

THE DIGITAL CULTURAL HERITAGE- DIGITCH PROGRAMME: EXPERIENCES OF DOCUMENTATION AND SURVEY FOR THE SMART FRUITION OF ARCHAEOLOGICAL HERITAGE

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Abstract

The paper describes the Digital Cultural Heritage-DigitCH programme, aimed at the “smart” documentation of archaeological finds or areas using computer-based visualization for exhibition in museums; in 2013, the programme pioneered the use of fast methods and low cost 3D survey for documenting and displaying archaeological heritage: finds to be presented with reconstruction visualizations of objects which, due to their dimensions and conservation issues, cannot be seen in the best way, but require an innovative visual approach and a detailed description of their context, workmanship, morphological characteristics and materials.

Keywords

Digital heritage, Archaeological survey, Interaction design, 3D printing, Smart museum

1. General scientific background

The actual digital technologies for the survey, representation and advanced visualization of cultural heritage have not only contributed to further technical innovation, but have also had a strong impact on many fields of professional design activities and common users’ experiences (Brusaporci, 2015).

In recent years, ICT has made the process of heritage documentation faster and more syncretic, and has simplified data acquisition and post-processing procedures (surveying → collecting → communicating data).

The transition from the operating sequence of different types of operational methods toward procedures with a high automatic integration level has led to the general progressive convergence of information into output for electronic devices: this means that highly consistent information resources are, in fact, extremely easy to use and accessible on a large-scale.

Recent innovations and digital technologies for the survey, advanced visualization and communication of cultural goods and interventions are now, therefore, a terrain fostering a veritable contamination of operational

competencies investing the variety of material Cultural Heritage¹: from environmental contexts to architecture to virtual archaeology, they turn the field of Surveying and Representation into a true terrain for the convergence of specialized activities ranging from documentation through ‘no contact’ survey methods, (such as surveys effected with LS or drones), to systems of digital photogrammetry (SFM) for creating realistic models from photographs, to the prototyping of 3D printing models, to electronic applications for fruition in museums.

Within contemporary museums, complex ideas, languages and debates take shape, but knowledge, in some way, is also produced outside

1 The cataloging of the various “service contexts” of digital heritage identified during the preparatory work of the DigitalHeritage 2015 Expo lists five themes that follow UNESCO’s classification of heritage: a) Built Heritage from monuments to archaeological sites, cities, and landscapes, b) Culture & Traditions from folklife to languages, crafts, song and dance, c) Museums & Collections from movable objects to museums, d) Libraries & Archives documentary heritage from books to audiovisual and e) Art & Creativity from digital / new media art to creative digital and online culture. See Pescarin, S. (2016). Digitalheritage into practice. *Scires-it* 6(1), 1-2. Retrieved from <http://caspur-ciberpublishing.it/index.php/scires-it/issue/view/772>

the museum itself, in the necessary network of relationships, allusions and metaphors permitting the contextualization, for the broader public, of museum materials in an innovative way, now accessible only thanks to an accurate action focused on the contamination of knowledge and cross-field approach aiming to connect humanistic contents and cultural language with technical fruition.

These topics are closely related to the emergence of new information models for knowledge and dissemination of cultural heritage that in a certain sense represent a challenge for the relationship between heritage, museums and ICT development.

In particular, museum design has faced a new approach in museum communication producing a true "democratization" of culture for the best promotion of cultural heritage: using a substantial wealth of scientifically well-founded metadata it is possible to adopt systems of "interactive heritage", currently one of the main prerequisites for a truly expanded knowledge of the contents as well as the complexity of the elements according to functionally evolved models of representation and visualization of data².

The approach of a new generation of museum design (whether buildings or areas and sites) cannot ignore the role of a cultural institution as a powerful tool of mass communication and effective indicator of issues and trends in society, where in recent decades, a debate on models capable of producing and stimulating new effective languages and messages has strongly emerged.

In this overall theoretical framework, we also find the new trend of social museology³, which considers the needs of visitors from different points of view: from policies regarding disabled visitors or in favor of specific minorities, as well as the structured support for educational programmes and activities for lifelong learning; everything, in synthesis, that can shift the focus from the objects to the users, who cannot develop

any ability to "produce meanings"⁴, without active stimulus by a museum that involves their cultural backgrounds.

2. *The programme of Digital Cultural Heritage-DigitCH*

Digital Cultural Heritage-DigitCH combines, therefore, the many advanced competencies that need a unified framework of knowledge and use of ICT in regards to the very different needs of archaeologists, curators, restorers, museum managers, and more in general, all professionals working in the field of interventions and communication of cultural heritage.

The main scientific background of DigitCH interests the field of Survey (for the part dealing with data acquisition) and the complex topic of Representation (for the representation of data through different linguistic channels that include multimedia design contents, visualization of 3D digital models, 3D printing, AR and VR) with many specialist branches (dealing with archaeological interpretations and contents production, or electronic engineering design, etc.).

In this case, Representation has been seen as a real Information Architecture, which invests informational spaces of various types: procedural (for the entire process design), physical (in the design of the structures devoted to setting up installations in museums or in archaeological areas) and digital (for the interface's design and visual contents).

Focusing on research conducted in mixed groups by archaeologists, architects and computer scientists we find different points of view and competencies achieving different goals, which often do not produce a true common result; in this sense, the general aim of the DigitCH programme is to stimulate an interdisciplinary study approach and to realize a "multi-cluster" work area where a common and cooperative platform of competencies practice co-working.

Despite the fact that the interpretation and communication of data has to be calibrated and changed in function of its use in the different disciplines (restoration, museum design, virtual archaeology, etc.) today the ease of operation and

² See the phases individuated in the preparatory work for the *DigitalHeritage 2015 Expo*: 1) Digitization and Acquisition, 2) Computer Graphics and Interaction, 3) Analysis and Interpretation, 4) Theory, Methodologies, Preservation and Standards, 5) Digital Heritage Projects and Applications); See Pescarin, S. (2016). Digitalheritage into practice. *Scires-it* 6(1), 1-2. Retrieved from <http://caspub-ciberpublishing.it/index.php/scires-it/issue/view/772>

³ See the definition of "museologia" in www.treccani.it

⁴ The reference here is to the discipline of Museum studies coordinated by Susan Pearce at the University of Leicester since the Eighties.

a co-working approach make it possible to organize multidisciplinary work teams, in a more integrated and efficient way than in the past.

This is particularly necessary in archaeology where the reconstruction of the original object, if accurate and fully demonstrative of its physical and geometrical state, reveals most of its documentary value, the value, that is, not of objects to be admired because they are ancient or for their purely aesthetic value, but of artifacts which allow a historical reconstruction as well as a contact with the distant past that have somehow both determined our culture (Mencarelli & Gullini, 2000); this value is directly linked to the issue of the enhancement of archaeological heritage assets, that is, of making them available to the public in line with the idea that a “monument” is not only an object to know, but also an active part of society, transforming itself into a generator of cultural, economic and social values.”

The main feature of archaeological artifacts, which we have often received with a significantly different appearance from their original one and without anything that could help to complete our architectural, spatial and functional perception of them, demands that the public presentation of archaeological heritage must include, firstly, all forms of support which can permit the public to place the objects in their context and to understand the reciprocal roles as comprehensively as possible.

Already in 2008 the “Icomos Charter for the interpretation and presentation of cultural heritage sites” poses to the scientific community the problems of definition of contents, methodologies and best output for the correct proposal of the contents produced in the scientific activity using facilities and supports to the understanding for the wider public⁵.

5 “...In recognizing that interpretation and presentation are part of the overall process of cultural heritage conservation and management, this Charter seeks to establish seven cardinal principles, upon which Interpretation and Presentation—in whatever form or medium is deemed appropriate in specific circumstances—should be based. Principle 1: Access and Understanding; Principle 2: Information Sources; Principle 3: Attention to Setting and Context; Principle 4: Preservation of Authenticity; Principle 5: Planning for Sustainability; Principle 6: Concern for Inclusiveness; Principle 7: Importance of Research, Training, and Evaluation”. See The Icomos Charter for the interpretation and presentation of cultural heritage sites, ICOMOS 16th General Assembly Québec 2008.

The DigitCH activities have therefore been working keeping in mind the aim of increasing the understanding and perceptibility of the archaeological heritage by the public, not as imaginative reconstruction but as a logical process of interpretation and development logically provable, pushing on the collaboration between architects, ICT and archaeological research.

3. *DigitCH guidelines, methods and tools*

Since 2013 our research group has operated by setting up a series of research and training activities following the guidelines provided by the seven principles established in 2011 by the *Principles of Seville, International principles of Virtual Archaeology*, aiming at establishing principles to govern practices in this field.

The research activity was developed targeting four main goals:

- 1) to experiment many different scales (from urban contexts, to architecture, to archaeological areas and finds);
- 2) to work following rigorous scientific standards in measurements, surveys and documentation for visual reconstructions and contents based upon the detailed and systematic analysis of environmental, archaeological, architectural, and historical data;
- 3) to spread contents strictly validated in terms of history and far from the “special effects” results;
- 4) to use only entry level technical platform choosing low cost hardware/software and fast procedures.

The compliance with criteria 2) and 4) is expressed through two types of validation, one concerning the process and another the result, again divided into “metric results” and “visual results”:

- validity of the process: the calibration of various technical sets of shooting and post processing with the gradual implementation of different processes, has allowed us to develop the methodology with “positivity” in results in 80% of the cases; in particular, we report here the concentration of failure for the objects which have very concave surfaces;
- validity of the results: is articulated in double meaning; metric reliability qualities: to verify

the dimensions and morphology of the pieces, on the 3D models in wireframe "not real" output we made preliminary geometric, and subsequently, direct metric controls (two ornaments were tested); reliability of visual quality: for the best appreciation of the artifacts in all of their material characteristics, color, production and formal value, models complete with photorealistic texturing were finally displayed.

4. Three projects of DigitCH

The three case studies have resulted from very different occasions, with workflow only partly comparable (see Fig. 1), and have produced set results in two cases (the "Falisci in 3D" Project and "A museum in every sense" Project), while the "Baratti in 3D" Project is a work in progress, which, however, we want to share although it is still in a provisional stage.

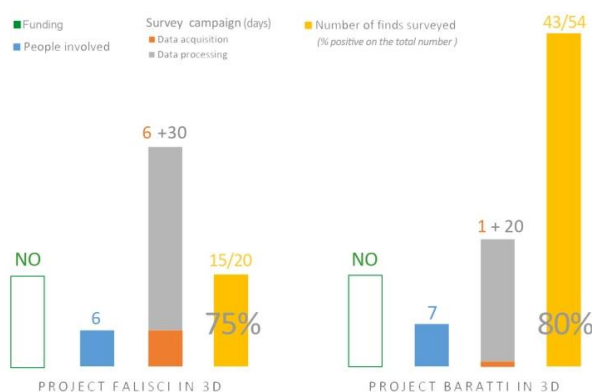


Fig. 1: DigitCH programme: the comparison of performances

In the start-up phase (2013-2014) the DigitCH programme focused on the development and refinement of procedures that the research programme is given as essential methodologies and strictly follows Principle 6: Efficiency, of the *Principles of Seville*⁶. This step includes the "Falisci in 3D" Project, made operative as directed by Principle 4 of the London Charter for

6 *Principles of Seville, 2011, International principles of Virtual Archaeology*; see Principle 6: Efficiency "The concept of efficiency applied to the field of virtual archaeology depends inexorably on achieving appropriate economic and technological sustainability. Using fewer resources to achieve steadily more and better results is the key to efficiency."

computer-based visualization of cultural heritage⁷.

The second phase of the programme (2015-2017) dealt with the step relating to operations that the Seville Charter placed between Virtual recreation⁸ and Anastilosys⁹; the "Baratti in 3D" Project is indeed organized into three steps:

- 1) acquisition of morphometric data of the Etruscan tombs in the Necropolis of St. Cerbone;
- 2) acquisition of morphometric data of mobile archaeological finds (which are exhibited in two museums) from these tombs;
- 3) the recreation by virtual models of the original location of the movable finds in the context of origin.

Different is the case of the "A museum in every sense" Project, which is framed within the general aims of Principle 6 of the *London Charter for computer-based visualization of cultural heritage, 2009* (concerning the access to CH policy¹⁰) and the objectives of the Principles of Seville, 2011, *International principles of Virtual Archaeology* "Open new doors for the application of digital methods and techniques in archaeological research, conservation and dissemination."

7 This step was operated following the *London Charter for computer-based visualization of cultural heritage, 2009*; see Principle 4: Documentation "4.1 Documentation strategies should be designed and resourced in such a way that they actively enhance the visualization activity by encouraging, and helping to structure, thoughtful practice. 4.2 Documentation strategies should be designed to enable rigorous, comparative analysis and evaluation of computer-based visualizations, and to facilitate the recognition and addressing of issues that visualization activities reveal."

8 *Principles of Seville, 2011, International principles of Virtual Archaeology*; see Definitions: "Virtual recreation: this involves using a virtual model to visually recover an archaeological site at a given moment in the past, including material culture (movable and immovable heritage), environment, landscape, customs, and general cultural significance."

9 *Principles of Seville, 2011, International principles of Virtual Archaeology*; in particular in Principle 4: Authenticity, we read "remains that have been returned to their original position (real anastilosys); areas that have been partially or completely rebuilt on the original remains".

10 *London Charter for computer-based visualization of cultural heritage, 2009*; see Principle 6/6.1 "The aims, methods and dissemination plans of computer-based visualization should reflect consideration of how such work can enhance access to cultural heritage that is otherwise inaccessible due to health and safety, disability, economic, political, or environmental reasons, or because the object of the visualization is lost, endangered, dispersed, or has been destroyed, restored or reconstructed."

4.1 The “Falisci in 3D” Project

The complex “Falisci in 3D” Project was conceived following a multidimensional scientific, methodological and technical strategy including the critical issues related to the aspects of Historical rigour¹¹, of the added value of the Interdisciplinarity of the technical problems linked to the experimentation of the TTT in the dissemination of archaeological heritage (see Fig. 2).

The Faliscan ethnic group, although the lesser of the three major pre-Roman ethnic groups of central Italy (Etruscans, Latins, Sabines), has been since the end of the nineteenth century the subject of great attention surely due to its strenuous and suicidal resistance to Romanization. Large excavations of the Faliscan and Capenate territories, in the 80s of last century, brought to light a culture with original results, which transformed stimuli from their neighbors into a "multi-ethnic" product with an exuberant stylistic imprint.

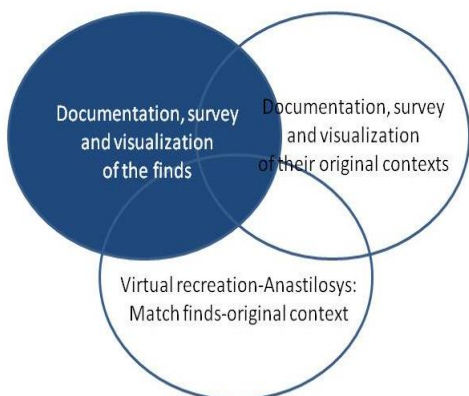


Fig. 2: The goals of the Falisci in 3D project

In 2014 the exhibition “Falisci. The people of the Hills. Faliscan and Capenate finds in the National Archaeological Museum of Florence” was devoted to showing a wide selection of more than 800 finds of the Museo Archeologico Nazionale di Firenze, which represent the many

¹¹ *Principles of Seville, 2011, International principles of Virtual Archaeology*, see Principle 5: Historical rigor 5.4 ... New techniques such as photogrammetry or laser scanners can be used to increase the quality of the scientific documentation. In the way that better metric documentation of archaeological heritage is carried out higher will be the chance to monitor and obtain historically and valuable replicas.

funerary Faliscan and Capenate grave goods acquired by Luigi Adriano Milani for the Florentine museum at the turn of the nineteenth century.



Fig. 3: Funerary grave goods from Tomb B-23 in the necropolis of Pizzo Piede; sketches by Luigi Adriano Milani

The exhibition has been the first occasion to show the Faliscan finds after their restoration from the damage due of the river flood occurred in Florence in 1966 and has enabled to complete in their entirety numerous contexts dating from the late Bronze Age to the Romanization of the area.

The case study focuses on objects from a the grave of a woman, objects of the highest quality from Tomb B-23 in the necropolis of Pizzo Piede (Narce, Viterbo) (see Fig. 3). The grave goods can be dated between the end of the Iron and the first Orientalizing age and comes from a burial consisting of a sarcophagus in a deep pit with a niche adjacent to contain the rich objects of two kinds: the personal objects of the defunct: including princely rank items like an elaborate belt with bronze plating; home tools placed with the body including a censer in bronze plate and a

tripod complete of a large bowl and three smaller bowls (Camilli & Cianferoni, 2014) (see Fig. 4).



Fig. 4: Tripod complete of a large bowl and three smaller bowls, censer in bronze plate and belt with bronze plating from the grave goods

The work had a duration of 6 months, divided into four phases: the preliminary screening and planning together with the museum’s staff, the acquisition of data and survey campaigns, the representations of data, the design of exhibition (contents, layout and production of video and boards) with a strong effort towards increasing the involvement of the visitors in terms of greater accessibility (at least visually) and understanding of finds.

In the early stage we used software with a negative result (123D Catch and PhotoScan), certainly connected to the (nowadays) well-known current constraints derived from the limits of the process (Remondino & Campana, 2014). In the following attempt we tested Strata Design 3D/2013 and the outcome of the experiment was entirely satisfactory (see Fig. 5).

The results achieved must be framed within the limits of the project, primarily related to the reduced time-frame for access (the finds can be kept for a short time outside the alarm-equipped glass boxes) and the low budget available; holding firmly the reference to this framework, the results can be considered as positive and described according to the validations detailed above in the DigitCH’s guidelines (see Fig. 6).

Of the total of 32 objects found in the tomb’s sarcophagus, in our research the surveys of 20 pieces were carried out, with mixed results.

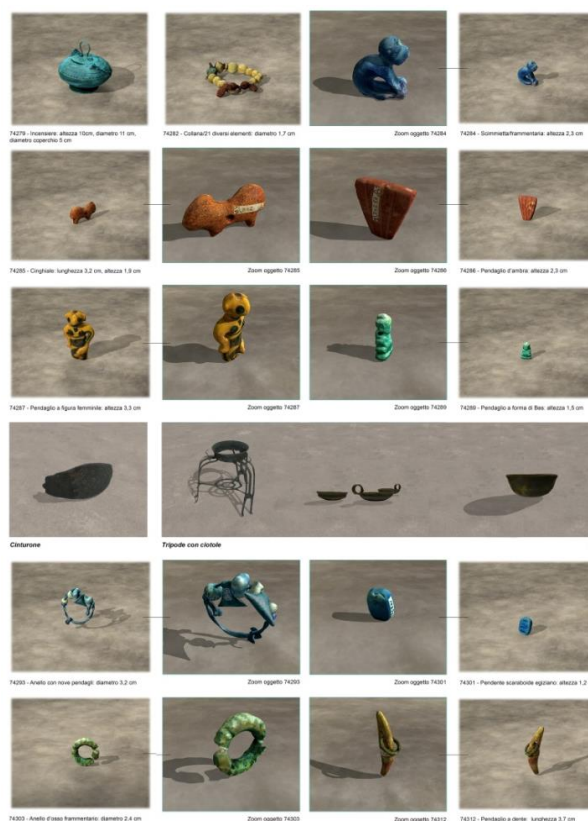


Fig. 5: Board of the 3D models

The results which we consider reliable, both in terms of the compliance of metric characteristics and of the realistically visual features of the materials, were produced following the parameters described in Fig. 6 and can be declared for about 15 finds, which have been shown in the section of the exhibition by projection of 3D reconstructions in a scale from 20:1 to 50:1.

The video projected in the dedicated section of the exhibition is available at the link <https://youtu.be/KhEEIRaY UY>.

4.2 The “Baratti in 3D” Project

For centuries, Populonia was a major iron centre supported by its proximity to the sea – it was the only Etruscan city with this peculiarity – and its position at the junction of important commercial routes of the Mediterranean: such factors contributed to the wealth and prosperity of this Etruscan and Roman city. The vast resources that made Populonia a very rich city thanks to metalworking emanating from its territory and from the island of Elba, allowed the most powerful families around the seventh

PHASES	ACTIVITIES	TIMING	TOOLS
phase 1	preliminary evaluation of technical options and definition of data acquisition	2013 September	briefings museum visits evaluation of technical test
phase 2	data capture: acquisition of morphological and texture data, made through HDR photo shoots circling around the object <i>(each picture overlapped in at least 40 %; the shoots have been made in diffused artificial light conditions)</i>	2013 Nov-dec (11/11-12/19/2013)	Mat ø cm: 7,8; 13,9; 19,4; 38,3 <i>Photocameras:</i> Sony Alpha 330 Fujifilm S100 Fs Nikon V1
phase 3	post processing of the data via photo modeling and realization of the textured 3D models optimized for visualization	2014 February-april	123D Catch PhotoScan Strata Design 3D/2013 Rhinoceros Cinema 4D
phase 4	multimedia contents: -production of digital clip (creation of animation .avi in fixed chamber) -2D boards (information boards about the project and the scientific detailed contents)	2014 June	After effects Photoshop CS

Fig. 6: Workflow and datasheet of the “Falisci in 3D” Project

century BC to build the monumental necropolis that today we can see in front of the gulf of Baratti: rich burials of precious objects coming from faraway and so impressive as to be known as the "tombs of the princes."

In the period 2007-2013 our research group conducted the *Project Necropoli/Surveys* split into seven annual campaigns of surveys for the first documentation (by measurements) of the necropolis of San Cerbone's tombs, the main focus of the visitors to the Archaeological Park of Baratti and Populonia¹² (Tuscany, Italy).

12 At present, it is an important institution in the context of European archaeological sites: with its 80 hectares that include the promontory of Populonia and the gulf of Baratti, it offers many scientific activities as well as information and tourist facilities. The Parco Archeologico di Baratti e Populonia also represents an important and constant research center for numerous scientific activities still in progress, under the constant coordination of the Superintendence for Archaeological Heritage of Tuscany; see Casini A., Zucconi M., *Un'impresa per sei parchi. Come gestire in modo imprenditoriale il patrimonio culturale ed ambientale pubblico*, Il sole 24ore, Milano 2003.

The necropolis consists of a large number of structures, still being excavated, ranging from the seventh century B.C. to the third century B.C., and are mainly concentrated on three main types (burial mounds, *oikoi*, sarcophagi), which have all measured, processed and represented in traditional 2D drawings and in 3D models (Puma, 2014).

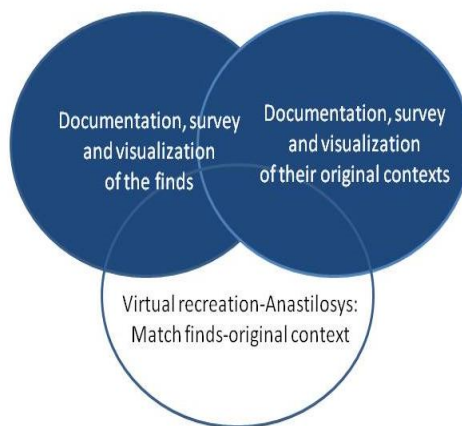


Fig. 7: The goals of the Baratti in 3D project



Fig. 8: Boards of the 3D models and rendering process

The “Baratti in 3D” Project is a spin-off of the Project Necropoli/Survey, aiming at the virtual recreation of the finds (exhibited in the Museo Archeologico Nazionale di Firenze and in the Museo del territorio di Populonia in Piombino) in their original context, to visually include material culture (movable and immovable heritage), environment, landscape, and the general cultural significance of this heritage (see Fig. 7).

In 2015 the first survey campaign of the grave goods from two graves (Tomba del Bronzetto di Offerente and Fossa della Biga) took place at the Museum of the Territory of Populonia in Piombino.

The work is in progress and is strongly aimed towards two objectives to be realized in succession: firstly the possibility for the visitor to see the small finds in better conditions than observing it in the museum showcases (via their visualization in scales greater than the actual) and, at a later time, to see again (at least in digital recreation) the finds in the tombs where they were deposited at a given moment in the past and found at the time of excavation.

The documentation work carried out for the first finds had a duration of 5 months, divided into four phases: the preliminary screening and planning together with the museum’s staff, the acquisition of data and survey campaigns, the representations of data, the design of the presentation (setting of contents, layout and production of videos). In this case study as in the previous case study, we were authorized to keep the finds outside the alarm-equipped glass boxes only for a short time; which meant we had to use various shooting sets simultaneously.

By calibrating three different settings of data acquisition by Strata Design 3D/2013 (with photo-frames in different angle/circle overlapping

and different positions of the object on the target board) and through processing, we reached the quality objectives defined by metrically reliable 3D reconstructions in double graphics output: geometric “not real” output for the appreciation of the dimensions and morphology of the pieces and texturized output for the visual

PHASES	ACTIVITIES	TIMING	TOOLS
phase 1	preliminary evaluation of technical options and definition of data acquisition	2015 September	briefings museum visits evaluation of technical test
phase 2	data capture: acquisition of morphological and texture data, made through HDR photo shoots circling around the object <i>(each picture overlapped in at least 30 %; the shoots have been made in diffused artificial light conditions)</i>	2015 November (02-05/11/2015)	Mat Ø cm: 20; 30; 40 <i>Photocameras:</i> Nikon D700 (ob. Nikkor 16-35 f.35 mm) Nikon D700 (ob. Nikkor 40) Canon Eos-1200D
phase 3	post processing of the data via photo modeling and realization of the textured 3D models optimized for visualization	2014-2015 December-February	Strata Design 3D/CX Rhinoceros Cinema 4D+ VRay
phase 4	multimedia contents: -production of digital clip (creation of animation .avi in fixed chamber)	2015 March	After effects Photoshop CS Adobe Premiere

Fig. 9: Workflow and datasheet of the “Baratti in 3D” Project

appreciation of their workmanship value and characteristics of the material (see Fig. 8).

The survey results were rated as excellent by the archaeologists, with respect to the project’s time and budget limits, in up to 80% of the total of the 54 pieces documented (see Fig 9).

The provisional results are shown in a short video which documents the procedure (data acquisition and processing) operated by the three staff and the first visualizations.

The video needs to be completed inserting the right information regarding the metric dimensions of the objects, the list of acknowledgments and so on: the actual version of the video is available at the link <https://youtu.be/lC-tEEYhGko>.

4.3 The “A museum in every sense” Project

The communication gap that plagues many Italian museums, is well known and is present in various forms of limitation resulting from lack of efficient information devices, from the established rule of "Do not touch" the objects and from the problems occurring when the context of a visit is not easy, as for some archaeological

areas of difficult enlarged accessibility; all this elements severely limit the experience of the museum visit.

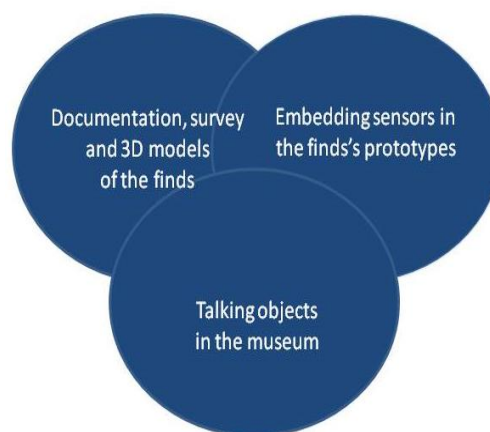


Fig. 10: The goals of the “A museum in every sense” project

As part of the enhancement of a heritage museum, in fact, we often see a lack of communication of the wealth of information that characterizes the visible objects in the glass showcases, or visiting an archaeological site: the

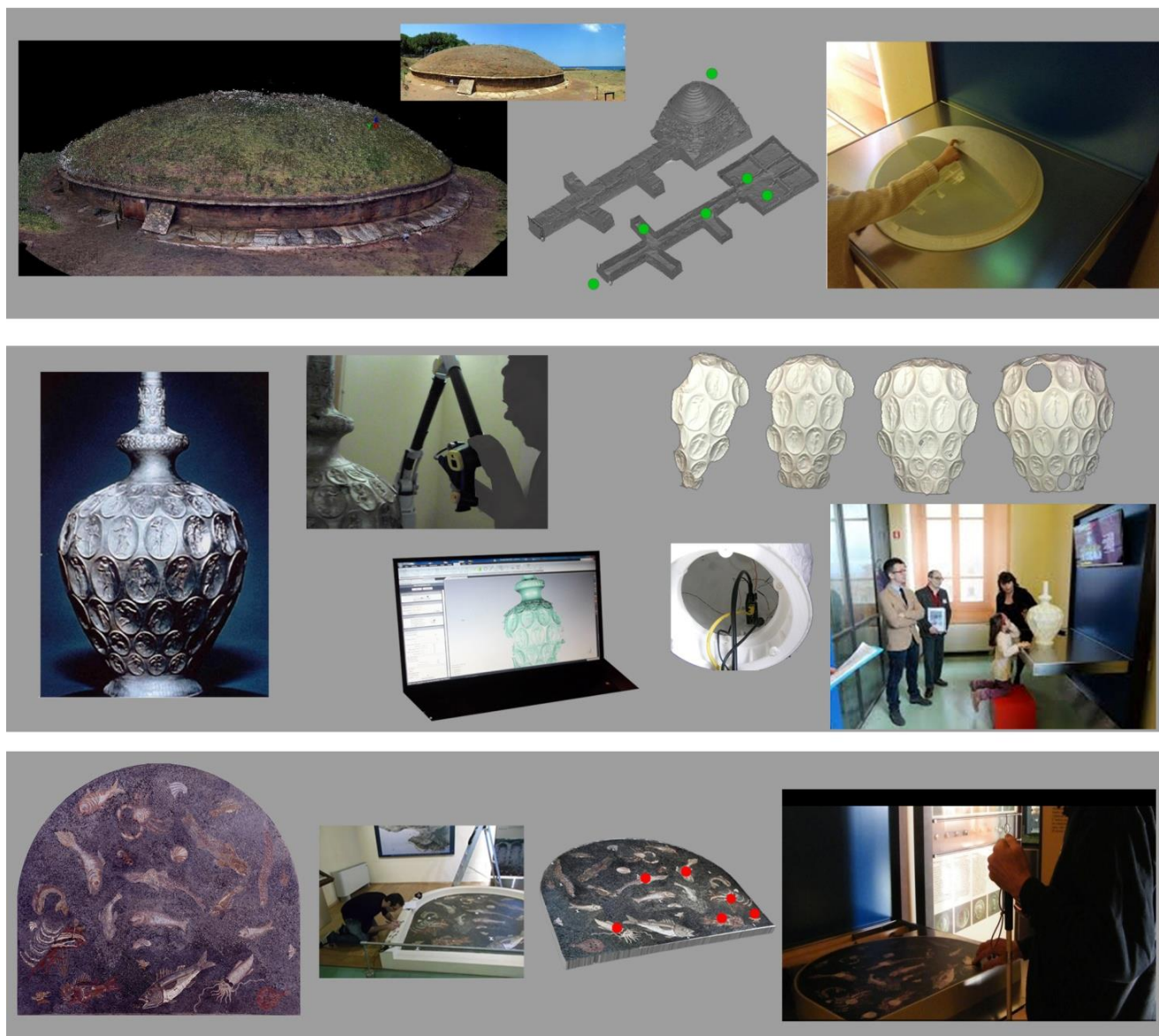


Fig. 11: Visual workflow of the “A museum in every sense” Project

information regarding the discovery of the excavation, information descriptive of the object itself (material, measures, production method) and the possible visual reconstruction of the original site.

There are many cases, in fact, in which a true and profound appreciation of the quality of the object exposed would require a physical contact and/or different appreciation from the cognitive point of view: as when the major peculiarities of the object are catalyzed on its surface (and would require to be appreciated by touch), or when looking at an archaeological site from afar without being able to run all the physical paths, or when the impossibility to imagine the original structure limits comprehension. The research project “A museum in the every sense” was born

with the aim to test an innovative strategy of cultural communication using technologically advanced ways of fruition of archaeological finds mixing storytelling and coding: by letting the objects in the museum “talk” to the visitor and creating an interactive environment it is possible to establish a true dialogue with the visitor-user, generating stimulus and the foundation of an effective cultural process (see Fig. 10).

The project focused on three well known artifacts belonging to the Archaeological Museum of Populonia in Piombino (Tuscany, Italy); two of them are archaeological artifacts located in the Necropolis of San Cerbone in the Archaeological Park of Populonia and Baratti (the Etruscan Tomb of the Chariots and the Roman marine mosaic) and the third is the most important find of the

PHASES	ACTIVITIES	TIMING	SKILLS/GROUP
phase 1	preliminary evaluation of technical options and definition of data acquisition	2014 June - July	DigitCH Museum staff
phase 2	data capture: acquisition of morphological and metric data	2014 September- Dec	DigitCH Microgeo srl
phase 3	post processing of the data via 3D modeling and realization of the models optimized for 3D printing	2015 March-May	DigitCH
phase 4	3D printing of the 3 prototypes	2015 October-Dec	Syde srl
phase 5	Sensors embedding the 3 prototypes	February 2016	Brainbox srl
phase 6	production of the 3 digital clip	2015 March-May	DigitCH Museum staff
phase 7	Museum exhibition set up	March-April 2016	DigitCH Museum staff Brainbox srl

Fig. 12: Workflow and datasheet of the “A museum in every sense” Project

Museo del territorio di Populonia in Piombino: the Amphora of Baratti.

The Tomb of the Chariots is the largest tomb in the monumental necropolis of the Etruscan town of Populonia and the best known and most significant example of the “tombs of the princes” that make the monumental Necropolis of Baratti so important in the landscape of Etruscan funerary archaeology (Zifferero 2000). Its diameter is about 28 ml, and it is set at a higher position than the other graves.

The marine mosaic was made entirely of marble, between 150 and 100 BC, and takes its name from the seabed that is represented, populated by 25 marine animals. The tiles give it its mat surface and its dark aspect: the background is, in fact, in a very dark gray color that maximizes the contrast with the dark red, white, yellow ocher, dark green, black and light gray used for fish and shellfish.

The Amphora of Baratti is a valuable vase dated around 400 d. C., and it is supposed to be wrecked on a ship coming from Antioch or Rome. The feature that makes it an item so rare is being completely covered by a number of 132 ovals, finished by chisel, arranged in 10 lines; moreover the amphora is made of 96% pure silver and has a weight of 7.3 kg and a height of 61 cm, with a maximum diameter of 34.7 cm and was able to

contain more than 22 liters of liquid, certainly the best quality wine destined to noble pagan cult libations -still practiced at the time in Constantinople, inferred by the exceptional aesthetic level of such a precious object (see Fig. 11).

The DigitCH team carried out the project in 24 months (June 2014-April 2016) in two different roles: as responsible of the scientific project (leader of other groups with specialized competencies which worked in "collaborative design"), and as an autonomous group. In this second role, the DigitCH group contributed to the project with activities, including some of an experimental nature, related to the entire workflow of documentation and advanced representation data.

The three archaeological artifacts were documented in three surveys campaigns (the data acquisition process was calibrated in three different procedures: LS for the Tomb of the Chariots, fast photogrammetry for the marine mosaic, LS in Hyper quality for the Amphora of Baratti) and the three objects were then reproduced in 3D printed prototypes.

The final step of the preparation stage was to embed the prototypes with touch sensors which thus become "talking" objects": through the engineering of models, in fact, an interactive

museum context is created, where the visitor interrogates the object that explains itself in visual and sounding way (see Fig. 12).

The video is available at the link <https://youtu.be/DWAMgamntHM> and documents the procedure (data acquisition, data processing, sensoring, museum set-up) of the project.

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