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3.1. Cástulo in the 21st Century: A Test Site for a New Digital Information System

Marcelo Castro López
University of Jaén, macaslo@ujaen.es

Francisco Arias de Haro

Libertad Serrano Lara
University of Jaén, libertad.serrano@gmail.com

Ana L. Martínez Carrillo

Manuel Serrano Araque

See next page for additional authors

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Authors

Marcelo Castro López, Francisco Arias de Haro, Libertad Serrano Lara, Ana L. Martínez Carrillo, Manuel Serrano Araque, and Justin St. P. Walsh

MOBILIZING *the* PAST *for a* DIGITAL FUTURE

The Potential of
Digital Archaeology



Edited by
Erin Walcek Averett
Jody Michael Gordon
Derek B. Counts

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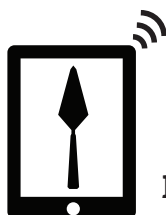
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Preface & Acknowledgments

This volume stems from the workshop, “Mobilizing the Past for a Digital Future: the Future of Digital Archaeology,” funded by a National Endowment for the Humanities Digital Humanities Start-Up grant (#HD-51851-14), which took place 27-28 February 2015 at Wentworth Institute of Technology in Boston (<http://uwm.edu/mobilizing-the-past/>). The workshop, organized by this volume’s editors, was largely spurred by our own attempts with developing a digital archaeological workflow using mobile tablet computers on the Athienou Archaeological Project (<http://aap.toumazou.org>; Gordon *et al.*, Ch. 1.4) and our concern for what the future of a mobile and digital archaeology might be. Our initial experiments were exciting, challenging, and rewarding; yet, we were also frustrated by the lack of intra-disciplinary discourse between projects utilizing digital approaches to facilitate archaeological data recording and processing.

Based on our experiences, we decided to initiate a dialogue that could inform our own work and be of use to other projects struggling with similar challenges. Hence, the “Mobilizing the Past” workshop concept was born and a range of digital archaeologists, working in private and academic settings in both Old World and New World archaeology, were invited to participate. In addition, a livestream of the workshop allowed the active participation on Twitter from over 21 countries, including 31 US states (@MobileArc15, #MobileArc).¹

¹ For commentary produced by the social media followers for this event, see: <https://twitter.com/electricarchaeo/status/571866193667047424>, <http://shawngraham.github.io/exercise/mobilearcday1wordcloud.html>, <https://twitter.com/electricarchaeo/status/571867092091338752>, <http://www.diachronicdesign.com/blog/2015/02/28/15-mobilizing-the-past-for-the-digital-future-conference-day-1-roundup/>.

Although the workshop was initially aimed at processes of archaeological data recording in the field, it soon became clear that these practices were entangled with larger digital archaeological systems and even socio-economic and ethical concerns. Thus, the final workshop's discursive purview expanded beyond the use of mobile devices in the field to embrace a range of issues currently affecting digital archaeology, which we define as the use of computerized, and especially internet-compatible and portable, tools and systems aimed at facilitating the documentation and interpretation of material culture as well as its publication and dissemination. In total, the workshop included 21 presentations organized into five sessions (see program, <http://mobilizingthepast.mukurtu.net/digital-heritage/mobilizing-past-conference-program>), including a keynote lecture by John Wallrodt on the state of the field, "Why paperless?: Digital Technology and Archaeology," and a plenary lecture by Bernard Frischer, "The Ara Pacis and Montecitorio Obelisk of Augustus: A Simpirical Investigation," which explored how digital data can be transformed into virtual archaeological landscapes.

The session themes were specifically devised to explore how archaeological data was digitally collected, processed, and analyzed as it moved from the trench to the lab to the digital repository. The first session, "App/Database Development and Use for Mobile Computing in Archaeology," included papers primarily focused on software for field recording and spatial visualization. The second session, "Mobile Computing in the Field," assembled a range of presenters whose projects had actively utilized mobile computing devices (such as Apple iPads) for archaeological data recording and was concerned with shedding light on their utility within a range of fieldwork situations. The third session, "Systems for Archaeological Data Management," offered presentations on several types of archaeological workflows that marshal born-digital data from the field to publication, including fully bespoke paperless systems, do-it-yourself ("DIY") paperless systems, and hybrid digital-paper systems. The fourth and final session, "Pedagogy, Data Curation, and Reflection," mainly dealt with teaching digital methodologies and the use of digital repositories and linked open data to enhance field research. This session's final paper, William Caraher's "Toward a Slow Archaeology," however, noted digital archaeology's successes in terms of

time and money saved and the collection of more data, but also called for a more measured consideration of the significant changes that these technologies are having on how archaeologists engage with and interpret archaeological materials.

The workshop's overarching goal was to bring together leading practitioners of digital archaeology in order to discuss the use, creation, and implementation of mobile and digital, or so-called "paperless," archaeological data recording systems. Originally, we hoped to come up with a range of best practices for mobile computing in the field – a manual of sorts – that could be used by newer projects interested in experimenting with digital methods, or even by established projects hoping to revise their digital workflows in order to increase their efficiency or, alternatively, reflect on their utility and ethical implications. Yet, what the workshop ultimately proved is that there are many ways to "do" digital archaeology, and that archaeology as a discipline is engaged in a process of discovering what digital archaeology should (and, perhaps, should not) be as we progress towards a future where all archaeologists, whether they like it or not, must engage with what Steven Ellis has called the "digital filter."

So, (un)fortunately, this volume is not a "how-to" manual. In the end, there seems to be no uniform way to "mobilize the past." Instead, this volume reprises the workshop's presentations—now revised and enriched based on the meeting's debates as well as the editorial and peer review processes—in order to provide archaeologists with an extremely rich, diverse, and reflexive overview of the process of defining what digital archaeology is and what it can and should perhaps be. It also provides two erudite response papers that together form a didactic manifesto aimed at outlining a possible future for digital archaeology that is critical, diverse, data-rich, efficient, open, and most importantly, ethical. If this volume, which we offer both expeditiously and freely, helps make this ethos a reality, we foresee a bright future for mobilizing the past.

* * *

No multifaceted academic endeavor like *Mobilizing the Past* can be realized without the support of a range of institutions and individ-

uals who believe in the organizers' plans and goals. Thus, we would like to thank the following institutions and individuals for their logistical, financial, and academic support in making both the workshop and this volume a reality. First and foremost, we extend our gratitude toward The National Endowment for the Humanities (NEH) for providing us with a Digital Humanities Start-Up Grant (#HD-51851-14), and especially to Jennifer Serventi and Perry Collins for their invaluable assistance through the application process and beyond. Without the financial support from this grant the workshop and this publication would not have been possible. We would also like to thank Susan Alcock (Special Counsel for Institutional Outreach and Engagement, University of Michigan) for supporting our grant application and workshop.

The workshop was graciously hosted by Wentworth Institute of Technology (Boston, MA). For help with hosting we would like to thank in particular Zorica Pantić (President), Russell Pinizzotto (Provost), Charlene Roy (Director of Business Services), Patrick Hafford (Dean, College of Arts and Sciences), Ronald Bernier (Chair, Humanities and Social Sciences), Charles Wiseman (Chair, Computer Science and Networking), Tristan Cary (Manager of User Services, Media Services), and Claudio Santiago (Utility Coordinator, Physical Plant).

Invaluable financial and logistical support was also generously provided by the Department of Fine and Performing Arts and Sponsored Programs Administration at Creighton University (Omaha, NE). In particular, we are grateful to Fred Hanna (Chair, Fine and Performing Arts) and J. Buresh (Program Manager, Fine and Performing Arts), and to Beth Herr (Director, Sponsored Programs Administration) and Barbara Bittner (Senior Communications Management, Sponsored Programs Administration) for assistance managing the NEH grant and more. Additional support was provided by The University of Wisconsin-Milwaukee; in particular, David Clark (Associate Dean, College of Letters and Science), and Kate Negri (Academic Department Assistant, Department of Art History). Further support was provided by Davidson College and, most importantly, we express our gratitude to Michael K. Toumazou (Director, Athienou Archaeological Project) for believing in and supporting our

research and for allowing us to integrate mobile devices and digital workflows in the field.

The workshop itself benefitted from the help of Kathryn Grossman (Massachusetts Institute of Technology) and Tate Paulette (Brown University) for on-site registration and much more. Special thanks goes to Daniel Coslett (University of Washington) for graphic design work for both the workshop materials and this volume. We would also like to thank Scott Moore (Indiana University of Pennsylvania) for managing our workshop social media presence and his support throughout this project from workshop to publication.

This publication was a pleasure to edit, thanks in no small part to Bill Caraher (Director and Publisher, The Digital Press at the University of North Dakota), who provided us with an outstanding collaborative publishing experience. We would also like to thank Jennifer Sacher (Managing Editor, INSTAP Academic Press) for her conscientious copyediting and Brandon Olson for his careful reading of the final proofs. Moreover, we sincerely appreciate the efforts of this volume's anonymous reviewers, who provided detailed, thought-provoking, and timely feedback on the papers; their insights greatly improved this publication. We are also grateful to Michael Ashley and his team at the Center for Digital Archaeology for their help setting up the accompanying Mobilizing the Past Mukurtu site and Kristin M. Woodward of the University of Wisconsin-Milwaukee Libraries for assistance with publishing and archiving this project through UWM Digital Commons. In addition, we are grateful to the volume's two respondents, Morag Kersel (DePaul University) and Adam Rabinowitz (University of Texas at Austin), who generated erudite responses to the chapters in the volume. Last but not least, we owe our gratitude to all of the presenters who attended the workshop in Boston, our audience from the Boston area, and our colleagues on Twitter (and most notably, Shawn Graham of Carlton University for his word clouds) who keenly "tuned in" via the workshop's livestream. Finally, we extend our warmest thanks to the contributors of this volume for their excellent and timely chapters. This volume, of course, would not have been possible without such excellent papers.

As this list of collaborators demonstrates, the discipline of archaeology and its digital future remains a vital area of interest for people who value the past's ability to inform the present, and who

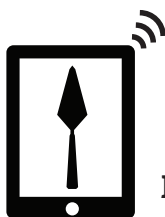
recognize our ethical responsibility to consider technology's role in contemporary society. For our part, we hope that the experiences and issues presented in this volume help to shape new intra-disciplinary and critical ways of mobilizing the past so that human knowledge can continue to develop ethically at the intersection of archaeology and technology.

Erin Walcek Averett (Department of Fine and Performing Arts and Classical and Near Eastern Studies, Creighton University)

Jody Michael Gordon (Department of Humanities and Social Sciences, Wentworth Institute of Technology)

Derek B. Counts (Department of Art History, University of Wisconsin-Milwaukee)

October 1, 2016



How To Use This Book

The Digital Press at the University of North Dakota is a collaborative press and *Mobilizing the Past for a Digital Future* is an open, collaborative project. The synergistic nature of this project manifests itself in the two links that appear in a box at the end of every chapter.

The first link directs the reader to a site dedicated to the book, which is powered and hosted by the Center for Digital Archaeology's (CoDA) Mukurtu.net. The Mukurtu application was designed to help indigenous communities share and manage their cultural heritage, but we have adapted it to share the digital heritage produced at the "Mobilizing the Past" workshop and during the course of making this book. Michael Ashley, the Director of Technology at CoDA, participated in the "Mobilizing the Past" workshop and facilitated our collaboration. The Mukurtu.net site (<https://mobilizingthepast.mukurtu.net>) has space dedicated to every chapter that includes a PDF of the chapter, a video of the paper presented at the workshop, and any supplemental material supplied by the authors. The QR code in the box directs readers to the same space and is designed to streamline the digital integration of the paper book.

The second link in the box provides open access to the individual chapter archived within University of Wisconsin-Milwaukee's installation of Digital Commons, where the entire volume can also be downloaded. Kristin M. Woodward (UWM Libraries) facilitated the creation of these pages and ensured that the book and individual chapters included proper metadata.

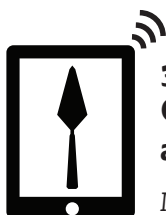
Our hope is that these collaborations, in addition to the open license under which this book is published, expose the book to a wider audience and provide a platform that ensures the continued availability of the digital complements and supplements to the text. Partnerships with CoDA and the University of Wisconsin-Milwaukee reflect the collaborative spirit of The Digital Press, this project, and digital archaeology in general.

Abbreviations

AAI	Alexandria Archive Institute
AAP	Athienou Archaeological Project
ABS	acrylonitrile butadiene styrene (plastic)
ADS	Archaeological Data Service
Alt-Acs	Alternative Academics
API	application programming interface
ARA	archaeological resource assessment
ARC	Australian Research Council
ARIS	adaptive resolution imaging sonar
ASV	autonomous surface vehicle
BLM	Bureau of Land Management
BLOB	Binary Large Object
BOR	Bureau of Reclamation
BYOD	bring your own device
CAD	computer-aided design
CDL	California Digital Library
CHDK	Canon Hack Development Kit
cm	centimeter/s
CMOS	complementary metal-oxide semiconductor
CoDA	Center for Digital Archaeology
COLLADA	COLLABorative Design Activity
CRM	cultural resource management
CSS	Cascading Style Sheet
CSV	comma separated values
DBMS	desktop database management system
DEM	digital elevation model
DINAA	Digital Index of North American Archaeology
DIY	do-it-yourself
DoD	Department of Defense
DVL	doppler velocity log
EAV	entity-attribute-value
EDM	electronic distance measurement
EU	excavation unit/s
FAIMS	Federated Archaeological Information Management System
fMRI	functional magnetic resonance imaging
GIS	geographical information system
GCP	ground control point
GNSS	global navigation satellite system
GPR	ground-penetrating radar

GUI	graphic user interface
ha	hectare/s
hr	hour/s
Hz	Hertz
HDSM	high-density survey and measurement
ICE	Image Composite Editor (Microsoft)
iOS	iPhone operating system
INS	inertial motion sensor
IPinCH	Intellectual Property in Cultural Heritage
IT	information technology
KAP	Kaymakçı Archaeological Project
KARS	Keos Archaeological Regional Survey
km	kilometer/s
LABUST	Laboratory for Underwater Systems and Technologies (University of Zagreb)
LAN	local area network
LIEF	Linkage Infrastructure Equipment and Facilities
LOD	linked open data
LTE	Long-Term Evolution
m	meter/s
masl	meters above sea level
MEMSAP	Malawi Earlier-Middle Stone Age Project
MOA	memoranda of agreement
MOOC	Massive Online Open Course
NGWSP	Navajo-Gallup Water Supply Project
NeCTAR	National eResearch Collaboration Tools and Resources
NEH	National Endowment for the Humanities
NHPA	National Historic Preservation Act
NPS	National Park Service
NRHP	National Register of Historic Places
NSF	National Science Foundation
OCR	optical character reader
OS	operating system
PA	programmatic agreement
PAP	pole aerial photography
PARP:PS	Pompeii Archaeological Research Project: Porta Stabia
PATA	Proyecto Arqueológico Tuti Antiguo
PBMP	Pompeii Bibliography and Mapping Project
PDA	personal digital assistant

PIARA	Proyecto de Investigación Arqueológico Regional Ancash
PKAP	Pyla-Koutsopetra Archaeological Project
Pladypos	PLAtform for DYnamic POSitioning
PLoS	Public Library of Science
PQP	Pompeii Quadriporticus Project
PZAC	Proyecto Arqueológico Zaña Colonial
QA	quality assurance
QC	quality control
QR	quick response
REVEAL	Reconstruction and Exploratory Visualization: Engineering meets ArchaeoLogy
ROS	robot operating system
ROV	remotely operated vehicle
RRN	Reciprocal Research Network
RSS	Rich Site Summary
RTK	real-time kinetic global navigation satellite system
SfM	structure from motion
SHPO	State Historic Preservation Office
SKAP	Say Kah Archaeological Project
SLAM	simultaneous localization and mapping
SMU	square meter unit/s
SU	stratigraphic unit/s
SVP	Sangro Valley Project
TCP	traditional cultural properties
tDAR	the Digital Archaeological Record
UAV	unmanned aerial vehicle
UNASAM	National University of Ancash, Santiago Antúnez de Mayolo
UQ	University of Queensland
USACE	U.S. Army Corp of Engineers
USBL	ultra-short baseline
USFS	U.S. Forest Service
USV	unmanned surface vehicle
UTM	universal transverse mercator
XML	Extensible Markup Language



3.1.

Cástulo in the 21st Century: A Test Site for a New Digital Information System

Marcelo Castro López, Francisco Arias de Haro, Libertad Serrano Lara, Ana L. Martínez Carrillo, Manuel Serrano Araque, and Justin St. P. Walsh

The Ibero-Roman city of Cástulo, located on the right bank of the Guadalimar River in Spain, was one of the major centers in the south of the Iberian Peninsula during antiquity, as is evident from the extent of its walled enclosure (50 ha) and from its strategic position at the head of the Guadalquivir valley, which leads 250 km to the Atlantic Ocean. The city stood out as a major hub in the road network of its time, and throughout its history it maintained privileged access to the mineral resources of the Sierra Morena. The *oppidum*, or fortified settlement, of Cástulo was initially the most important population center of the Iberian region of Oretania; later it became a Roman *municipium* before finally serving as an episcopal see during the late Roman imperial era (FIG. 1).

Classical authors gave special recognition to the city of Cástulo. Pliny the Elder (*HN* 3.25) described its role during the Second Punic War, and Livy (*Ab urbe condita* 27), Polybius (10.38.40), and Appian (*Iberia* 34) each chronicled the events surrounding the battle of Baecula (208 B.C.), located in the vicinity of Cástulo, which took place between the Roman commander Cornelius Scipio (Africanus) and the Carthaginians under Hasdrubal. Polybius (3.3.37) and Silius Italicus also described the strategic importance of this region for mastering a hold on the Iberian Peninsula and its mineral resources. Hannibal was aware of the importance of this location, and he sought to make a pact for control of Cástulo's territory by arranging his own marriage with the Oretan princess, Imilké. The Romans arrived in the peninsula under the command of the brothers Publius and Gnaeus Cornelius Scipio

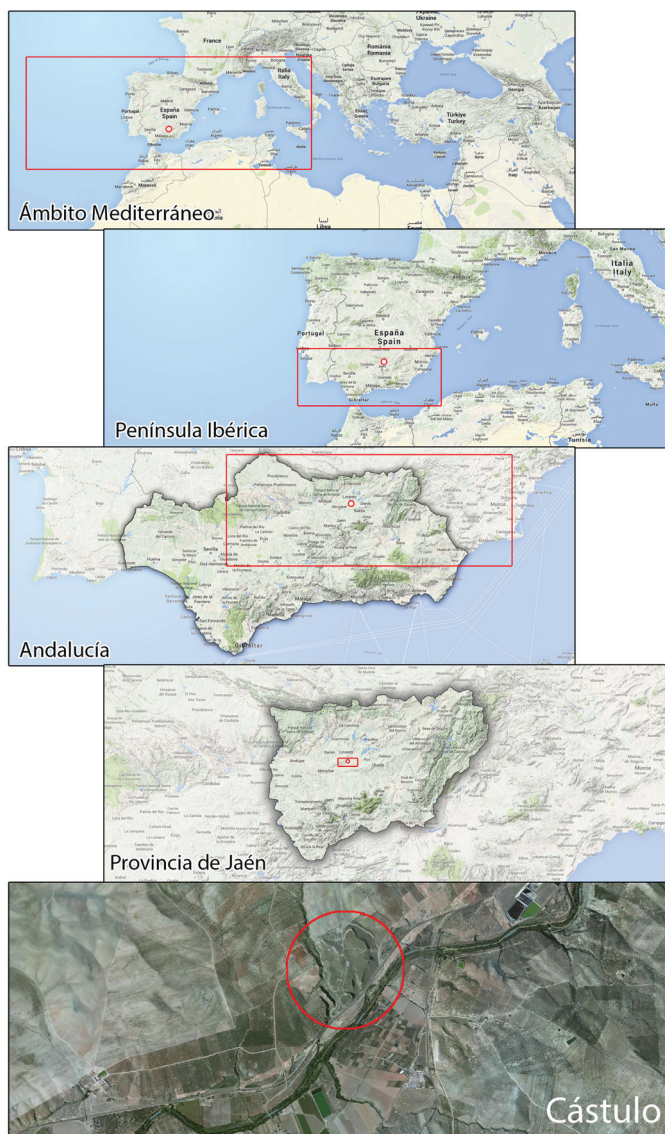


Figure 1: Map of the Iberian Peninsula with increasing level of detail showing the location of Cástulo.

in 218 B.C., and by 214 B.C. they were already showing interest in the mining area of Cástulo. Publius and Gnaeus were ultimately defeated, but Cornelius Scipio Africanus (Publius' son and Gnaeus' nephew) won a victory for the Romans at Baecula, inflicting a bloody revenge on Cástulo's neighbor Iliturgi, and finally earning the surrender of Cástulo. From this point on, the city remained under Roman rule. Strabo (*Geographia* 3.4.2) described how, during the Roman imperial period, when Hispania Baetica (now modern Andalusia) was constituted as a senatorial province, the border of neighboring Hispania Tarraconensis (an imperial province) was purposely arranged so that the emperor maintained direct control of Cástulo. Despite the city's initial faithfulness to the Carthaginian cause, the negotiation of its surrender and its alliance with Rome allowed Cástulo to maintain an unusual political independence, including the right to coin money (Cabrero 1993: 183–196).

In April 2011, the geographic definition of the archaeological site of Cástulo was published in the *Official Journal of the Government of Andalusia* (*Boletín Oficial de la Junta de Andalucía*), and in July of that year a decree formally creating the archaeological site was passed by the Andalusian regional government (<http://www.juntadeandalucia.es/boja/2011/155/26>). At that time, the excavation project *Forvm MMX* materialized with a workplan titled, *Location and first characterization of the forum of the Roman city of Cástulo*, initiating the archaeological fieldwork. *Forvm MMX* is a project of the Institute for Iberian Archaeological Research (University of Jaén), and it is promoted by the City of Linares and funded by the Ministry of Economy, Innovation, Science and Employment of Andalusian regional government. Excavation began in 2011, and permission was granted to continue from 2012 to 2014, with further activity aimed at conservation and upgrading the excavated areas for presentation to the public. These seasons of excavation have revealed two important public buildings from the monumental center of the Roman city (the city's forum has not yet been located in the areas under investigation).

Overall, the data collected indicates that the city built major public works between the first and second centuries A.D., including a bath complex and latrines, which were already known from previous excavations in the 1970s and 1980s. Levels for much of the second and third centuries are scarce, indicating a collapse in political and economic activity during which institutions were located in the earlier public



Figure 2: Orthophoto of the area covered by the archaeological site, representing more than 3,230 ha within the territories of three city councils: Linares, Torreblascopedro, and Lupión. To the northeast (just right of center in this image), next to the river, is the oppidum, or fortified settlement.

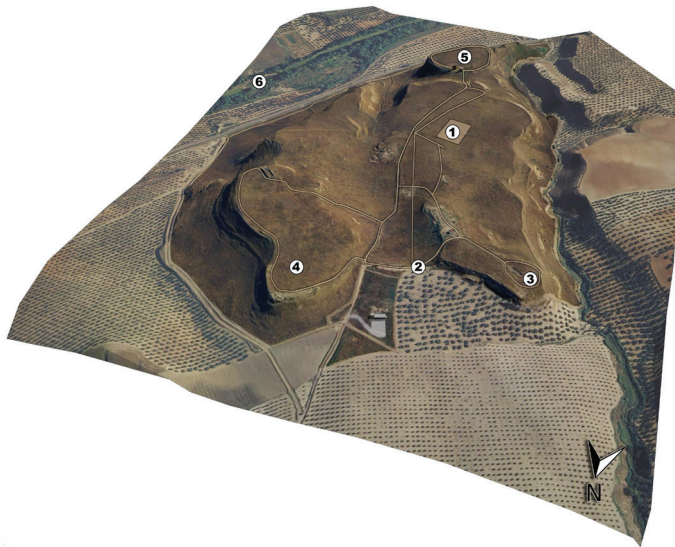


Figure 3: Cástulo oppidum, with the areas of Forvm MMX's major archaeological interventions marked with numbers.



Figure 4: Technology used in the field with Imilké recorder system: digital smartpen, paper form, and smartphone.

architecture. Additionally, an increase of activity in the two areas explored indicates that the city seems to have risen from the ashes once more during the fourth and fifth centuries (Blázquez 1975).

Cástulo's designation only recently as an "Andalusian Archaeological Ensemble" (*Conjunto Arqueológico de Andalucía*) means that the remains recovered so far are somewhat fewer relative to other sites with longer excavation histories; nevertheless our efforts clearly demonstrate the high heritage value of Cástulo and provide a better idea of the work that remains to be done (for further information about the Andalusian Archaeological Ensembles, see <http://www.museosdeandalucia.es/cultura/museos/>).

STRATIGRAPHY: REGISTRATION AND VIRTUAL DOCUMENTATION

Forvm MMX is an interdisciplinary team whose members come from a variety of backgrounds (e.g., conservation, topography, biology, computer science, public dissemination, education), and whose work will offer open-access results in a digital format to other researchers and educators interested in a holistic global analysis of the documentation generated by an archaeological excavation. Since 2011, Forvm MMX received a total of €1.1 million in funding from the Regional Ministry of Education, Culture, and Sport of Andalusia to hire these specialists and to develop digital techniques. Our project has developed since its initial seasons. Upon reflection on the inner workings of how archaeological information is recorded at all phases of research, we felt it was necessary to develop a unique recording system. This system, named "Imilké" (for the princess of Cástulo), has been designed so that information derived from archaeological excavation is simplified and rationalized (Castro López 2014: 16).

The Imilké system starts from a series of paper forms relating to different kinds of archaeological information, including stratigraphy, objects, and locations. Working in two computer applications, one for the real-time scanning of the paper forms to the centralized database in the laboratory, and a second application that allows further editing of the data from the intranet, the system was designed in collaboration with the private technology company Ayco as a bespoke archaeological register system for Cástulo. The computerization of the data collected on the paper forms is carried out as follows: data is recorded by hand

on the forms, which are completed with a smartpen. The pen scans the data from the paper form as it is written and interprets it by OCR (optical character recognition), before sending it to a smartphone. The phone forwards the data via cellular connection and stores it in the database. So, once the pen translates the text into digital form and the smart phone has translated the data, all of the information is instantly available from the database for the consultation, editing, and export for use in other applications (FIG. 4).

The first item of note is our project's emphasis on the documentation and preservation of data while information is being recorded in the field. This is essential because of the destructive nature of archaeological excavation and ephemeral quality of the information. As a result of these problems, the permanence and accuracy required for documentation is clear. This priority forms the basis for all of the assumptions, approaches, and interpretations that define a particular excavation, and the recording system should therefore be designed to be as rational and homogeneous as possible, and modified as often as is necessary (Kimball 2014: 24). Using Imilké, we obtain a highly accurate visual description of the components that form the archaeological context (volumes, surfaces, layers of materials, and object records). This detailed recording also enables further 3D virtual reconstruction.

Of course, our system also allows the digital capture and recording of textual and related graphical information in the field. For this task, several special forms have been designed for recording data such as the type of deposit, the materials recovered, and the excavation process. The first type of unit defined is the "volume." A volume is a three-dimensional unit defined by horizontal coordinates (x , y), with levels associated with the vertical (z). The form distinguishes between four different types of volumes: (1) surface level, (2) division by a complete construction of the space, (3) division of space by a wall, or, finally, (4) a conventional and arbitrary excavated area of space. The second type of unit defined on a form is the "stratum," a unit into which volumes are divided, and which itself can contain different subunits, referred to as "levels." For each of the registered levels it is possible to add an image and to record its universal transverse mercator (UTM) coordinates, which are taken using a total station. Later, through GIS, those UTM coordinates allow us to recompose the puzzle in Imilké's virtual model, using the parts we have measured to create a three-dimensional model of a volume.

Recording Visual Information

In our project, we use the following photogrammetric process for data capture and information processing. The data capture method is fast and simple; for every area excavated it is sufficient simply to take several photographs of the area. The photographer moves around the perimeter of the trench, taking photos in sequence. The same procedure is repeated each time the excavation level is changed (i.e., when a new stratum or volume is identified). The greater the number of pictures taken, the more information the 3D model will have, but we must also bear in mind that this will generate a larger file. Following the data capture, the pictures are then processed with Agisoft PhotoScan software (<http://www.agisoft.com>). During this process, the images are sent to the server where a 3D model is then generated. The process can take minutes or hours depending on the size of the photographs taken and sent to the server. This software also allows for previewing the generated 3D model.

The visual documentation that has been generated in the field (such as photographs taken in a determined area and turned into a 3D model) can also produce 2D visual documentation (such as accurate scale drawings of trench plans and stratigraphic profiles) from a 3D model of the volume selected. This represents a quantum leap in the quality of visual information preparation, as the usual method is the reverse (creation of 3D reconstructions from time-consuming excavation profile or plan drawings).

Using photogrammetry, we are thus able to create 3D models of every excavated stratigraphic unit. These are integrated into the database using GIS, which gives universal access to them in a virtual form and allows users to understand stratigraphic relationships and their interpretation directly on a geographical virtual model of the archaeological site. The UTM coordinates associated with every stratigraphic unit (inside every volume) facilitate the use of a site map in the Imliké's GIS database (Supplemental Material 1).

ARCHAEOLOGICAL ARTIFACTS: REGISTRATION AND VIRTUAL DOCUMENTATION

Archaeological artifact records are divided into either three-dimensional records or individual records. Using a form designed specifically for them, three-dimensional records are spatially linked to the volume that contains them; this kind of form also determines the type of content and treatment of materials and it is possible to add pictures of the process, details, and/or results at any time during the excavation process.

Individual records, by contrast, are reserved for objects that are thought to be particularly significant, such as complete vases found in situ. The form for individual records for artifacts contains the same information as the three-dimensional records, but with the difference that in these tables the object's exact position has been marked in order to be able to reproduce it later; hence, we assign $x/y/z$ coordinates.

The artifacts are processed in various stages as they make their way through the project: conservation, cataloging, drawing and photography, publication, and didactic use. We have multiple goals that are achieved through the use of 3D recreations. These models obviously enable greater study and public dissemination of cultural heritage, but they also help us improve our conservation activities. For example, they reveal the state in which the artifact appeared during excavation and initial treatment. A model can therefore be used as a point of comparison with the conserved object at a later date, during or after treatment, and if, by some chance, damage to or loss of the object occurs, the model can even serve as a record of it.

Our 3D models form part of the database's "catalog card" as an interactive PDF document and, like all of the system's data, the models will be available for study and research by future archaeologists (the models will be made available at <http://www.europeana.eu/portal/> and <http://3dicons-project.eu/eng/About>). Our analysis collects all possible data about the item, starting logically from an archaeometric and morphological definition, along with a topological analysis. Both analyses are essential for the development of a particular and general chronology, indicating the object's relationship with other nearby materials and its archaeological context. We thereby enable an exhaustive archaeological analysis of the object, including all the data needed for interpretation. Nonetheless, we are aware of some

complications related to certain kinds of data, such as texture, weight, and measurements that are to be specified in the interactive “catalog card.” We have therefore not yet made our prototype catalog cards public in the 3D PDF format and are instead waiting until we can develop them to an appropriate degree (Supplemental Material 2).

On 27 October 2011, the European Commission made a recommendation to all European Union member states in which some objectives and deployment advice for digitization and preservation of cultural heritage were included. The digitization of more than 30 million objects, including great European masterpieces that are no longer restricted by copyright, is promoted by this policy and by a project called CARARE (<http://www.carare.eu/>) (D’Andrea *et al.* 2013: 163). In related policy documents known as the “Principles of Seville” and the “London Charter,” cautionary recommendations regarding the creation and use of virtualized cultural heritage were put forward (see <http://www.londoncharter.org/introduction.html>). These documents noted that the possibilities offered by visualizations for public outreach activities might yield “spectacular” results, however, they can also become obstacles to the sense of research and scientific rigor required from a digital record of archaeological items. Following principles laid out by the London Chapter, therefore, we never edit the artifact mesh obtained by photogrammetry in order to produce “nicer” (but ultimately inaccurate) results.

Our working practice focuses on interdisciplinary approaches to the 3D models. The modeling team consults with the restoration and cataloging teams to reach their conclusions regarding the artifact before we start developing and editing the model in Blender or SketchUp open-source 3D modeling suites (<http://www.blender.org/manual>; <http://www.sketchup.com>). We decide whether it is possible to reconstruct the artifact (and if, e.g., it is an interesting architectural component, whether it could be worthwhile to restore it as part of a virtual building). We also consider whether the 3D artifact could form part of a study of how to deploy virtual light and shading, and whether we might be able to create a presentation in which a hypothesis for the function or use of artifacts could be tested (Escriba Esteban and Madrid García 2010: 14). Our public dissemination efforts are not intended to replace an exhibition of the real artifacts in our museum in the city of Linares, but they are rather intended to create a virtual experience that forms part of the museography designed for presentation in the

interpretative center at the archaeological site itself, or online as part of a website.

The ability to link literary and planimetric data, the infinite possibility of modifying hypotheses, and the proximity and force a virtual model can exert on the public are some advantages of virtual archaeology. But as a synthesis we share Rabinowitz's sentiment that "a good surrogate is not merely a copy: it is supposed to provide, in some sense, access to the original, now made ubiquitous and opened for inspection on a level of detail that the original itself might not allow" (Rabinowitz 2015: 29).

That the virtual model can serve as a surrogate for an artifact is particularly advantageous when it comes to matters of restoration. The digital visualization of archaeological artifacts can show the possible results of restoration of a piece prior to actual intervention on it and allow for different approaches for future treatment at a higher level of detail than traditional restoration methodologies that work directly with the physical object. Virtual models and reconstructions are indeed beneficial, as we note here, but they can never replace the ultimate goal: the preservation and exhibition of the artifact (Roof Sebastian 2005: 135). Our ideas about virtual restoration work are clearly articulated by Aparicio Resco (2015) when he states: " . . . las reconstrucciones virtuales nos permiten planear con mayor cuidado las reconstrucciones reales y nos dan la posibilidad, posteriormente, de imprimir en 3D los fragmentos perdidos para incorporarlos a nuestra pieza durante la restauración real, otorgando a este proceso una precisión mucho mayor que si fuera realizado con un modelado manual" ("virtual reconstructions allow us to plan actual restorations more carefully, and give us the possibility, later, to print the missing parts in three dimensions so that we can incorporate them during the actual reconstruction, giving the process a much greater precision than if it were done with manual modeling") (Supplemental Material 3).

With regard to the public dissemination of applications of "virtual archaeology," our process offers similar advantages of speed and accuracy as those found in our documentary archaeological study. Data and visualizations can be publicized using different social networks, meeting scientific expectations, and entertaining at the same time, and they can thereby awaken the interest of the public, who, in general, enjoy and value cultural heritage (Tejado Sebastián 2005:



Figure 5: The application of augmented reality to display an artifact: a 3D view of the paten from Cástulo created using a smartphone app, as demonstrated at the 20th Congress of the International Association for the History of Glass. 2015, Switzerland.



Figure 6: Oculus Rift experience displayed during the International Feria of Tourism, Madrid, 2015.



Figure 7: Detail of the “Mosaico de los Amores” from the second-century A.D. public building discovered in 2012.

147). For example, we use the Sketchfab platform for opening and displaying 3D models (see https://sketchfab.com/forvm_mmx), and we use YouTube to document the virtual reconstruction process (see <https://www.youtube.com/user/forvm2010>).

Finally, we are particularly interested in the possibilities represented by this format as a powerful motivational tool for art history and archaeology students since it allows us to customize our emphasis on the scientific content of the virtualized artifact, depending on the educational level of those students (Chysanthi and Caridakis 2014: 169-175) (Supplemental Material 4).

Augmented Reality and Virtual Reality Experiences

Overall, the virtual documentation of archaeological remains and artifacts obtained through photogrammetric techniques has facilitated the processing of information for scientific interpretation while allowing the creation of a basis for public dissemination of documented archaeological remains. Modeling 3D documentation of the archaeological remains with Blender or SketchUp software has allowed the development of different hypotheses about the areas of the site under investigation, thus facilitating interpretation and allowing the general public to interact with them through virtual reality experiences and augmented reality (FIGS. 5, 6). Virtual reconstructions of archaeological remains have been exported to the FBX format for use in Unity 3D, where reconstructed virtual environments can be developed for augmented-reality applications, such as using the Vuforia plugin to display different scenarios on the archaeological remains themselves through mobile devices like tablets or smartphones.

We offer an immersive approach to the history of the city of Cástulo using Oculus Rift, a virtual-reality headset. For example, users can take a tour of the major public building where the second-century “Mosaico de los Amores” was discovered in 2012 (FIG. 7). Through this format, visitors are brought in direct contact with the mosaic’s extraordinary technical work and iconographic complexity (the “Mosaico de los Amores” is now available for further studies with millimeter-resolution through the GigaPan web platform at <http://gigapan.com/gigapans/129300>). The other major artwork recovered by the project, a glass paten showing Christ in Majesty, can be observed

in Oculus Rift, allowing an approach to its findspot with a virtual flight through the 3D model of its “volume,” as well as a virtual recreation of the paten, one of the earliest and best-preserved examples of Christian art yet known from the Iberian peninsula.

POTTERY STUDIES: PRE-INVENTORY

The Imilké system is also useful for collections management. It generates a unique QR code for every single artifact in the database, including all pottery (an example of a QR code to document a pottery sherd and the virtual recreation of the whole form of the pottery sherd is accessible at <https://sketchfab.com/models/8bb762e5c0054f3ba0af4b6eb1090b20>; see also Martínez Carrillo *et al.* 2010: 117). The code is attached to the fragment (and a context QR code is placed in and on each set of pottery or other artifacts, in case the object code becomes detached from individual sherds), allowing for instant identification of any object and its relationship to the site. The typology of each ceramic fragment is documented and we calculate the total weight of the pottery set (classified by type), giving us a comprehensive picture of it.

CONCLUSIONS

Our system has a variety of benefits. In addition to its technical capabilities for research, it is also inexpensive in economic terms. Once the system is implemented, the only requirements are a cellular-data connection and the maintenance of computer equipment, so it can be extended to the vast majority of archaeological operations. In short, the development and consolidation of this system aims at creating a tool for use in the future work in the archaeological zone of Cástulo, with the longer-term goal of achieving consistency of documentation recording in excavations more generally.

High technical skill is clearly a highlight of the Forvm MMX project, but we also have a desire to continue to experiment and focus on public outreach. Therefore, our approach in the work of public dissemination is to create a new (virtual) experience that allow a closer approach to the ancient city of Cástulo through the archaeological objects found in it. We hope to create a more active, participatory encounter with the

past through the use of online platforms such as Sketchfab, YouTube, and others. The virtual recreation of housing spaces and 3D models of artifacts and transects have almost become sensory elements for visitors through the experience of site reconstructions using an Oculus Rift viewer. As with the rest of the methodology outlined in this chapter, the objectives of public dissemination have been improved by new technologies, which, at the same time, “improve” our ability to create a final documentation of the archaeological process. It is our goal that the results obtained have a sufficient level of standardization to permit the use of the same archaeological recording system by other future teams.



<https://mobilizingthepast.mukurtu.net/collection/31-cástulo-21st-century-test-site-new-digital-information-system>

http://dc.uwm.edu/arhist_mobilizingthepast/14

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