italy
Gian Piero Deidda, University of Cagliari, Italy
- 22 Use of Ground Penetrating Radar for Assessing Interconnections between Root Systems of Different Matured Tree Species**
Livia Lantini, University of West London, UK
Rich Holleworth, University of West London, UK
Daniel Egyir, University of West London, UK
Iraklis Giannakis, University of West London, UK
Fabio Tosti, University of West London, UK
Amir M. Alani, University of West London, UK

Special Session on Artificial intelligence for measurements in cultural heritage - PART I

Room: B 2.07 Hall, Cassino University Campus

Chairs: Francesco Colace, University of Salerno, Italy
Mario Molinara, University of Cassino and Southern Lazio, Italy

- 27 **Automatic Writer Identification in Medieval Books**
Claudio De Stefano, University of Cassino and Southern Lazio, Italy
Francesco Fontanella, University of Cassino and Southern Lazio, Italy
Marilena Maniaci, University of Cassino and Southern Lazio, Italy
Claudio Marrocco, University of Cassino and Southern Lazio, Italy
Mario Molinara, University of Cassino and Southern Lazio, Italy
Alessandra Scotto di Freca, University of Cassino and Southern Lazio, Italy
- 33 **Recognition of Oracle Bone Inscriptions Using Deep Learning based on Data Augmentation**
Lin Meng, Ritsumeikan University, Japan
Naoki Kamitoku, Ritsumeikan University, Japan
Katsuhiro Yamazaki, Ritsumeikan University, Japan
- 39 **Encoding and Simulating the Past. A Machine Learning Approach to the Archaeological Information**
Marco Ramazzotti, Sapienza University of Rome, Italy
Paolo Massimo Buscema, Semeion Research Centre of Sciences of Communication, Italy
Giulia Massini, Semeion Research Centre of Sciences of Communication, Italy
Francesca Della Torre, Semeion Research Centre of Sciences of Communication, Italy
- 45 **Deep learning for object detection in fine-art paintings**
Stanislav Smirnov, University of Paderborn, Germany
Alma Eguizabal, University of Paderborn, Germany
- 50 **Cultural Heritage Buildings Degradation Simulation**
Francisco Serrano, Polytechnic Institute of Leiria, Portugal
João Serrano, Polytechnic Institute of Leiria, Portugal
Alexandrino Gonçalves, Polytechnic Institute of Leiria, Portugal
Carlos Grilo, Polytechnic Institute of Leiria, Portugal
Nuno Rodrigues, Polytechnic Institute of Leiria, Portugal
Virgílio Hipólito-Correia, Conimbriga Monographic Museum, Portugal

General Session PART I

Room: 1.09 Hall, Cassino University Campus

Chairs: *Maria Grazia D'Urso, University of Cassino and Southern Lazio, Italy*

Marco Laracca, University of Cassino and Southern Lazio, Italy

- 56 **Sources**
Silvana Errico, FAI member, Italy
- 62 **Archaeology and archaeozoology: the alpine settlement of Orgères (La Thuile-Aosta, ITALY)**
Chiara Maria Lebole, University of Torino, Italy
Chiara Mascarello, University of Torino, Italy
Giorgio Di Gangi, University of Torino, Italy
- 66 **Developing automated digitization system for cultural heritage documentation - case study**
Maciej Karaszewski, University of Technology Warsaw, Poland
Eryk Bunsch, Museum of King Jan III's Palace at Wilanów, Poland
Krzysztof Lech, University of Technology Warsaw, Poland
Robert Sitnik, University of Technology Warsaw, Poland
- 72 **Digital models for archaeological documentation in urban context. 3D surveys in the new underground of Naples (Municipio station)**
Giovanni Caratelli, Institute for Technologies Applied to Cultural Heritage (ITABC) National Research Council (CNR), Italy
Cecilia Giorgi, Institute for Technologies Applied to Cultural Heritage (ITABC) National Research Council (CNR), Italy
- 78 **Problems in Three-Dimensional Measurement of Japanese Kenjutsu Using Existing Sensing Devices**
Risako Aoki, Meiji University, Japan
Ryusuke Miyamoto, Meiji University, Japan
-

Tuesday, October 23

Special Session on Metrological approaches to the study of ancient and medieval written Heritage - PART I

Room: Aula Magna, Cassino University Campus

Chairs: *Gianluca Del Mastro, Università degli Studi di Napoli Federico II, Italy*

- 84 **Panorama of writing inks: from late Antiquity to the Middle Ages.**
Ira Rabin, University of Hamburg, Germany
- 89 **The secrets of Herculaneum papyri revealed by synchrotron based techniques: writing and ink composition**
Silvia Romano, Institute for Microelectronics and Microsystems, Italy
Ana Sofia Leal, Institute for Microelectronics and Microsystems, Italy
Emmanuel Brun, ESRF, France
Daniel Delattre, CNRS-IRHT, France
Vito Mocella, Institute for Microelectronics and Microsystems, Italy
- 92 **Document analysis at AGH University of Science and Technology**
Tomasz Lojewski, AGH University of Science and Technology, Poland
- 97 **Scripta volant: measuring the purple spots biodeterioration of historical parchments by an interdisciplinary approach**
Nicoletta Perini, University of Rome Tor Vergata, Italy
Maria Cristina Thaller, University of Rome Tor Vergata, Italy
Alessandro Rubechini, Archivio Segreto Vaticano, Città del Vaticano
Fulvio Mercuri, University of Rome Tor Vergata, Italy
Silvia Orlanducci, University of Rome Tor Vergata, Italy
Luciana Migliore, University of Rome Tor Vergata, Italy

Special Session on Integrated Digital Survey Methodologies for the Knowledge and Enhancement of Architectural and Urban - PART I

Room: B 2.07 Hall, Cassino University Campus

Chairs: *Marco Giorgio Bevilacqua, University of Pisa, Italy*

- 102 **Parametric Thinking: Recognizing the "Architectural Formulas" in Cultural Built Heritage by Parametric Digital Modelling**
Roberta Spallone, Politecnico di Torino, Italy
Marco Vitali, Politecnico di Torino, Italy
- 107 **Spatial Data Analysis in Archaeology: A comparison of two available methods for site location**
Rafał Bieńkowski, Polish Academy of Science, Poland
Marta Lorenzon, The University of Helsinki, Finland
Agnieszka Kaliszewska, Polish Academy of Science, Poland
Krzysztof Leśniewski, Polish Academy of Science, Poland
- 111 **Assessment of workflows for creating 3D semantic libraries: a study on medieval bell towers in the central region of Sicily**
Cettina Santagati, University of Catania, Italy
Raissa Garozzo, University of Catania, Italy
Melissa Lengies, Carleton University, Ottawa
Graziana D'Agostino, University of Catania, Italy
Mariateresa Galizia, University of Catania, Italy
- 117 **Geochemical and petrographic analysis on the stones and integrated digital survey of the Cathedral of Sant'Antioco di Bisarcio (Ozieri, Italy)**
Stefano Columbu, Università di Cagliari, Italy
Marco Lezzerini, Università di Pisa, Italy
Giorgio Verdiani, Università di Firenze, Italy

Special Session on Artificial intelligence for measurements in cultural heritage - PART II

Room: 1.09 Hall, Cassino University Campus

Chairs: *Francesco Fontanella, University of Cassino and Southern Lazio, Italy*
Mario Molinara, University of Cassino and Southern Lazio, Italy

123 e-Tourism: A Context-Aware Framework for Services Dynamic Packaging

Fabio Clarizia, University of Salerno, Italy
Francesco Colace, University of Salerno, Italy
Massimo De Santo, University of Salerno, Italy
Marco Lombardi, University of Salerno, Italy
Francesco Pascale, University of Salerno, Italy
Domenico Santaniello, University of Salerno, Italy

127 Ancient Coin Classification Using Graph Transduction Games

Sinem Aslan, ECLT - CCHT, Ca' Foscari University of Venice, Italy, Ege University, Turkey
Sebastiano Vascon, ECLT - CCHT, Ca' Foscari University of Venice, Italy
Marcello Pelillo, ECLT - CCHT - DAIS, Ca' Foscari University of Venice, Italy

132 Automatic Mosaic Digitalization: a Deep Learning approach to tessera segmentation

Andrea Felicetti, (DII) Università Politecnica delle Marche, Italy
Alessandra Albiero, CNR, Italy
Roberto Gabrielli, CNR, Italy
Roberto Pierdicca, (DICEA) Università Politecnica delle Marche, Italy
Marina Paolanti, (DII) Università Politecnica delle Marche, Italy
Primo Zingaretti, (DII) Università Politecnica delle Marche, Italy
Eva Savina Malinverni, (DICEA) Università Politecnica delle Marche, Italy

137 A Double-layer Approach for Historical Documents Archiving

Marco Lombardi, University of Salerno, Italy
Francesco Pascale, University of Salerno, Italy
Domenico Santaniello, University of Salerno, Italy

Special Session on Using multivariate analyses to interpret lithic variability: contributions and limitations

Room: Aula Magna, Cassino University Campus

Chairs: *Alice Leplongeon, Muséum national d'Histoire naturelle, France*
Elena A.A. Garcea, University of Cassino and Southern Latium, Italy

141 Objectifying processes: The Multivariate analyses of the Acheulean Tools in the Western Europe

Paula García-Medrano, British Museum, UK
Eliás Maldonado-Garrido, British Museum, UK
Nick Ashton, British Museum, UK
Andreu Ollé, (IPHES), Spain

145 Raw material exploitation and lithic variability at the MSA site of Gotera, Southern Ethiopia: technological and quantitative approaches combined

Elena Carletti, "La Sapienza" University of Rome, Italy
Marianna Fusco, "La Sapienza" University of Rome, Italy
Andrea Zerboni, "La Sapienza" University of Rome, Italy
Marina Gallinaro, "A. Desio" Università degli Studi di Milano, Italy
Enza Elena Spinapolice, "La Sapienza" University of Rome, Italy

Special Session on Cultural Heritage: Measurement of Immeasurable Values - PART I

Room: B 2.07 Hall, Cassino University Campus

Chairs: *Magdalena Żmudzińska-Nowak, Silesian University of Technology, Poland*

151 CULTURAL HERITAGE: Values, Approaches, Interpretation

Magdalena Żmudzińska-Nowak, Faculty of Architecture Silesian University of Technology, Poland

157 Using modern techniques of digitalization in popularization of the Upper Silesia Heritage

Krzysztof Herner, The Coal Mining Museum in Zabrze, Poland

- 162 **Enforced oblivion. The heritage site and its intangible heritage tangled with the political narrative and social memory of the nations**
Beata Piecha-van Schagen, Coal Mining Museum, Poland
- 168 **Tools versus Ideas// Methods versus Imagination**
Antonio Castelbranco, Universidade de Lisboa, Portugal
Oksana Turchanina, Universidade de Lisboa, Portugal

Special Session on Geomatic Techniques for Integrated 3D Data Acquisition, Metric Validation and Management - PART I

Room: 1.09 Hall, Cassino University Campus

Chairs: *Gabriele Bitelli, Alma Mater Studiorum, University of Bologna, Italy*
Maria Grazia D'Urso, University of Cassino and Southern Lazio, Italy

- 173 **Crop marks detection through optical and multispectral imagery acquired by UAV**
Vittorio Casella, University of Pavia, Italy
Marica Franzini, University of Pavia, Italy
Maria Elena Gorrini, University of Pavia, Italy
- 178 **High resolution orthophotos and a digital surface model of the Roman city of Pollentia (Mallorca, Spain) using RPAS imagery, aerial images, and open data archives**
Eduard Angelats, (CTTC/CERCA), Spain
Miguel Ángel Cau Ontiveros, (ICREA) (ERAAUB), Spain
Catalina Mas Florit, (ERAAUB), Spain
- 183 **High-resolution 3D survey and visualization of Mesopotamian artefacts bearing cuneiform inscriptions**
Chiara Francolini, (DICAM) University of Bologna, Italy
Gianni Marchesi, (DiSCi) University of Bologna, Italy
Gabriele Bitelli, (DICAM) University of Bologna, Italy
- 188 **3D information management system for the conservation of an old deserted military site**
EVA S. MALINVERNI, (DICEA) Università Politecnica delle Marche, Italy
ANDREA A. GIULIANO, (DICEA) Università Politecnica delle Marche, Italy
FABIO MARIANO, (DICEA) Università Politecnica delle Marche, Italy
- 193 **CLOSE-RANGE IMAGERY FOR RECONSTRUCTING ARCHAEOLOGICAL FINDINGS**
Maria Grazia D'Urso, (DICeM) University of Cassino and Southern Lazio, Italy
Constantino Luis Marino, International Surveyance Company, Italy
Andrea Rotondi, (DICeM) University of Cassino and Southern Lazio, Italy

Special Session on Integrated Digital Survey Methodologies for the Knowledge and Enhancement of Architectural and Urban - PART II

Room: Aula Magna, Cassino University Campus

Chairs: *Marco Giorgio Bevilacqua, University of Pisa, Italy*

- 199 **Computational Design for As-Built Modeling of Architectural Heritage in HBIM processes**
Stefano Brusaporci, University of L'Aquila, Italy
Pamela Maiezza, University of L'Aquila, Italy
Alessandra Tata, University of L'Aquila, Italy
- 204 **The Building Information Modelling for the documentation of an archaeological site**
Ilaria Trizio, Construction Technologies Institute, Italy
Francesca Savini, University of L'Aquila, Italy
Alessandro Giannangeli, Construction Technologies Institute, Italy

- 211 **Deepening the knowledge of military architecture in an urban context through digital representations integrated with geophysical surveys. The city walls of Cagliari (Italy).**
Andrea Pirinu, DICAAR University of Cagliari, Italy
Roberto Balia, DICAAR University of Cagliari, Italy
Luca Piroddi, DICAAR University of Cagliari, Italy
Antonio Trogu, DICAAR University of Cagliari, Italy
Marco Utzeri, DICAAR University of Cagliari, Italy
Giulio Vignoli, DICAAR University of Cagliari, Italy
- 216 **Documentation systems for a urban renewal proposal in developing territories: the digitalization project of Bethlehem Historical Center**
Sandro Parrinello, DICAr University of Pavia, Italy
Francesca Picchio, DICAr University of Pavia, Italy
Raffaella De Marco, DICAr University of Pavia, Italy
- 222 **Integrated BIM-GIS system for the enhancement of urban heritage**
Marco Saccucci, University of Cassino and Southern Lazio, Italy
Assunta Pelliccio, University of Cassino and Southern Lazio, Italy

Special Session on Pondera Online: An international network for ancient and byzantine metrology

Room: B 2.07 Hall, Cassino University Campus

Chairs: *Charles Doyen, FNRS / UCLouvain, Belgium*

Maria Letizia Caldelli, Sapienza - Università di Roma, Italy

- 227 **The Pondera Online Database**

Doyen Charles, INCAL / CEMA, Belgium

Special Session on Full Coverage Geophysical Prospection on Protohistoric and Roman Central Settlements in Italy

Room: 1.09 Hall, Cassino University Campus

Chairs: *Frank Vermeulen, Ghent University, Belgium*

- 233 **Mapping Adriatic Landscapes project: geophysics and other prospecting methods in the discovery and re-discovery of pre-Roman settlements in northern Marche.**
Federica Boschi, University of Bologna, Italy
- 238 **Non-invasive Survey Approaches to Pre-Roman Settlement Centres in Central Adriatic Italy**
Wieke de Neef, Department of Archaeology Ghent University, Belgium
Frank Vermeulen, Department of Archaeology Ghent University, Belgium
- 244 **Urban survey on abandoned Roman sites: integrating archaeological geophysics and other topographic approaches in central-Adriatic Italy**
Frank Vermeulen, Department of Archaeology Ghent University, Belgium
- 249 **Integrated Geophysical Survey to Reconstruct Historical Landscape in Undug Areas of the Roman Ancient Town of Nora, Cagliari, Italy**
Luca Piroddi, (DICAAR) University of Cagliari, Italy
Francesco Loddo, (DICAAR) University of Cagliari, Italy
Sergio Vincenzo Calcina, (DICAAR) University of Cagliari, Italy
Antonio Trogu, (DICAAR) University of Cagliari, Italy
Martina Cogoni, (DICAAR) University of Cagliari, Italy
Gaetano Ranieri, (DICAAR) University of Cagliari, Italy
- 254 **The Impact of High Resolution Ground-Penetrating Radar Survey on Understanding Roman Towns: case studies from Falerii Novi and Interamna Lirenas (Lazio, Italy)**
Lieven Verdonck, Department of Archaeology Ghent University, Belgium
Frank Vermeulen, Department of Archaeology Ghent University, Belgium
Martin Millett, Faculty of Classics University of Cambridge, UK
Alessandro Launaro, Faculty of Classics University of Cambridge, UK

Special Session on Geomatic Techniques for Integrated 3D Data Acquisition, Metric Validation and Management - PART II

Room: Aula Magna, Cassino University Campus

Chairs: *Gabriele Bitelli, Alma Mater Studiorum, University of Bologna, Italy*
Maria Grazia D'Urso, University of Cassino and Southern Lazio, Italy

- 260 Public Archaeology and Open Data: a New Deal for Supporting and Interpreting Excavations**
Giorgio Di Gangi, University of Torino, Italy
Enrico Borgogno Mondino, University of Torino, Italy
Chiara Maria Lebole, University of Torino, Italy
- 265 EVALUATING A SLAM-BASED MOBILE MAPPING SYSTEM: A METHODOLOGICAL COMPARISON FOR 3D HERITAGE SCENE REAL-TIME RECONSTRUCTION**
Eva Savina Malinverni, (DICEA) Università Politecnica delle Marche, Italy
Roberto Pierdicca, (DICEA) Università Politecnica delle Marche, Italy
Carlo Alberto Bozzi, (DICEA) Università Politecnica delle Marche, Italy
Daniele Bartolucci, Geomax s.r.l, Italy
- 271 3D survey and modelling of the main portico of the Cathedral of Monreale**
Mauro Lo Brutto, University of Palermo, Italy
Donatella Ebolese, University of Palermo, Italy
Leonarda Fazio, University of Palermo, Italy
Gino Dardanelli, University of Palermo, Italy
- 277 Geomatic techniques for surveying and mapping an archaeological site**
Andrea Gennaro, (DISUM) University of Catania, Italy
Michele Mangiameli, (DICAR) University of Catania, Italy
Giovanni Muscato, (DIEEI) University of Catania, Italy
Giuseppe Mussumeci, (DICAR) University of Catania, Italy
Mariarita Sgarlata, (DISUM) University of Catania, Italy
- 282 Pre-Bonifica maps of the Agro Pontino: an assessment**
Valerio Baiocchi, DICEA Sapienza University, Italy
Luca Alessandri, GIA University of Groningen, The Netherlands
Francesca Giannone, Engineering Faculty Cusano University, Italy
Jan Sevink, IBED University of Amsterdam, The Netherlands
Wouter van Gorp, GIA University of Groningen, The Netherlands
Martijn van Leusen, GIA University of Groningen, The Netherlands

Special Session on Cultural Heritage: Measurement of Immeasurable Values - PART II

Room: B 2.07 Hall, Cassino University Campus

Chairs: *Magdalena Zmudzińska-Nowak, Silesian University of Technology, Poland*

- 287 The Museo dell'Arte della Lana in Stia: Culture and tradition of wool-making**
Andrea Gori, Museo Galileo, Italy
Emma Angelini, Politecnico di Torino, Italy
- 293 "The loop of history and art – how reinterpretation creates relations?"**
Jerzy Wojewódka, Silesian University of Technology Faculty of Architecture, Poland
Julia Giżewska, Silesian University of Technology Faculty of Architecture, Poland
- 298 Industrial heritage between identity and conflicts: analysis and possibilities for the industrial village of Rosignano Solvay in Tuscany**
Marco Giorgio Bevilacqua, DESTeC Università di Pisa, Italy
Stefania Landi, DESTeC Università di Pisa, Italy
Sonia Paone, Dipartimento di Scienze Politiche Università di Pisa, Italy
Giulia Zanaboni, Italy
- 303 Emptiness as a testimony of an orphaned heritage.**
Karolina Chodura, Silesian University of Technology, Poland
- 308 Vernacular immeasurable heritage - searching for uniqueness in the old way of building**
Elżbieta Rdzawska-Augustin, Silesian University of Technology, Poland

**Special Session on Non-invasive systems and techniques for "on site" monitoring and diagnosis
- PART II**

Room: 1.09 Hall, Cassino University Campus

Chairs: *Emanuele Piuzzi, Sapienza, University of Rome, Italy*
Livio D'Alvia, Sapienza, University of Rome, Italy

- 313 Photogrammetric survey to support Non Destructive Tests at St. Alexander Catacombs in Rome**
Marialuisa Mongelli, Department of Energy technologies ICT DIVISION ENEA, Italy
Irene Bellagamba, Department of Energy technologies ICT DIVISION ENEA, Italy
Antonio Perozziello, Department of Energy technologies ICT DIVISION ENEA, Italy
Samuele Pierattini, Department of Energy technologies ICT DIVISION ENEA, Italy
Silvio Migliori, Department of Energy technologies ICT DIVISION ENEA, Italy
Andrea Quintiliani, Department of Energy technologies ICT DIVISION ENEA, Italy
Giovanni Bracco, Department of Energy technologies ICT DIVISION ENEA, Italy
Angelo Tatì, Department of Energy technologies USER DIVISION ENEA, Italy
Paola Calicchia, Institute of Marine Engineering CNR-INM, Italy
- 319 Frequency Domain Analysis of the Minerva Medica Temple by means of the Motion Magnification Methodology**
Vincenzo Antonio Fioriti, ENEA, Italy
Ivan Roselli, ENEA, Italy
Gerardo De Canio, ENEA, Italy
- 324 Non-Destructive Survey Systems on Masonry: The Case of the Walls in the Archaeological Site of Canne della Battaglia**
Eduardo Caliano, Istemi s.a.s, Italy
Carmine Napoli, Istemi s.a.s, Italy
Nicolino Messuti, Istemi s.a.s, Italy
Rosangela Faieta, Istemi s.a.s, Italy
- 330 Structural Health Monitoring System for Masonry Historical Construction**
Francesco Lamonaca, University of Sannio, Italy
Renato S. Olivito, University of Calabria, Italy
Saverio Porzio, University of Calabria, Italy
Domenico Luca Carnì, University of Calabria, Italy
Carmelo Scuro, University of Calabria, Italy
- 336 Low density archaeometry with low energy using X-ray radiography and microtomography**
Ricardo Tadeu Lopes, PEN/COPPE/UFRJ, Brazil
Soraia Rodrigues Azeredo, PEN/COPPE/UFRJ, Brazil
Roberto Cesareo, University di Sassari, Italy
Regulo F. Jordan, Museo Señora de Cao and Fundacion Wiese, Peru
Arabel Fernandez, Museo Señora de Cao and Fundacion Wiese, Peru
Angel Bustamante, Universidad Nacional Mayor de San Marcos, Peru

Wednesday, October 24

General Session - PART II

Room: Aula Magna, Cassino University Campus

Chairs: *Marilena Maniaci, University of Cassino and Southern Lazio, Italy*
Eugenio Polito, University of Cassino and Southern Lazio, Italy

- 340 **In situ corrosion monitoring campaign of a weathering steel urban building**
Elisabetta Di Francia, Politecnico di Torino, Italy
Andrea Bussetto, Politecnico di Torino, Italy
Tilde De Caro, CNR, Italy
Marco Parvis, Politecnico di Torino, Italy
Emma Angelini, Politecnico di Torino, Italy
Sabrina Grassini, Politecnico di Torino, Italy
- 345 **Looking for the full scan: S. Zenone chapel**
Marco Carpiceci, Sapienza University Rome, Italy
Andrea Angelini, Institute for the Technologies Applied to Cultural Heritage National Research Council of Italy, Italy
- 351 **I-MEDIA-CITIES: Automatic Metadata Enrichment of Historic Media Content**
Alexander Loos, Fraunhofer Institute for Digital Media Technology Metadata Department, Germany
Christian Weigel, Fraunhofer Institute for Digital Media Technology Metadata Department, Germany
- 357 **Corrosion products of Cu-based coins from the River Tiber (Rome) analysed by micro-Raman spectroscopy**
Tilde de Caro, CNR-ISMN, Italy
- 362 **Dating of three kilns from Catalonia, general considerations on archaeomagnetic dating**
Albert Egea, Universitat Autònoma de Barcelona, Spain
Lluís Casas, Universitat Autònoma de Barcelona, Spain
Anna Anglisano, Universitat Autònoma de Barcelona, Spain
Carlota Auguet, Universitat Autònoma de Barcelona, Spain
Marc Prat, Universitat Autònoma de Barcelona, Spain
Josep Burch, Universitat Autònoma de Barcelona, Spain

Special Session on Metrological approaches to the study of ancient and medieval written Heritage - PART II

Room: 1.09 Hall, Cassino University Campus

Chairs: *Lucio Del Corso, University of Cassino and Southern Lazio, Italy*

- 367 **Parchment disinfection treatment by ionizing radiation**
Monia Vadrucchi, ENEA, Italy
Cristina Cicero, Tor Vergata University, Italy
Fabio Borgognoni, ENEA, Italy
Gabriele Ceres, Tor Vergata University, Italy
Nicoletta Perini, Tor Vergata University, Italy
Luciana Migliore, Tor Vergata University, Italy
Fulvio Mercuri, Tor Vergata University, Italy
Noemi Orazi, Tor Vergata University, Italy
Stefano Paoloni, Tor Vergata University, Italy
Alessandro Rubechini, Archivio Segreto Vaticano, Vatican City
- 373 **A signature of Pomponio Leto in the Oratory of SS. Annunziata in Cori (Latina)? The contribution of high-definition laser scanner in the study of scratched inscriptions (graffiti)**
Giovanni Caratelli, (ITABC) (CNR), Italy
- 379 **Study of ancient egyptian artefacts by nondestructive laser based techniques**
Luisa Caneve, FSN-TECFIS-Diagnostic and Metrology Laboratory ENEA, Italy
Valeria Spizzichino, FSN-TECFIS-Diagnostic and Metrology Laboratory ENEA, Italy
Emiliano Antonelli, Consorzio Croma, Italy

POSTER SESSION

Room: B 2.11 Hall, Cassino University Campus

Chairs: *Marco Laracca, University of Cassino and Southern Lazio, Italy*

Cristina Corsi, University of Cassino and Southern Lazio, Italy

- 384 **Hypothesis of virtual reconstruction for the Sphinxes Frieze at the Trajan's Forum in Rome**
Samuele Pierattini, ICT DIVISION ENEA, Italy
Marialuisa Mongelli, ICT DIVISION ENEA, Italy
Irene Bellagamba, ICT DIVISION ENEA, Italy
Beatrice Calosso, ICT DIVISION ENEA, Italy
Luciano De Martino, ICT DIVISION ENEA, Italy
Antonio Perozziello, ICT DIVISION ENEA, Italy
Daniele Visparelli, ICT DIVISION ENEA, Italy
Giovanni Bracco, ICT DIVISION ENEA, Italy
Andrea Quintiliani, ICT DIVISION ENEA, Italy
Silvio Migliori, ICT DIVISION ENEA, Italy
Marina Milella, Mercati di Traiano, Museo dei Fori Imperiali, Italy
Lucrezia Ungaro, Mercati di Traiano, Museo dei Fori Imperiali, Italy
- 390 **Use of the transmissibility function H for ambient vibration measurements of an archeological building**
Ivan Roselli, Department for Sustainability ENEA, Italy
Vincenzo Fioriti, Department for Sustainability ENEA, Italy
Gerardo De Canio, Department for Sustainability ENEA, Italy
- 396 **Compensating for Density Effect in Permittivity-Based Moisture Content Measurements on Historic Masonry Materials**
Emanuele PiuZZi, Sapienza University of Rome, Italy
Erika Pittella, Sapienza University of Rome, Italy
Stefano Pisa, Sapienza University of Rome, Italy
Andrea Cataldo, University of Salento, Italy
Egidio De Benedetto, University of Salento, Italy
Giuseppe Cannazza, University of Salento, Italy
Paolo D'Atanasio, ENEA, Italy
Alessandro Zambotti, ENEA, Italy
Livio D'Alvia, Sapienza University of Rome, Italy
Zaccaria Del Prete, Sapienza University of Rome, Italy
- 401 **WENDY: a Wireless Environmental Monitoring Device Prototype**
Livio D'Alvia, Sapienza University of Rome, Italy
Zaccaria Del Prete, Sapienza University of Rome, Italy
- 406 **Comparison between Routing Protocols for Wide Archeological Site**
F. Leccese, Science Department of Università degli Studi "Roma Tre", Italy
M. Cagnetti, Science Department of Università degli Studi "Roma Tre", Italy
S. Giarnetti, Science Department of Università degli Studi "Roma Tre", Italy
E. Petritoli, Science Department of Università degli Studi "Roma Tre", Italy
I. Luisetto, Science Department of Università degli Studi "Roma Tre", Italy
S. Tuti, Science Department of Università degli Studi "Roma Tre", Italy
M. Leccisi, Science Department of Università degli Studi "Roma Tre", Italy
R. Đurović-Pejčev, Institute of Pesticides and Environmental Protection, Serbiay
T. Đorđević, Institute of Pesticides and Environmental Protection, Serbiay
A. Tomašević, Institute of Pesticides and Environmental Protection, Serbiay
V. Bursić, Institute of Pesticides and Environmental Protection, Serbiay
V. Arenella, Fonderie Digitali s.r.l, Italy
P. Gabriele, Fonderie Digitali s.r.l, Italy
A. Pecora, Istituto per la microelettronica e microsistemi (IMM) of Consiglio Nazionale delle Ricerche, Italy
L. Maiolo, Istituto per la microelettronica e microsistemi (IMM) of Consiglio Nazionale delle Ricerche, Italy
E. De Francesco, SeTeL s.r.l, Italy
G. Schirripa Spagnolo, Dipartimento di Matematica e Fisica of Università degli Studi "Roma Tre", Italy
R. Quadarella, RoTechnology s.r.l, Italy
L. Bozzi, RoTechnology s.r.l, Italy
C. Formisano, Systemdesign s.r.l, Italy

- 411 The ArchaeoTrack Project: Use of Ground-Penetrating Radar for Preventive Conservation of Buried Archaeology Towards the Development of a Virtual Museum**
Luca Bianchini Ciampoli, Dept. of Engineering Roma Tre University, Italy
Andrea Benedetto, Dept. of Engineering Roma Tre University, Italy
Fabio Tosti, University of West London, UK
- 416 A 3D topographic network for the study and maintenance of the Insula III of Herculaneum**
Andrea D'Andrea, Università degli Studi di Napoli "L'Orientale", Italy
Antonella Coralini, Università degli Studi di Bologna, Italy
Angela Bosco, Università degli Studi di Salerno, Italy
Andrea Fiorini, Università degli Studi di Bologna, Italy
Rosario Valentini, Università degli Studi di Napoli "L'Orientale", Italy
- 422 Integrated geomatic survey and virtual reality navigation engines for the historical-architectural analysis. The paradigmatic case of a "Modern Age" fortification: the Fortezza Vecchia in Livorno.**
Andrea Piemonte, University of Pisa, Italy
Denise Ulivieri, University of Pisa, Italy
Federico Caprioli, University of Pisa, Italy
Gabriella Caroti, University of Pisa, Italy
Stefano Bennati, University of Pisa, Italy
- 427 Stone artefacts from Roman age in the Southern Latium**
Gianluca De Rosa, University of Cassino and Southern Latium, Italy
Eugenio Polito, University of Cassino and Southern Latium, Italy
- 431 TLS and photogrammetry for 3D modelling of a low relief: case study of ancient archive, Palazzo Bo, Padua**
Andrea Masiero, University of Padova, Italy
Alberto Guarnieri, University of Padova, Italy
Francesca Fissore, University of Padova, Italy
Marco Piragnolo, University of Padova, Italy
Francesco Pirotti, University of Padova, Italy
Antonio Vettore, University of Padova, Italy
- 437 Mapping of archaeological evidences and 3D models for the historical reconstruction of archaeological sites**
Maria Grazia D'Urso, University of Cassino and Southern Lazio, Italy
Ester Corsi, University of Cassino and Southern Lazio, Italy
Cristina Corsi, University of Cassino and Southern Lazio, Italy
- 443 Metrological aspects in the Nubian pottery from the collection of the University of Cassino and Southern Latium**
Bruna Maria Andreoni, University of Cassino and Southern Latium, Italy
- 449 Comparison and deformation analysis of five 3D models of the Paleolithic wooden point from the Ljubljana River**
Enej Gucek Puhar, University of Ljubljana, Slovenia
Miran Eric, Institute for the Protection of Cultural Heritage of Slovenia, Slovenia
Katja Kavkler, Institute for the Protection of Cultural Heritage of Slovenia, Slovenia
Anja Cramer, Romisch-Germanisches Zentralmuseum Archaeological Research Institute, Germany
Kristijan Celec, INTRI d.o.o., Slovenia
Lidija Korat, Slovenian National Building and Civil Engineering Institute, Slovenia
Ales Jakli, University of Ljubljana, Slovenia
Franc Solina, University of Ljubljana, Slovenia

- 455 **Deep Transfer Learning for writer identification in medieval books**
Alessandro Bria, University of Cassino and Southern Lazio, Italy
Nicole Dalia Cilia, University of Cassino and Southern Lazio, Italy
Claudio De Stefano, University of Cassino and Southern Lazio, Italy
Francesco Fontanella, University of Cassino and Southern Lazio, Italy
Claudio Marrocco, University of Cassino and Southern Lazio, Italy
Mario Molinara, University of Cassino and Southern Lazio, Italy
Alessandra Scotto di Freca, University of Cassino and Southern Lazio, Italy
Francesco Tortorella, University of Cassino and Southern Lazio, Italy
- 461 **Spatial analysis of the Khartoum Variant Site 8-B- 10C (8th-6th mill. BC) at Sai Island (Sudan): Preliminary results**
Elena A.A. Garcea, University of Cassino and Southern Lazio, Italy
Vincenzo Spagnolo, University of Siena, Italy
- 466 **ARCA 2.0: Automatic Recognition of Color for Archaeology through a Web-Application**
Filippo Luigi Maria Milotta, University of Catania, Italy
Camillo Quattrocchi, University of Catania, Italy
Filippo Stanco, University of Catania, Italy
Davide Tanasi, University of South Florida, Florida
Stefania Pasquale, INFN CHNet Catania, Italy
Anna Maria Gueli, University of Catania, Italy
- 471 **The digital surface model processing for detection and mapping of preparatory sketches for frescoes**
Jakub Markiewicz, University of Technology Warsaw, Poland
Magdalena Pilarska, University of Technology Warsaw, Poland
Agnieszka Kaliszewska, Academy of Science Warsaw, Poland
Rafał Bieńkowski, Academy of Science Warsaw, Poland

Special Session on Non-Destructive Analytical Approaches applied to the Study of Ancient Stone Materials

Room: Aula Magna, Cassino University Campus

Chairs: *Giulio Lucarini, University of Cambridge, UK*

Andrea Manzo, University of Naples L'Orientale, Italy

- 476 **Between the sea and the river: Geochemical characterization of the obsidian artefacts from Mahal Teglinos (Kassala, Sudan), 4th - 2nd millennia BC**
Giulio Lucarini, University of Cambridge, UK
Donatella Barca, University of Calabria, Italy
Andrea Manzo, University of Naples L'Orientale, Italy
- 479 **Characterization and weathering of archaeological glasses from late antique Sicily**
Anna M. Gueli, University of Catania & INFN CHNet CT, Italy
Quentin Lemasson, Centre de Recherche et de Restauration des Musées de France, France
Giuseppe Stella, University of Catania, Italy
Stefania Pasquale, INFN CHNet CT, Italy
Brice Moignard, Centre de Recherche et de Restauration des Musées de France, France
Giuseppe Politi, University of Catania & INFN CT, Italy
Davide Tanasi, University of South Florida, United State of America
Claire Pacheco, Centre de Recherche et de Restauration des Musées de France, France
Stephan Hassam, University of South Florida, United State of America
Laurent Pichon, Centre de Recherche et de Restauration des Musées de France, France

Special Session on Archaeopalynology for the reconstruction of environmental and cultural landscapes

Room: B 2.07 Hall, Cassino University Campus

Chairs: *Assunta Florenzano, University of Modena and Reggio Emilia, Italy*

Sebastián Pérez-Díaz, Spanish National Research Council, CSIC, Spain

- 484 **Palynology narrates climate, environment and society changes in the human history**
Alessia Masi, Sapienza University Rome, Italy, Max Planck Institute for the Science of Human History Jena, Germany
- 489 **Reconstruction of mosaic landscapes in the Balearic Islands, Western Mediterranean**
Gabriel Servera-Vives, Universitat de les Illes Balears Palma, Spain
Llorenç Picornell-Gelabert, Universitat de les Illes Balears Palma, Spain
- 494 **The “Vasca Inferiore di Noceto”: palynological data for the reconstruction of the Po Plain landscape in the Bronze Age**
Eleonora Clò, Università di Modena e Reggio Emilia, Italy
Marta Mazzanti, Università di Modena e Reggio Emilia, Italy
Paola Torri, Università di Modena e Reggio Emilia, Italy
Rossella Rinaldi, Università di Modena e Reggio Emilia, Italy
Maria Chiara Montecchi, Università di Modena e Reggio Emilia, Italy
Anna Maria Mercuri, Università di Modena e Reggio Emilia, Italy
Mauro Cremaschi, Università Statale di Milano, Italy
- 499 **Archeobotanical investigations in the ancient city of Gonfienti, Italy (Bronze Age, Iron Age)**
Francesco Ciani, University of Florence, Italy
Davide Attolini, University of Florence, Italy
Cristina Bellini, University of Florence, Italy
Miria Mori Secci, University of Florence, Italy
Tiziana Gonnelli, University of Florence, Italy
Pasquino Pallecchi, Soprintendenza Archeologia, Belle Arti e Paesaggio per la città metropolitana di Firenze e le province di Pistoia e Prato, Italy
Marta Mariotti Lippi, University of Florence, Italy
- 504 **Woodland-use in Tyrrhenian southern Tuscany during the Middle Ages (mid-7th-13th century AD)**
Mauro Paolo Buonincontri, University of Siena, Italy
Pierluigi Pieruccini, University of Turin, Italy
Carmine Lubritto, University of Campania “Luigi Vanvitelli”, Italy
Marta Rossi, University of Siena, Italy
Davide Susini, University of Siena, Italy
Paola Ricci, University of Campania “Luigi Vanvitelli”, Italy
Giovanna Bianchi, University of Siena, Italy
Gaetano Di Pasquale, University of Naples “Federico II”, Italy
- 510 **Palynological approach to reconstruct cultural landscape evolution: case studies from South Italy**
Assunta Florenzano, Università di Modena e Reggio Emilia, Italy

General Session - PART III

Room: 1.09 Hall, Cassino University Campus

Chairs: *Assunta Pelliccio, University of Cassino and Southern Lazio, Italy*
Lucio Del Corso, University of Cassino and Southern Lazio, Italy

- 515 **On the Suppression of Mixed Gaussian and Impulsive Noise in Color Images**
Damian Kusnik, Silesian University of Technology Institute of Informatics, Poland
Bogdan Smolka, Silesian University of Technology Institute of Automatic Control, Poland
- 521 **The Environmental Monitoring Campaign of the Museum of the Faculty of Archaeology of the Sohag University (Egypt)**
Ahmed Elsayed, Politecnico di Torino, Italy
Luca Lombardo, Politecnico di Torino, Italy
Marco Parvis, Politecnico di Torino, Italy
Emma Angelini, Politecnico di Torino, Italy
Sabrina Grassini, Politecnico di Torino, Italy

- 527 **Measuring and leveling roman aqueducts to estimate their flows**
Claudio Alimonti, Sapienza University Rome, Italy
Valerio Baiocchi, Sapienza University Rome, Italy
Giorgia Bonanotte, Sapienza University Rome, Italy
Gabor Molnar, MTA-ELTE Geological, Geophysical and Space Science Research Group, Hungary
- 532 **Analysis of items recommendations methods for heritage sites**
Wael Jradi, Cesi and University of Rouen, France
Mourad Messaadia, Cesi, France
Anne Louis, Cesi, France
Laurent Heutte, University of Rouen, France
- 537 **Indoor geolocation based on earth magnetic field**
Salim Alioua, CESI, France
Mourad Messaadia, CESI, France
Mohamed-Amin Benatia, CESI, France
Souleyman SAHNOUN, SITUSED, France
Andi Smart, University of Exeter, UK

Special Session on Dating and Provenance of Ancient Artifacts: Methods, Applications and Future Perspectives

Room: Aula Magna, Cassino University Campus

Chairs: *Enzo Ferrara, Istituto Nazionale di Ricerca Metrologica, Italy*
Lluís Casas, Universitat Autònoma de Barcelona, Spain

- 542 **Provenance of marbles from Baths of Nero (Pisa, Italy)**
Marco Lezzerini, Università di Pisa, Italy
Germana Sorrentino, Università di Pisa, Italy
Stefano Columbu, Università di Pisa, Italy
Claudia Rizzitelli, Belle Arti e Paesaggio per le province di Pisa e Livorno, Italy
Maria Letizia Gualandi, Università di Pisa, Italy
- 548 **Archaeomagnetic dating of two baked clay structures excavated at Libarna, Northern Italy**
Evdokia Tema, Università degli Studi di Torino, Italy
Enzo Ferrara, INRiM, Italy
Alessandro Quercia, Soprintendenza Archeologia belle arti e paesaggio per la città metropolitana di Torino, Italy
Barbara Strano, Cooperativa Archeologia, Italy
Simone Giovanni Lerma, Soprintendenza Archeologia belle arti e paesaggio per le province di Alessandria, Asti e Cuneo, Italy

Special Session on Measuring in the past: ancient instruments

Room: B 2.07 Hall, Cassino University Campus

Chairs: *Margherita Bongiovanni, Politecnico di Torino, Italy*
Emma Angelini, Politecnico di Torino, Italy

- 554 **Rings, Armillae and Other Spherical Instruments. The representation of the Sky in three dimensions**
Giancarlo Truffa, Independent Scholar, Italy
- 559 **The Jacquard loom between Science and Technology**
Emma Angelini, Politecnico di Torino, Italy
Andrea Gori, Museo Galileo, Italy
- 564 **Curioni and the experimental measurements on the strength of materials in the Scuola di applicazione per gli ingegneri of Turin**
Federica Stella, Politecnico di Torino, Italy
Margherita Bongiovanni, Politecnico di Torino, Italy
Mauro Borri-Brunetto, Politecnico di Torino, Italy

Special Session on Technological information and learning patterns in pottery production

Room: 1.09 Hall, Cassino University Campus

Chairs: *Elena A.A. Garcea, University of Cassino and Southern Latium, Italy*

Giulia D'Ercole, Ludwig Maximilians-University Munich, Germany

570 The Emergence of Pottery in the Middle Nile Valley: Technology and Function of Early Holocene Complexes from Sudan

Giulia D'Ercole, Institute of Egyptology and Coptology Ludwig-Maximilians University, Germany

Elena A.A. Garcea, Institute of Egyptology and Coptology Ludwig-Maximilians University, Germany

575 Index of Authors

Encoding and Simulating the Past. A Machine Learning Approach to the Archaeological Information

Marco Ramazzotti
Department of Classics
LAA&AAS
Sapienza University of Rome
Rome, Italy
marco.ramazzotti@uniroma1.it

Paolo Massimo Buscema
Semeion
Research Centre of Sciences of
Communication
Rome, Italy
m.buscema@semeion.it

Giulia Massini
Semeion
Research Centre of Sciences of
Communication
Rome, Italy
g.massini@semeion.it

Francesca Della Torre
Semeion
Research Centre of Sciences of
Communication
Rome, Italy
f.dellatorre@semeion.it

Abstract — The encoding of the spatial-temporal archeological, historical and anthropological records can be considered an ideal-typical representation of the human reasoning and thus also an artificial membrane interposed between the researcher and the past. These membranes are here considered artificial networks and can undergo interrogation processes through the most advanced analytical tools for learning and modeling complex configurations. The aim of this paper is to synthesize recent advances in Artificial Intelligence and Computer Science and – at the same time – to support the connectionists and symbolic computational paradigms as a new epistemic frontier in the automatic annotation of tangible and intangible heritage as well in the contemporary theories and methods of the archeological thought.

Keywords — Analytical Archaeology, Artificial Intelligence, Computer Science, Computer Semiotic, Artificial Adaptive Systems, Biological Computing, Computational Modeling

I. INTRODUCTION

The semiotic and logicist encoding of the spatial-temporal archeological, historical, geographical and anthropological records can be considered an ideal-typical representation of the contextual reality inspired by the human reasoning and thus also an artificial adaptive membrane interposed between the observer / researcher and the past (1).

Nowadays, these epistemic networks are semantic segmentations and can undergo interrogation processes through the most advanced analytical tools for learning and modeling complex data-set configurations. Encoding the epistemic contexts of the past and simulating the dynamic and complex behavior of the high variability of the natural and cultural factors in artificial membranes thus conceived equals tracking down, selecting, and separately recreating a wide variety of

functions associating variables, a wide variety of inferences controlling their semantic structure, and an equally wide variety of causes producing their transformation (2).

In this specific sense, a machine learning approach to the quantity and to the quality of the archaeological information has value: it recreates a possible world of other associations of meaning from the body of lacking sources and dispersed information, exhibits the nuances and complex interrelations, and, furthermore, helps the researcher to codify other, unforeseen or even hidden interrelations.

II. EPISTEMOLOGY

Since the end of the 1980s, a matrix encoding of the different archaeological complex systems has been in the process of development for the purpose of tracking down, selecting, and recreating the functions, inferences, and rules that produced the economic, politic and aesthetic transformations of the ancient cultural *milieux* (3).

The artificial formal networks obtained by such structural and semantic matrix encoding were thus continuously and massively described, analyzed, and simulated through symbolic and connectionist paradigms of the new Artificial Intelligence at Department of Classics and at Laboratory of Analytical Archaeology and Artificial Adaptive Systems (LAA&AAS) at Sapienza University, and at the Semeion Research Centre of Rome (4).

In fact, the ‘connectionist paradigm’ aims at massively parallel models that consist of many simple and uniform processing elements interconnected with extensive links (the artificial neural networks) and the ‘symbolic paradigm’ has been conceived as the development of models using symbol

manipulation, and the computation in the models is based on explicit encoding that contain signs organized in some specific and semantic structures (5).

After some 30 years of such theoretical, computational and experimental broad spectrum advanced researches on different historical, archaeological and anthropological empirical contexts of the past, Artificial Intelligence connectionist and symbolic paradigms seem to maintain a distinct value in the recent history of the archaeological thought (6).

This distinct value is most evident in the Analytical and Spatial Archaeology, where the simulations through the most advanced technique for deep learning and data mining serve both as a new paradigm for computational modeling and as a new theoretical approach for the study natural and cultural complex systems.

The aim of this paper is to synthesize recent advances in the measurement and simulation of the archeological systemic complexity (here intended as historical, archaeological, linguistic and anthropological complexity) and – at the same time – to support the connectionists and symbolic paradigm of the Artificial Intelligence as a new epistemic frontier in the automatic annotation of tangible and intangible heritage as well in the contemporary history of the archeological thought.

III. RECENT ADVANCES IN ARTIFICIAL INTELLIGENCE: FROM LEARNING THE COMPLEXITY OF THE PAST THROUGH THE SYSTEM ECOLOGY STRATEGY (SES)

Digital archiving allows the cataloguing of a mass of data coming from *records* (archaeological, anthropological, figurative and epigraphic) that have a multi-dimensional nature. Today in Computer Science we define the mass of this information Big Data. To question, analyze and integrate this vast and diversified context of information the Artificial Intelligence seems to be the only resource that can answer to the needed in this direction (7).

The Deep Learning system utilizes the Big Data into traditional Neural Networks based on the gradient descent method with many hidden levels. Each hidden layer can have different local activities (convolution, filter selection, invariant detection) to find the deep characteristics and features of the input models (8).

However, this procedure does not generate a true deep learning, but implements an effective and iterative pruning of the input from a single point of view, so to detect the deep abstract invariant elements of the different patterns.

These large networks do not extract from the data an abstract scheme that can be applied effectively to another completely different set of data (9).

METANET (Semeion ©)

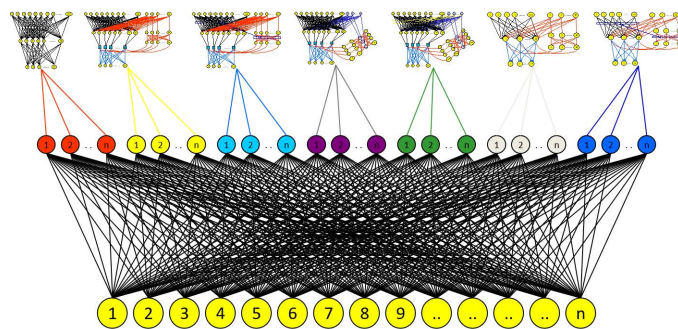


Fig. 1 An example of Ecological System: Metanet © Semeion

Therefore, we propose a new approach: the information coming from different sources must interact to be able of simulating complex scenario and find the rules that determine the spread / diffusion both of natural and cultural processes.

The new framework we propose works in a different way from what is called Deep Learning: it is an “ecological” system composed of different neural networks, evolutionary algorithms, dynamic associative memories, auto encoder, that work with different mathematics independently and simultaneously on the same data set or on different data sets that will be made to interact.

We have called this new artificial organism “Systems Ecology Strategy” (for short SES) (10).

SES observes the same phenomenon from different point of views (fig. 1): analyzes the dynamics and the rules that make it up or have generated and determined it; predicts its development or on the contrary retraces segments lost and / or inadequate, simulates scenarios; identifies the semantic network of relationships that connects it with other cultural and social phenomena and lastly can generates prototypes.

Every selected theme / aspect of a complex phenomenon can be thus analyzed because the points of views from which it is looked at are different, this theme / aspect can be artificially immersed in a context of relationships that define its domain of existence (11).

IV. A MACHINE LEARNING APPROACH TO THE SYSTEMIC COMPLEXITY OF THE PAST: UNSUPERVISED LEARNINGS, ALGORITHMIC DESCRIPTIONS AND TOPOLOGICAL CENTROIDS

Recent advances in Artificial Intelligence are revealing a completely new epistemic frontier also in the automatic annotation of tangible and intangible heritage as well in the contemporary history of the archeological thought.

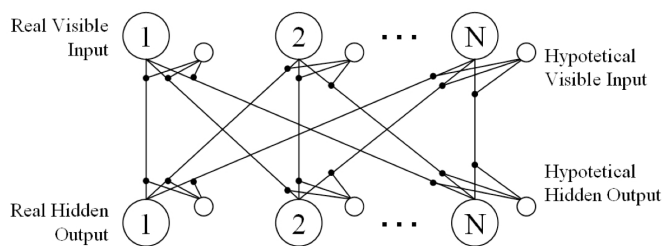


Fig. 2: Dynamic Associative Memory New Recirculation ANN © Semeion

In particular, the study of the natural and cultural complexity of the past through Analytical Archaeology, Computer Semiotics and Artificial Adaptive Systems is now declined to program and to shape a specific “Systems Ecology Strategy” for modelling and simulating the higher complexity of sign’s systems coming from the Past.

Is now important to delineate the recent history of this theoretical and methodological approach, following the passages between the first unsupervised learnings of complex configurations and the modern biological computing of the cultural systems.

The spatial organization of the Mesopotamian Urban Revolution Landscape (MURL) in central-southern Babylonia has been the first archeological, historical and anthropological context to introduce a machine learning approach based on different types of Artificial Neural Networks for the multifactorial analysis of the first world Urbanism.

The Recirculation Artificial Neural Networks (fig. 2) were first applied to typological subdivision of the Fourth and Third Millennium BC southern Mesopotamian pottery considered as Constraint Satisfaction (CS) problem, in which the recognition of a class or a type must satisfy a number of constraints.

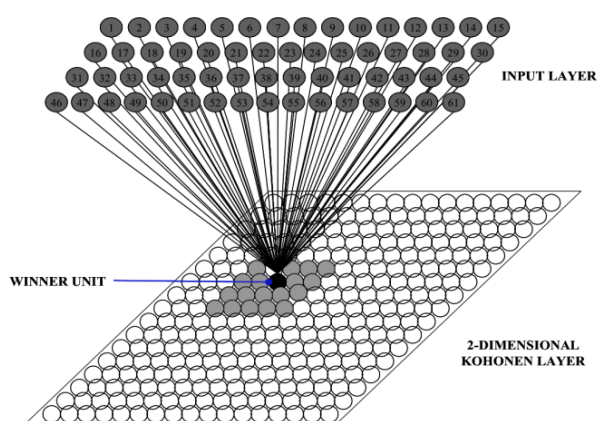


Fig. 3: Unsupervised ANN for natural clustering Self-Organizing Map

The unsupervised algorithms (fig. 2), such Self-Organizing Map (SOM) were contextually applied to classify and to delineate the Fourth and Third millennium BC human mobility trends in central-southern Babylonia, depending on a multifactorial, fuzzy and unforeseen correlations between many different variables (12).

A turning point in the planning of a machine learning approach to the archeological complexity has been the possibility for searching unforeseen and fuzzy connections in Big Data coming from direct and indirect encoding of archeological records.

A procedure based on Auto-CM and MST algorithms has been first tested in the Settlement Archaeology to investigate the possible spatial location of one of the most relevant cemetery of the ancient near east, the Royal Mausoleums recorded in the Royal Archives of Ebla – Tell Mardikh in northern Syria and dated back to the second half of the Third Millennium BC (13).

Auto-CM is one of the most powerful algorithms for searching for unknown or hidden connections in Big Data is called the Auto-Contractive Map (Auto-CM) (14). This powerful algorithm is able to encode the many to many relationships of similarity and to synthesize them within a matrix $N \times N$ of weights, where N is the number of variables (or records) among which we want to investigate relationships and connections.

The peculiarity of this unsupervised artificial neural network is that the final output will be zero while all knowledge will be combined in a highly non-linear way and stored in a matrix $N \times N$ in which each cell ij denotes how much variable i and variable j are similar to each other, also considering the interactions had with all other $N-2$ variables.

Since reading an $N \times N$ matrix is not very easy, especially when you have a very high N number of relationships to “measure”, new techniques have been designed to make them visible and self-explanatory.

It is possible to visualize the most important relations in terms of strength through a two-dimensional graph that represents on a plane the N variables in the form of points.

A pair of points (P_i, P_j) , i.e. a pair of variables, is connected by a link l only if the value of their connection, determined by the weight found by Auto-CM, respects certain constraints. Filters of this kind are the Minimum Spanning Tree and the Maximally Regular Graph (15).

One of the innovations brought about by the use of the Auto-CM algorithm is the possibility of querying the network through the Spin Algorithm. The Spin Net algorithm was programmed to exploit Auto-CM’s ability to understand the deep structure of the world of which the learned data is a part.

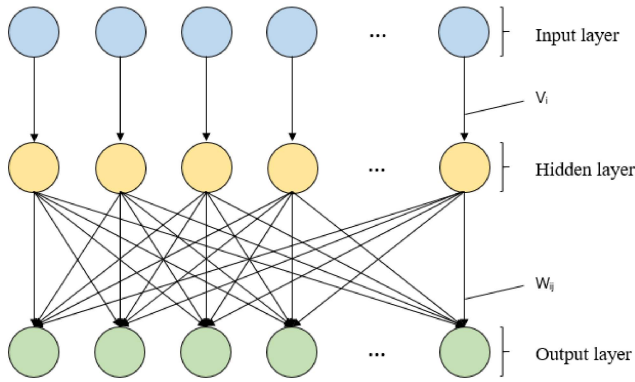


Fig. 4: Auto-CM © Semeion

Spin Net belongs to that category of algorithms called “associative memories” and is able, once an incomplete record is proposed as input, to reconstruct it exploiting the knowledge embedded in the weights (16).

The output of Spin Net is therefore constituted by an N-variables vector whose values, iteration after iteration, stabilize following a continuous dialogue and interaction among themselves based on the weights determined by Auto-CM. The potentialities of spin net in the artificial intelligence filed are decidedly relevant.

On the one hand, once a damaged record or one with missing values is input, the network will be able to converge towards the most probable correct values. Otherwise, activating only some of the variables will have the effect of a real questioning: “What would happen if ...?” and the system will simulate the most plausible scenario.

The recent advances in the programming of a more sophisticated machine learning approach has been supported by powerful algorithms specifically designed to analyze the dynamic morphology of a processes, and has been first experimented to simulate the spatial origin and the topology of the central Babylonia settlement systems during the Vth, IVth and IIIrd millennium BCE in the region between Eridu and Nippur in southern Iraq (17).

If there is an interest in the evolution of a phenomenon or a process, it is possible to use sophisticated algorithms designed to analyze the diffusion of space/time processes through an innovative model called topological approach based on the Topological Weighted Centroid (TWC) theory (18).

The TWC is a complex evolutionary algorithm that, starting from a dataset consisting of at least the spatial coordinates of events, tries to reconstruct the points and relevant areas related to the starting distribution.

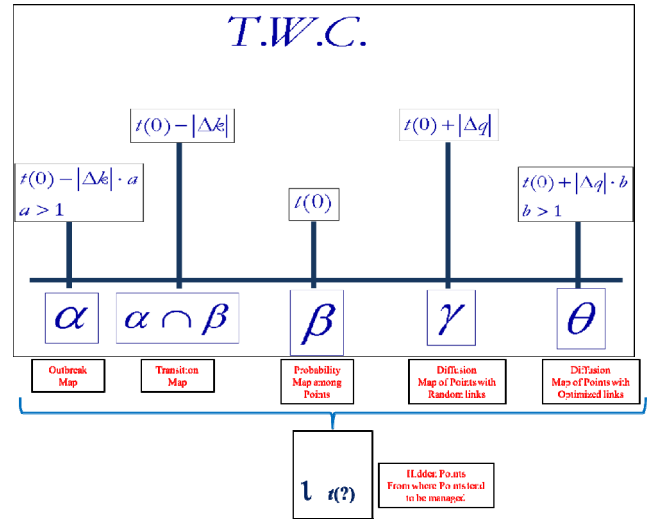


Fig. 5: TWC © Semeion

The basic intuition behind the topological approach is that every distribution of point in space has an implicit semantics, provided the following conditions are met: 1) Each point of the distribution represents a discrete occurrence of the same process; 2) The distribution of points is statistically representative of the process to be analyzed; Once again, the objective of this innovative technique is to extract Implicit information, hidden in the relations among the data-points.

The salient points related to the distribution that the TWC technique can determine are of two different natures. The Alpha point, which corresponds to spatial estimate of the hidden (outbreak) point, where the process under study originated. Iota points, instead, are the vantage points from where the distribution of points becomes most intelligible.

While the Alpha point, by its nature, lies within the convex hull of the distribution and is unique (19), Iota points can be more than one and generally fall outside the smallest convex containing the points. It is possible to determine the activation strength of each of the iota points and display it via heat map to determine the respective areas of influence (Iota map). The determination of these points is very complex and sophisticated, for complete mathematical details see the publication cited.

In addition to determining points of interest, the TWC algorithm is able to generate heat maps to predict the possible development of distribution in the past (TWC alpha map), present (TWC beta map) and future (TWC Gamma and TWC theta maps). The algorithm is also able to draw directly on the map the possible nonlinear trajectories that have allowed communication between the points of the distribution (Gamma and Theta paths).

If the dataset containing the event locations is also equipped with other attributes (e.g. extra information about the events),

it is possible to make the TWC system interact with Auto-CM by creating an additional space semantization. Although the two systems are completely different and designed to analyze different aspects can be used to increase the points of view, and therefore the knowledge, on the same problem, a biodiversity of information extractors (20).

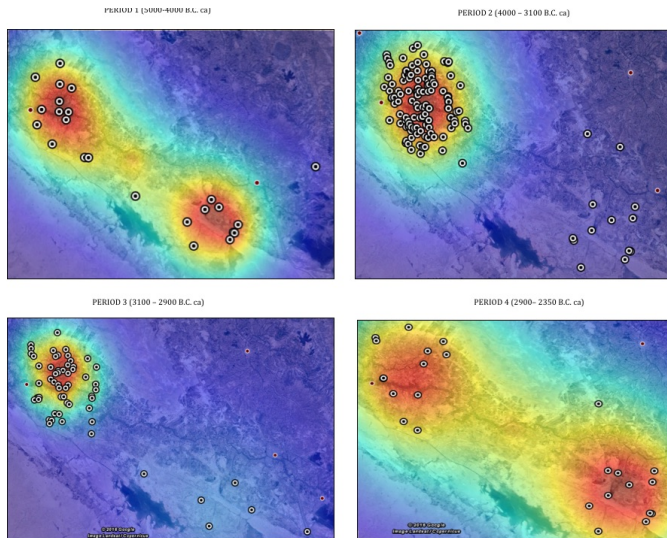


Fig. 6: TWC topological analysis of the first urbanism process in central-southern Mesopotamia © Semeion / LAA&SAA

The last frontier of our machine learning approach is to formalize an “ecological system” that addresses complex classification problems by analyzing them from multiple points of view and implementing different mathematics finds its realization with the algorithms grouped under the name of “MetaNets” (23).

In fact, MetaNets are unsupervised meta-classifiers: they classify the records of the problem on the basis of the attributions that have already been carried out by other classification algorithms usually called “component classifiers”. They are neural networks that take in input all the output nodes of all the component classifiers and produce in output their own choice.

All the MetaNets have the same architecture but different equations to determine the output. Using different MetaNets on different component classifiers with the same dataset multiplies the point of view through which analyze the problem, letting each element say its opinion, as in a parliament. Because of their equations, MetaNets do not know the architecture of the component networks but base their response on the relative outputs and, therefore, also on the errors.

In this way, it is possible to use together extremely different models and let MetaNets, independently, give them more or less credibility. The weights, in fact, take into account the

plausibility and the implausibility of each classification, considering excitatory and inhibitory credibility of each composing classifier. Furthermore, it is possible, by means of an evolutionary algorithm called GenD (21) to determine the subset of base classifiers that produce the best result.

One of the prerogatives of the MetaNets is not to consider, as one would expect, only the best of the component classifiers but also some of the weakest that, perhaps, implement different mathematics and make mistakes of different nature. This methodology has been applied with excellent results in several fields (22).

ACKNOWLEDGMENT

We are grateful to La Sapienza University of Rome who made new computational researches on ancient Near Eastern urbanisms and urbanizations possible, awarding the interdisciplinary project Analytical Archaeology for the Southern Mesopotamian Urbanism (AASMU) in 2014. We thank all the colleagues working at Analytical Archaeology and Artificial Adaptive Systems Laboratory (LAA&AAS) at La Sapienza Department of Classics for a very thorough and thoughtful review, which improved the analytical, experimental and applied archaeological research significantly.

REFERENCES

- [1] M. Ramazzotti 2010, *Archeologia e Semiotica. Linguaggi, codici, logiche e modelli*, Torino: Bollati Boringhieri.
- [2] M. Ramazzotti 2013, “Logic and Semantics of Computational Models for the Analysis of Complex Phenomena. Analytical Archaeology of Artificial Adaptive Systems”, in *Human Mobility, Climate Change and Local Sustainable Development*, A. Montanari ed., Rome: La Sapienza, pp. 23–56; M. Ramazzotti 2013, “Archeosema. Sistemi Artificiali Adattivi per un’Archeologia Analitica e Cognitiva dei Fenomeni Complessi”, *Archeologia e Calcolatori*, 24, pp. 283–303.
- [3] M. Ramazzotti, 2014, “Analytical Archaeology and Artificial Adaptive Systems”, in *Archeosema Artificial Adaptive Systems for the Analysis of Complex Phenomena. Collected Papers in Honour of David Leonard Clarke*, M. Ramazzotti, ed. Firenze: All’Insegna del Giglio, 2014, pp. 15–52.
- [4] M. Ramazzotti, 2014, “Analytical Archaeology and Artificial Adaptive Systems Laboratory (LAA&AAS)”, in *Archeosema Artificial Adaptive Systems for the Analysis of Complex Phenomena. Collected Papers in Honour of David Leonard Clarke*, M. Ramazzotti, ed. Firenze: All’Insegna del Giglio, 2014, pp. 53–84.
- [5] M. Ramazzotti, 2016, “Archeologia e traduzione. Prolegomena alla meccanografia e alla simulazione artificiale del sema.”, in *Il segno tradotto. Idee, immagini, parole in transito*, M. Ramazzotti, S. Celani, F. Fava Eds., Milano: Marcos y Marcos, pp. 17–26; M. Ramazzotti, *Introduzione all’archeologia del paesaggio. Geografia cosmica, simulazioni geomatiche, ricostruzioni potenziali e ipersuperfici neurali*, in *Digital Humanities: strumento o fine? Elementi per una riflessione metodologica (Status Quaestionis X)*, Celani, S. (a cura di), 2016, pp. 99 – 113.
- [6] M. Ramazzotti, 2018, “Landscape Archaeology and Artificial Intelligence: the Neural Hypersurface of the Mesopotamian Urban Revolution”, in *CyberResearch on the Ancient Near East and Neighboring Regions Case Studies on Archaeological Data, Objects, Texts, and Digital Archiving*, V. Bigot Juloux, A. Rebecca Gansell, A. di Ludovico, Eds., Leiden, Boston: Brill, pp. 60–82.

- [7] Firmani, D., Mecella, M., Scannapieco, M., & Batini, C., 2016, On the meaningfulness of “big data quality”, *Data Science and Engineering*, 1(1), pp. 6–20.
- [8] Hinton, G. E., Salakhutdinov, R. R., 2006, “Reducing the dimensionality of data with neural networks”, *Science*, 313(5786), pp. 504–507; Bengio, Y., 2009, Learning deep architectures for AI. *Foundations and trends, Machine Learning*, 2(1), 1–127.
- [9] Buscema, P. M., Sacco, P. L., 2017, “Digging deeper on “deep” learning: a computational ecology approach”, *Behavioral and Brain Sciences*, 40, pp. 28-29.
- [10] Buscema, P. M., Sacco, P. L., Della Torre, F., Massini, G., Breda, M., & Ferilli, G., 2018, Theory of Impossible Worlds: Toward a Physics of Information, *Chaos: An Interdisciplinary Journal of Nonlinear Science*, 28(5), 055914.
- [11] Buscema, P. M., Ferilli, G., Sacco, P. L., 2017, What Kind of ‘World Order’? An Artificial Neural Networks Approach to Intensive Data Mining, *Technological Forecasting and Social Change*, 117, pp. 46-56.
- [12] Ramazzotti, M., 1997, “La fase ‘Middle Uruk’: studio tramite Reti Neurali Artificiali su un orizzonte latente nella protostoria della Bassa Mesopotamia.” in *Studi in memoria di Henri Frankfort (1897-1954)* presentati dalla scuola romana di Archeologia Orientale, edited by Paolo Matthiae, pp. 495–522. CMAO VII. Roma: La Sapienza; Ramazzotti, M., 1999, La Bassa Mesopotamia come laboratorio storico in età protostorica. Le Reti Neurali Artificiali come strumento di ausilio alle ricerche di archeologia territoriale. CMAO VIII. Roma: La Sapienza; Ramazzotti, M., 1999, Analisi qualitativa dei depositi archeologici come indice guida delle ricerche a scala territoriale, in *Reti Neurali Artificiali e sistemi sociali complessi. Teoria - Metodi - Applicazioni. Voll. II*, pp. a cura di P. M. Buscema, 1999, pp. 261–269, Franco Angeli, Milano; Ramazzotti, M., 2002, “La ‘Rivoluzione Urbana’ nella Mesopotamia meridionale. Replica ‘versus’ processo.” *Accademia Nazionale dei Lincei. Classe delle Scienze Morali Storiche e Filologiche, Rendiconti IX 13*: 651–752; Ramazzotti, M., 2009, “Lineamenti di archeologia del paesaggio mesopotamico. Descrizioni statistiche e simulazioni artificiali adattive per un’analisi critica della demografia sumerica e accadica.” In *Geografia del popolamento*, edited by Giancarlo Macchi Jánica, 193–202. Siena: Fieravecchia.
- [13] Ramazzotti, M., 2013. “Where Were the Early Syrian Kings of Ebla Buried? The Ur-Eridu Survey Neural Model as an Artificial Adaptive System for the Probabilistic Localization of the Ebla Royal è madim.” *Scienze dell’Antichità*, 19, pp. 10–34.
- [14] Buscema, P. M., Massini, G., Breda, M., Lodwick, W. A., Newman, F., & Asadi-Zeydabadi, M. (2018). Artificial Adaptive Systems Using Auto Contractive Maps: Theory, Applications and Extensions (Vol. 131). Springer.
- [15] Buscema, M., & Sacco, P. L. (2010), “Auto-contractive maps, the H function, and the maximally regular graph (MRG): a new methodology for data mining”, in *Applications of mathematics in models, artificial neural networks and arts* (pp. 227-275). Springer, Dordrecht.
- [16] Therefore, this system has potentially infinite fields of application. In the archaeological field it can be used for the reconstruction of missing or incomplete data, to determine possible scenarios assuming the evolution of phenomena on the basis of its previous knowledge. Buscema, P. M., Massini, G., Breda, M., Lodwick, W. A., Newman, F., & Asadi-Zeydabadi, M. (2018). Auto-CM as a Dynamic Associative Memory. In *Artificial Adaptive Systems Using Auto Contractive Maps* (pp. 147-179). Springer, Cham.
- [17] The artificial neural training of the surveyed, collected, selected and codified archaeological records between Eridu and Nippur in central-southern Babylonia has been systematically explored through integrating data mining and geographic profiling algorithms. The neural spatial analysis here advanced is founded on natural computing machine learning and reveals both a new computational methodology for Spatial Archaeology and a new theoretical approach to the cultural, economic and political complexity of the Urban Revolution. Some of the first preliminary results here summarized were presented by M. Ramazzotti during a workshop on the ‘Landscapes of Settlements in the Ancient Near East’ at the American School of Oriental Research (ASOR 2016) annual meeting held in 2016 in San Antonio (Texas) and during a workshop on the ‘Corpus of Analysis in the Research on Ancient Eastern Mediterranean and Western Asia: Encoding, Information Collection, Digital Collaboration, and Investigating Strategies’ at the Computer Application in Archaeology (CAA 2017) annual meeting held in 2017 in Atlanta (Georgia). Ramazzotti, M., *in prep.*, A Neural Spatial Analysis of the Southern Mesopotamian Urban Landscape.
- [18] Buscema, M., Massini, G., & Sacco, P. L. (2018). The Topological Weighted Centroid (TWC): A topological approach to the time-space structure of epidemic and pseudo-epidemic processes. *Physica A: Statistical Mechanics and its Applications*, 492, 582-627.
- [19] Buscema, M., Grossi, E., Bronstein, A., Lodwick, W., Asadi-Zeydabadi, M., Benzi, R., & Newman, F. (2013). A new algorithm for identifying possible epidemic sources with application to the German Escherichia coli outbreak. *ISPRS International Journal of Geo-Information*, 2(1), 155-200.
- [20] Buscema, M., Sacco, P. L., Ferilli, G., Breda, M., & Grossi, E. (2015). Analyzing the semantics of point spaces through the Topological Weighted Centroid and other mathematical quantities: The hidden geometry of the global economic order. *Computational Intelligence*, 31(3), 532-567.
- [21] Buscema, M., Newman, F., Grossi, E., & Tastle, W. (2010, July). Application of adaptive systems methodology to radiotherapy. In *Fuzzy Information Processing Society (NAFIPS), 2010 Annual Meeting of the North American* (pp. 1-8). IEEE.
- [22] Buscema, M. (2004). Genetic doping algorithm (GenD): theory and applications. *Expert Systems*, 21(2), 63-79
- [23] Buscema, M., Tastle, W. J., & Terzi, S. (2013). Meta net: A new meta-classifier family. In *Data mining applications using artificial adaptive systems* (pp. 141-182). Springer, New York, NY. For the epistemic and archeological context of our contemporary reserches based on Meta net theories and models see: Ramazzotti, M., 2016, Back to the Future. Structuring an Analithical Model for the Mesopotamian Urbanism: a view from the South, *Trajectories of Complexity. Socio-economic Dynamics in Upper Mesopotamia in the Neolithic and Chalcolithic Periods: Proceedings of the 9th International Congress on the Archaeology of the Ancient Near East at Basel (Studia Chaburensia 6)*, M. Iamoni (ed.), pp. 183-194, Wiesbaden, Harrassowitz Verlag.