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Sharing of archaeological documentation

Which infrastructure support for visual data creation and visualization?

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Abstract: Visual data are nowadays a basic component of the massive data gathered in archaeology. With the term *visual data* we mean any *visual representation* that could be associated to an artwork, architecture or site, to describe its shape in terms of visual and geometric elements. Therefore, the term *visual data* stands for different representations: 2D images (standard images, panoramic images, Reflection Transformation Images - RTI), 2D graphical representations such as maps or drawings (usually represented by standard digital image files), 3D models (either sampled or reconstructed with modelling systems) or finally videos (grabbed from reality or produced with computer animations).
In the framework of the ARIADNE project, we are focusing on the services that an infrastructure for archaeological documentation should provide for managing these media. Our first goal has been to present to users the capabilities of current technology (both commercial tools and resources produced in recent EU projects) and to understand how to map the real needs of the user community to potential services for production, sharing and visualization of visual media.
Training is an important component of an infrastructure project, due to the many media available and the complexity of both mastering data creation/presentation and of understanding which media fits better the specific documentation or visual analysis needs. Our purpose will be to help our community in building a clear view of the affordances of particular genres of representations, clarifying their documentation potential and the possible limitations w.r.t. storing, discovery, accessing, connecting with other data, and rendering.
Designing an infrastructure requires also focusing on *configuration* and/or *development* (e.g. customization to user needs of open source solutions and of academic prototypes developed by EU projects). Obviously, visual data cannot be treated independently from the other data. Integration should be designed to allow advanced visual data creation and visualization to inter-operate with standard databases and repositories.

Keywords: archaeological datasets, visual media, digitization, images, 3D models.

Introduction

The ARIADNE project is an effort financed by the European Commission (2013-2017). The goal of this infrastructure project is to bring together and integrate existing archaeological research data infrastructures, so that researchers can use the various distributed datasets and new and powerful technologies as an integral component of the archaeological research methodology. There is now a large availability of archaeological digital datasets that, together, span different periods, domains and regions; more are continuously created as a result of the increasing use of IT.

Our specific focus in the ARIADNE project is to provide support for the management of visual *media*. As defined in the abstract, the concept of visual data can be broadly described as any type of visual representation of archaeological objects, i.e.: standard 2D images (including high resolution and high dynamic range, HDR), advanced images (PTM, RTI, panoramic images), 3D models, and videos. Therefore, any media that could help archaeologists to better represent, to document and to communicate the artworks under investigation or study. Visual media are not new instruments of work for archaeologists, since drawings and images have been used for centuries, and they are part of the common working practice. The new issue is how to make a proficient use of those media when different digital incarnations are made available by the progress of ICT technology. A number of new, cheap and commodity opportunities for the easy acquisition of digital visual representation are now available and largely used on the field. What is still cumbersome is how to open those data to the external world (considering both experts and common people), how to publish them in an easy and efficient manner. Specific to this application domain is the required wide scale of size: represented archaeological artworks should include the small finds (few centimetres) up to an entire archaeological site (tens or hundreds meter).

Our activity in the first year of the project, briefly reported in this paper, has been to listen to the user, to understand their expectations and needs and to find a proper match between user needs and current enabling technologies. The final goal of this first year is to define the specification of the services concerning visual data that we would like to implement and offer in ARIADNE.

These themes have been discussed at the Workshop on “Ariadne infrastructure for Multimedia data: Matching technologies and user needs” which took place in October 7th-8th, 2013, at CNR-ISTI (Pisa, Italy). The goal of the Workshop was to bring together ARIADNE *data providers* and *technical partners* in order to find a consensus on what should we mean with visual data and which support should we plan and provide in the framework of the ARIADNE project.

The next sections present our view on the main types of visual data, as emerged by the discussion at the Pisa workshop, and our guidelines for supporting them. We will briefly describe the technologies, some of them highly innovative; we plan to deploy to make much easier the publication on the web and the sharing of visual data resources.

The 2D realm

Images are the more common visual media, and they have been part of archaeological datasets from the very beginning, originally by means of the analog, printed version and more recently by means of digital supports (either digitally native images or scanned from old prints/slides). Those data are part of many digital archives and collections. As an example, more than 800K images are stored in the Arachne archive managed by the DAI - German Archaeological Institute (see at http://arachne.uni-koeln.de/). Images are also an important component of the archives of the Archaeology Data Service (ADS), York University, UK (see at http://archaeologydataservice.ac.uk/).

Images are a resource type that has been part of archaeological datasets right from the beginning. Even on existing datasets, the amount of available images (sometimes of very high quality) is already very high.

While images are a medium that is fully integrated with the web and html since its birth, there are a few aspects that lack of a standard solution for archival and visualization purposes.

2D images – Coping with high resolution images

Most of the images produced nowadays are very high-resolution. High-resolution images are now a commodity resource, with the impressive evolution of digital photography (just to mention a single example, a recent off-the-shelf Smartphone provides a 41 MPix camera).

When high-resolution images are available, the visualization on the web can be cumbersome, due to the amount of data that have to be downloaded before my web browser is able to present visually something (when the old approach first transmit the entire file and then visualize it is used). Another important and critical issue could be the necessity to protect the data.

Several solutions for handling in an efficient manner those data are now possible, adopting a “Google Maps” approach (i.e. adopting a multi-resolution representation of the image, and the progressive transmission of image portions on demand). An already available CNR-ISTI implementation in WebGL, through SpiderGL [DI BENEDETTO et al, 2010], can provide these features in an easy and efficient way (e.g. experiment it on the Cenobium system, http://cenobium.isti.cnr.it/ [CORSINI et al, 2010]).

Planned service in ARIADNE

We plan to design, implement and support a service that should allow users to:

- Upload and process high-resolution images (converting standard plain formats like jpg or tiff into a multi-resolution encoding);
- Manage the easy presentation on the web of those high-res images, by means of a WebGL component for their integrated visualization on Web browsers.

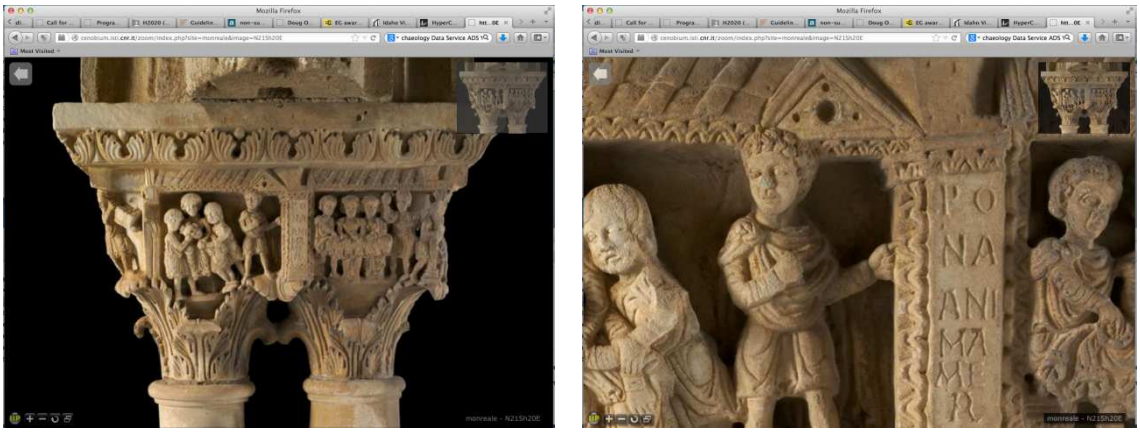

Fig. 1 – Progressive transmission and visualization of high-resolution images on the web (Cenobium system).

2D images - Visualization of High Dynamic Range (HDR) images

HDR images give the possibility to store a higher amount of f-stops in order to acquire more Dynamic Range and have richer images, with a much better representation of ark and lighted zones in the view field

[REINHARD et al., 2010]. The use of this type of data is becoming more and more usual, and HDR data will soon be a standard part of any archaeological documentation campaign. Archaeology is an ideal domain of application for HDR images, since in many cases we are forced to acquire images in contexts characterized by a strongly uneven distribution of light (simply think to the case of an archaeology excavation in southern Europe, with direct sharp sun illumination and several zones of the view under shadows, or photos taken in the interior of a tomb with scarce and uneven illumination).

HDR images can be hard to store and visualize, especially because Low Dynamic Range (LDR) monitors cannot visualize the data in a proper way. For this reason, the current approach is to transform the HDR data into a standard LDR image. Unfortunately, by converting an HDR image into an LDR image we usually loose a lot of content.

WebGL, through SpiderGL, can provide an easy way to visualize HDR images using their original data, without converting to an LDR format. Here the idea is to allow the user to indicate interactively what is the focus region in the current inspection of the image; thus making it possible to perform an adaptive selection of the exposure. The user can interactively vary the focus area (in real time, during the visualization session) in order to be able to spot all the details of the image and avoid to loose or compress the content. A demo of this interactive approach is provided on the web page at http://spidergl.org/example.php?id=13 .

Planned service in ARIADNE

We plan to design, implement and support a service to upload and process HDR images, and a WebGL component for their interactive and integrated visualization in Web browsers (following the example already available in SpiderGL, see at http://spidergl.org/example.php?id=13).

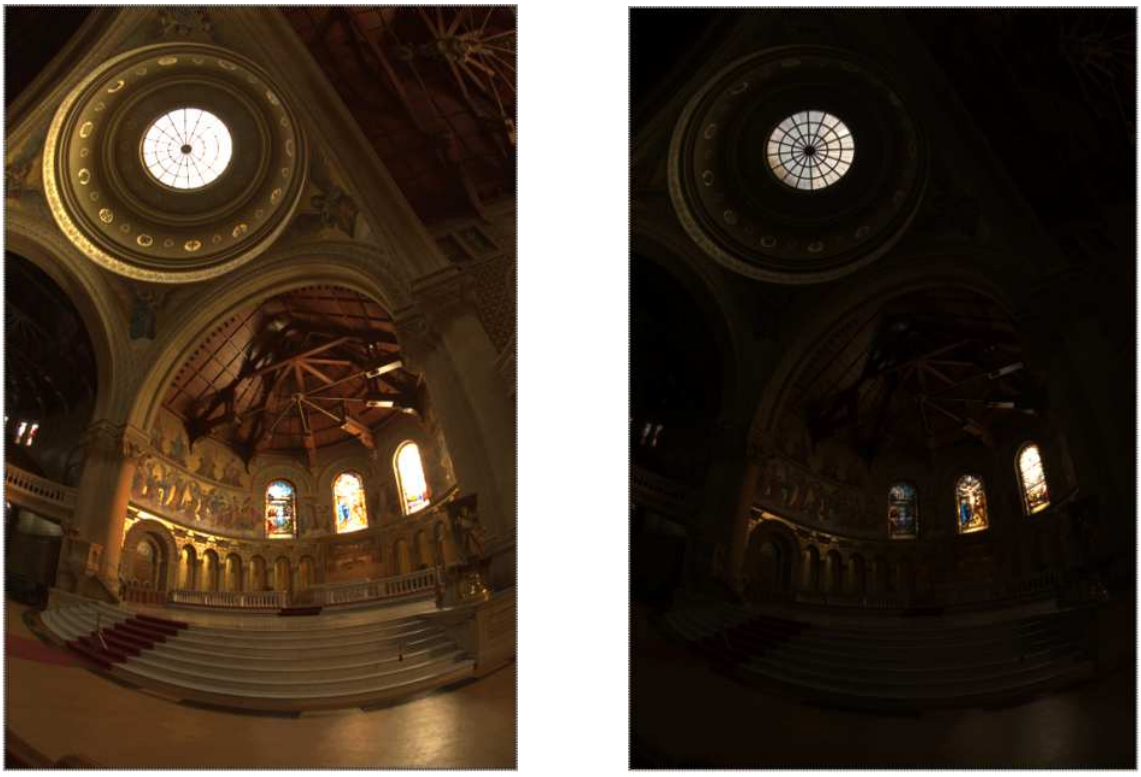

Fig. 2 – Visualization in SpiderGL of the same HDR image with two different exposition values

2D Images - Visualization of big images datasets

The number of images stored in archaeological archives can be extremely large, easily in the order of thousands (if not tens or hundreds thousands). Hence, the search and navigation over these images can be time consuming and difficult. The standard approach nowadays is still the search by definition of keywords, which is very frustrating when we just search for artworks similar to one we are studying. Browsing over a large set of image icons (that is the approach provided by most operating systems or by common interfaces to browse the search result set over archive of images) is very tiring and inefficient. For this reason, a method supporting an easier navigation and semantic ordering over large amounts of images could be useful.

A possible solution is the use of the Pilebars approach [BRIVIO et al., 2012], which gives the possibility to order/sort and visualize the images following several possible semantics. The Pilebars approach works in an interactive way, giving to the user the possibility to use several different methods to sort and group the images and a nice presentation layout (see fig. 3).

Planned service in ARIADNE

A similar service would require the implementation in WebGL of the Pilebars approach, and the design and implementation of a pre-processing service to pre-compute multiple groupings of the images following different semantics. This effort will require considerable manpower effort.

After consultation with potential users, this service was given a lower priority than the previous ones (high-res images and HDR images). Therefore, we will take a decision on the possible implementation later on, according to residual manpower.

Fig. 3 – An example of the appearance of the Pilebars browsing interface.

Enhanced 2D Images – Production and visualization of panoramic images

Panoramic images are now a commodity resource, after the adoption by Google's StreetView application (https://www.google.com/maps/views/streetview?gl=us), now integrated with Google maps. They are extremely useful to present visually an archaeological context/site, the interior of a building, etc. Among the positive characteristics of panoramic images is also the high speed and easiness of the content production.

Planned service in ARIADNE

Since the status of commercial tools for the acquisition and visual presentation is quite well consolidated, we do not plan to offer specific tools developed in the ARIADNE framework. The service provided therefore might include:

- Training of ARIADNE partners and professionals in the acquisition and presentation of panoramic images, adopting commercial instruments.

Enhanced 2D Images – Production and visualization of RTI images

Re-lightable images (usually called Reflection Transformation Images, RTI) are becoming an increasingly used technology to acquire a detailed documentation on small quasi-planar objects, or over objects characterized by a complex light reflection attributes. The advantage of this representation is the possibility to change the light direction over the image in real time (i.e. at visualization time), and the availability of using enhanced visualization modes over those RTI data, which are useful to analyse fine details (see fig.4).
RTI images have been successfully applied in a number of applications, but they are especially adequate for collections of small objects like coins, cuneiform tablets, inscriptions, carvings, bas-reliefs, or even jewellery. Moreover, RTI images give the possibility to acquire a digital representation of artworks made of materials that cannot be acquired by usual 3D scanning technologies (glass, semi-transparent materials, highly reflective metals, etc.).

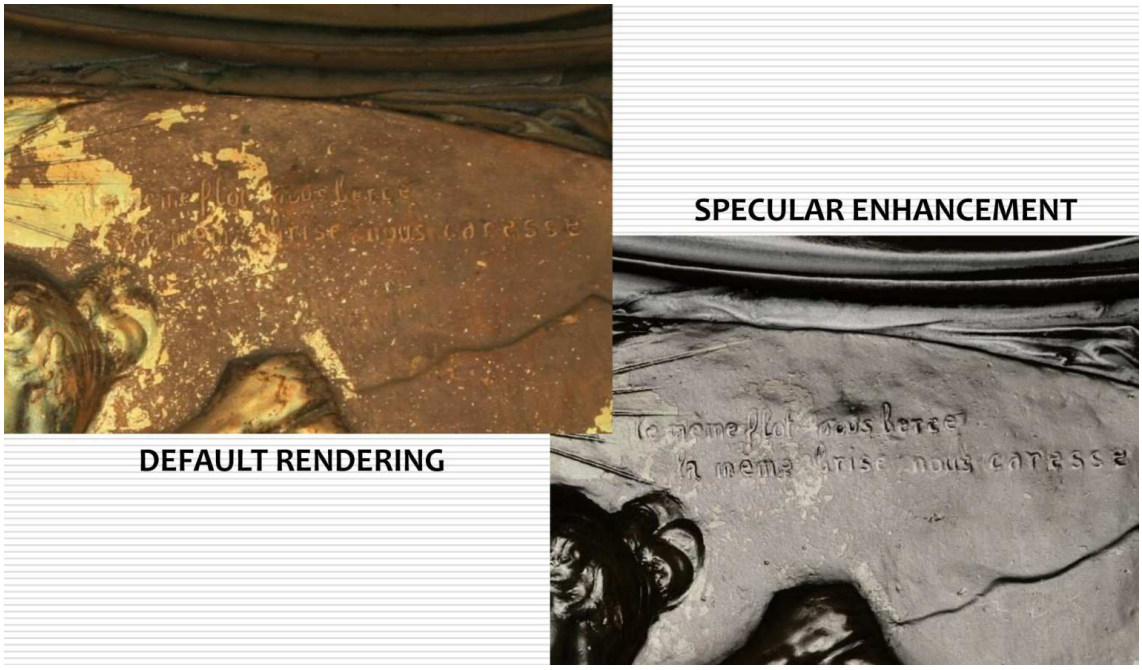

Fig. 4 – Examples of two different visualization modes applied to the same RTI image

CNR-ISTI built an automatic acquisition device that permits to acquire a single object in approximately five minutes (non including the post-processing of the sampled data), and produce the RTI images in an automatic way (see fig. 5).

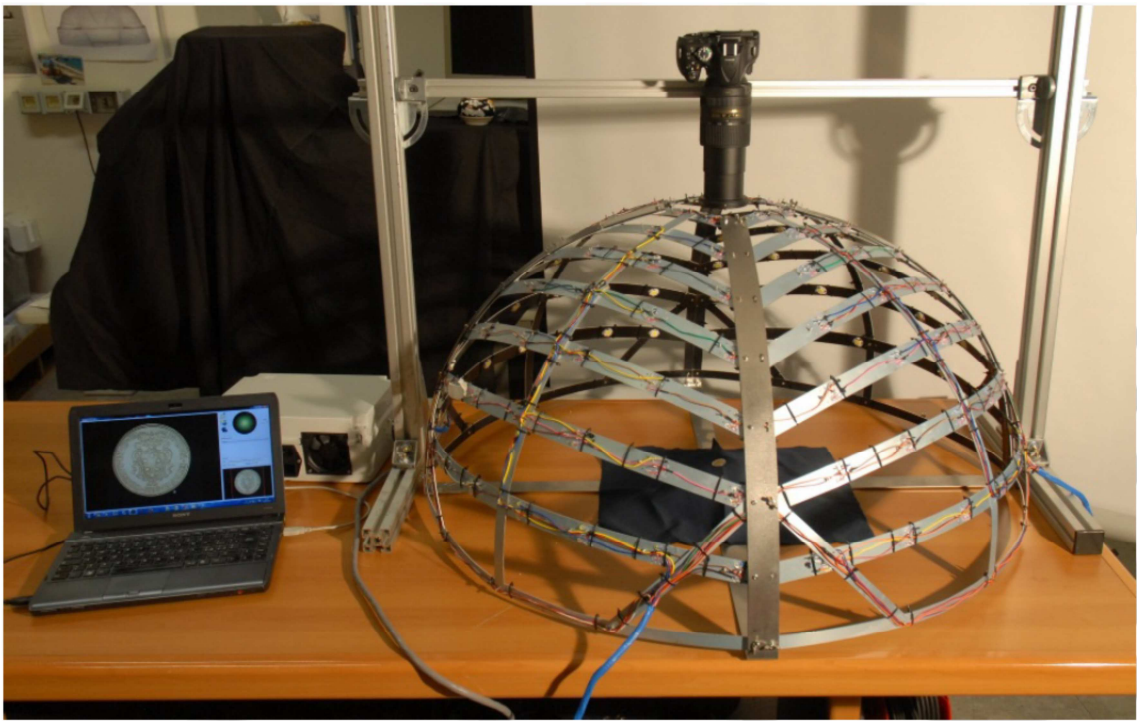

Fig. 5 – The RTI acquisition device developed by CNR-ISTI

Moreover, the interactive visualization of RTI images can be supported both locally, using freely available tools, and on the web, using a WebGL component (again, CNR-ISTI designed proprietary technology for rendering RTI images).

Planned service in ARIADNE

Supporting RTI data will require:

- The deployment of the CNR-ISTI acquisition device at partners for the acquisition of collections of small objects, or the training needed to acquire bigger objects without a specific gantry.
- The design and implementation of a service to upload and process RTI images, and of the WebGL component for the RTI integrated visualization in Web browsers and inside standard web pages.

Full 3D representations

3D representations are now becoming quite common in archaeology. Two classes of models are produced:

- *Sampled models*, usually produced with active 3D scanning (i.e. systems using controlled laser light or structured light) or adopting the more recent approaches based on photogrammetry (production of 3D models from stream of images);
- Modelled representations produced using the user-driven modelling systems designed for 3D modelling and computer animation applications.

In the context of the professional archaeological applications, sampled models are more common, since those models give much more control on the accuracy of the representation than hand-modelled

representations (this has been verified at the Pisa workshop, where most of the 3D models presented by content providers were part of this first class, such as for example the excellent models demonstrated by the Discovery Programme at the Pisa workshop, see at http://www.discoveryprogramme.ie/technology/3d-modelling.html).
Modelled representations, on the other hand, are more common in the applications oriented to the large public (e.g. to produce videos or virtual reconstructions for still images).

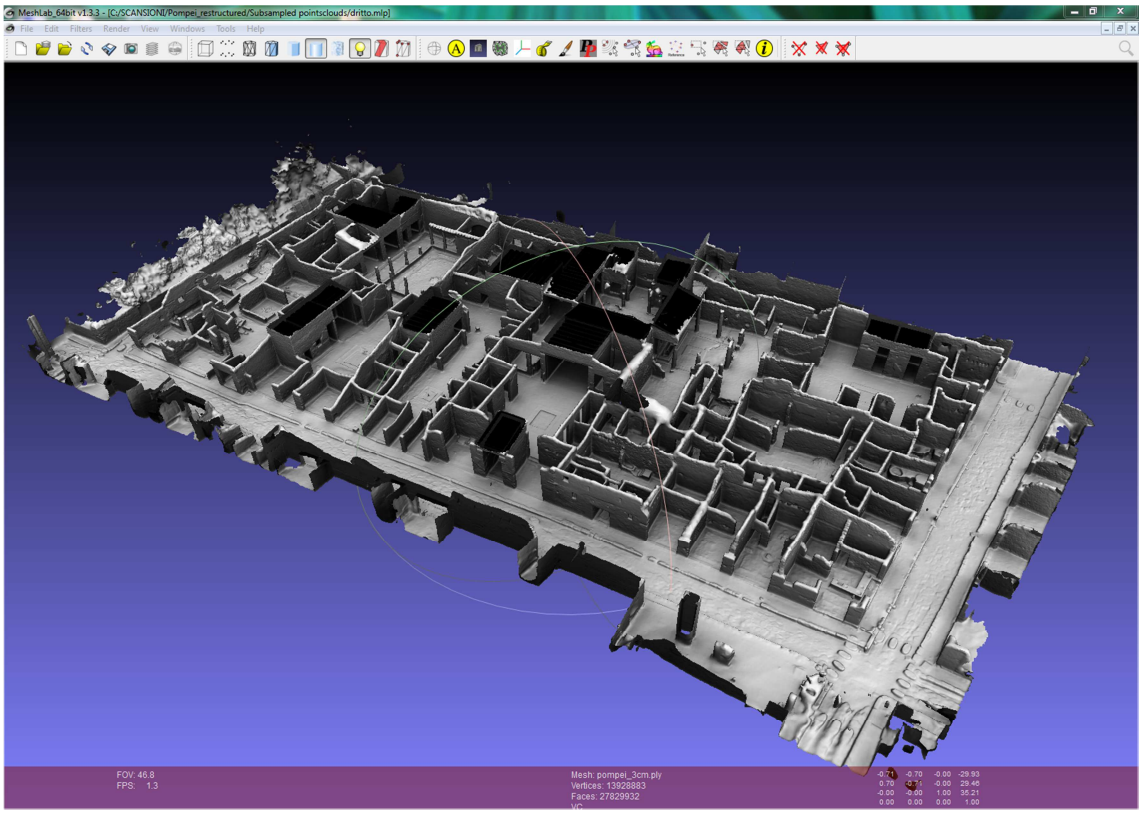

Fig. 6 – The MeshLab open source system, rendering a 3D model of an insula in Pompei.

Sampled 3D models – Supporting the production phase

The open source geometry processing system MeshLab developed by CNR-ISTI is widely used tool for processing sampled data resulting from 3D scanning or stereo-photogrammetry (http://meshlab.sourceforge.net/). With more than 350.000 downloads in 2013, MeshLab has now a consolidated and very large community of users.
MeshLab has been widely used and improved in the context of previous and ongoing EU projects, such as 3D-COFORM, 3D-ICONS and V-Must. The last release includes a number of different functionalities that could be used for the processing and presentation of 3D models.
Among the features that could be used in the ARIADNE infrastructures, we would mention here:

- The complete pipeline for processing 3D scanned data
- The pipeline supporting colour projection on 3D models
- Topological features removal and fixing
- Snapshots production using several different rendering modes

- A command line version of MeshLab (***MeshLabServer***) that gives the possibility to apply a set of filters on a large number of 3D Models (in batch, unattended mode).

Planned service in ARIADNE

We will continue to support MeshLab and develop it further. The major effort in ARIADNE will be devoted to training of project partners and external users of MeshLab, since the maintenance and development costs will be mostly funded by other projects.

3D models – Presentation on the web

Presentation on the web of complex models (e.g. obtained by 3D scanning) is still a complex task, either because the data are complex and hard to be transmitted/rendered in real time, or due to the complexity of publishing 3D material on the web. On the other hand, 3D models cannot be confined to the single archaeologist's archive, but should be shared with the community, to increase knowledge and stimulate further study.

CNR-ISTI has recently developed two resources in EC NoE V-Must project (http://www.v-must.net/) to support easier publishing on the web of high-fidelity 3D models.

3D HOP (3D Heritage On-Line Presenter) is a set of templates and components for the development of a Virtual Museum or effective presentations on the Web of digital 3D assets. Its main features include: easy presentation of different types of 3D content (e.g. re-lightable images, single high-res 3D model, collections of 3D objects...), sophisticated customization capabilities for Web presentation, integration with different multimedia data (see fig.7). We designed it for users at different level of expertise, even considering the case of a curator with little ICT experience, with the goal to be simple and effective. Some components supported are: terrain visualization, single and multi 3D models navigation, high-resolution images and RTI images. Other components are under implementation.

Another goal of V-MUST is the creation of a set of Web services for unattended handling 3D data. The services will be mainly automatic, and aimed at performing the processing and preparation of 3D models for visualization on the Web. An already existing example is the **ModelConvert** service, which automatically performs a standard cleaning and fixing procedure, in order to remove and fix topological artifacts from a 3D model. The same service is also able to convert a standard 3D model into a format that can be immediately visualized on a standard web page. In this case, the service returns directly the URL of the web page that will allow users to browse the 3D model (using either the X3DOM or the SpiderGL browsers; as an example, see fig. 8).

Planned services in ARIADNE

- We will deliver and give support and training on 3D HOP, aiming at the easy creation of visualization pages and interactive presentations with MM components.
- We will deliver and give support and training on ModelConvert web services, that offers support for processing and preparation of the 3D models required before their archival.

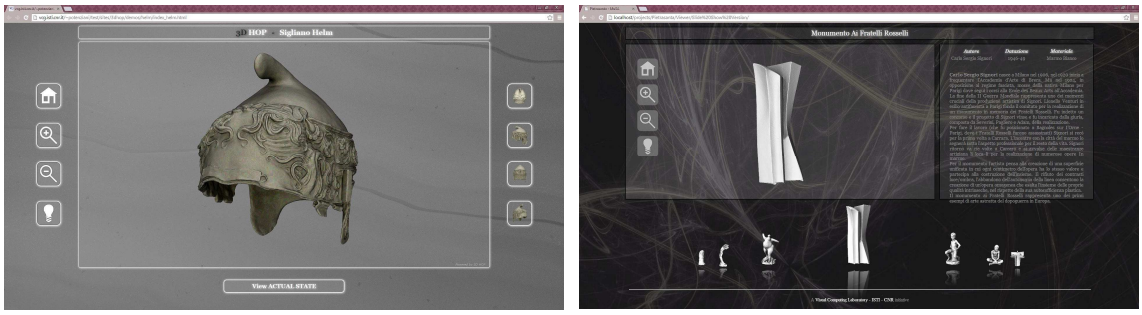

Fig. 7 – Two examples of different visualization layout for 3D models supported by 3DHOP

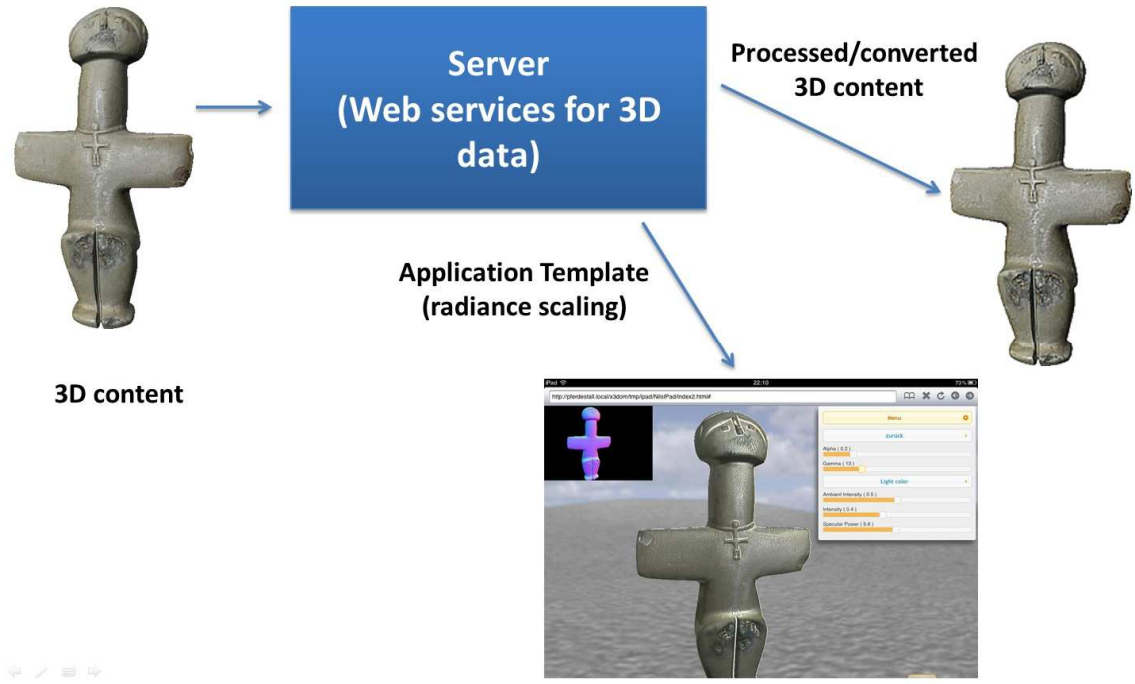

Fig. 8 – The ModelConvert service of V-Must

Videos

Videos (either captured with digital video cameras or standard cameras, or produced by using computer animation) are a well-known resource for visual presentation in archaeology.

Planned service in ARIADNE

Since the status of the commercial tools for video production is quite well consolidated, we do not plan to offer specific tools developed in the ARIADNE framework. The service provided therefore could include:

- Training of ARIADNE partners and professionals in the production of videos in computer animation, adopting commercial instruments.

Since the production of videos in computer animation is a quite complex task, where the instruction of beginners cannot be carried out in a few days of an intense course, we plan to give to this activity a very low priority; according to the feedback received so far by ARIADNE users.

Discussion and conclusions

Among the main issues and comments discussed at the Pisa workshop, we would like to report here the following:

- **Metadata.** Metadata management is a big issue when different types of data have to be handled in the context of an archaeological dataset. In the case of visual data, metadata should involve the artwork represented, the technologies used to produce the representation, and the process adopted to process raw sampled data and to produce the final model(s). The CARARE project has already proposed a metadata description approach for 3D data (http://www.carare.eu/). We should also be able to measure and document the *quality* of a representation (accuracy of both geometry and texture).
- **Web-based vs. Desktop tools.** Most of the ongoing work for the visualization seems to go in the direction of remote web functionalities, because desktop tools usually need a local installation. The need of installing tools is usually not appreciated by the users. Hence, remote visualization may be an option. However, some of the operations (especially geometry processing, and complex navigation) are not easy to implement for Web-based solutions. In addition, it could be complicated to develop and support the same tools in both a web-based and a desktop version. A reasonable compromise would be to keep the main processing tools in desktop solutions (e.g. MeshLab), and devote lighter processing and visualization tasks to web-based tools.
- **Simple vs. complex.** Should simpler visual media be preferred in order to guarantee better preservation? Long-term preservation of complex visual data and of complex multimedia productions is an open issue.
- **Enhanced visualization.** Should we provide enhanced visualization features in the tools delivered to users? As an example, cut-through sections, interactive measures, production of snapshots have been suggested. Another issue is how to embed intelligence/knowledge in visual data, assigning attributes to datasets with archaeological information or with results of archaeological analysis.
- **DRM.** Digital rights management, licensing and copyright issues of visual data poses many problems; open data solutions will be beneficial, especially in the context of research applications.

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