ARIADNEplus Visual Media Service 3D configurator: toward full guided publication of high-resolution 3D data

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ABSTRACT

The use of digital visual media in everyday work is nowadays a common practice in many different domains, including Cultural Heritage (CH). Because of that, the presence of digital datasets in CH archives and repositories is becoming more and more relevant. However, the correct management of these assets, specialized and often complex, it's not always trivial, especially for communities of users lacking specific training. In these cases, systems enabling assisted data publishing may be a solution.

The Visual Media Service (VMS) is a web-based platform that enables the easy publication of complex visual media assets, specifically targeting the CH domain. It allows users to upload high-resolution images, relightable images, and 3D models, transforming them into an efficient format for interactive web visualization. VMS is an end-to-end solution able to support the entire publishing process, from data uploading to presentation customization. To expand its adoption in the CH community, the ARIADNEplus project aimed to enhance its features, providing innovative services for archaeological data management.

This paper introduces the VMS 3D configurator, a new tool designed to improve the visual organization of 3D archaeological datasets in the VMS. The configurator guides content creators through a multi-step wizard, offering customization options for 3D models presentations. The configurator consists of five different configuration stages, each providing specific customization features, such as model orientation, appearance, scene navigation, viewer interface, and annotation of points of interest.

In addition to providing a detailed description of all the configuration possibilities, the paper will also discuss uses, limitations, and potential developments of the 3D configurator, and of the entire platform too, highlighting the value of VMS as a tool for publishing, exploring, and disseminating CH data.

Keywords: Visual Media Service, Web Publishing and Visualization, 3D Models, Web3D, WebGL.

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Introduction

Using cutting-edge visual technologies for analyzing, documenting, preserving, and sharing artifacts is a consolidated trend in the Cultural Heritage (CH) domain (Bustillo et al., 2015). As is well established that, to become valuable resources for learning, study, and research, the digital datasets generated by these technologies should be Findable, Accessible, Interoperable, and Reusable (Wilkinson et al., 2016). The Visual Media Service (VMS)[1] (Ponchio et al., 2016) is a platform designed following these principles.

Developed in the context of the EC Infra ARIADNE project (Meghini et al., 2017), the VMS provides easy publication and presentation on the web of complex visual media assets. It is an automatic service aimed at people working in the CH domain, that allows content creators to upload three different visual media (high-resolution images, relightable?? images, and 3D models) on a server and to transform them into an efficient web format, making them ready for web-based visualization.

To boost the penetration of the service in the CH community, possibly transforming the VMS in a solution exploitable in a more systematic and structured way, the Horizon 2020 ARIADNEplus project[2] aimed at expanding the VMS features, implementing innovative services for users addressed to archaeological data management.

In this context, one of the goals of the project was to design and develop new services for improving the visual organization of 3D archaeological datasets. Initially planned as a simple redesign of the way of linking the 3D model of an artifact or a monument to its archaeological documentation, finally the work has involved not only the 3D data enrichment stage, but also all the other configuration options already provided for customizing the VMS 3D presentation.

The result of this work is a brand-new configurator for 3D models, proposed as a complete multi-step wizard able to guide the content creator through the publication process. The current 3D configurator is composed of 5 different configuration steps, appropriately divided according to the type of customization they provide: Alignment, Material & Light, Navigation, Interface, and finally Annotation.

This paper introduces the VMS 3D configurator and the key concepts behind its design. After a brief introduction of the VMS platform, useful to contextualize the application domain, the different configuration stages of the 3D setup wizard will be presented in detail and illustrated with practical examples. The paper concludes with a discussion of uses, limitations, and possible development directions of the proposed 3D data publishing approach.

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Visual Media Service

Visual Media Service (Figure 1) is a web service developed in the framework of the ARIADNE and ARIADNEplus projects. It is a ready-to-use platform enabling large digital datasets to be processed and displayed seamlessly and quickly.

VMS provides easy publication on the web of three different complex visual media assets:

- "reality-based" **3D models**, the ones created with optical scanners or photogrammetry (high-resolution unstructured geometries);
- high resolution **2D images** (i.e., gigapixel photographs or huge planar images);
- Reflection Transformation Images (**RTI**), a 2D+ image, created through computational photography, where the user can interactively change the lighting at viewing time.

VMS allows content creators to upload these visual media on a server that automatically transforms them into an efficient web format ready for online publication. Moreover, it also creates a web-based presentation enabling content creators, but also end users, to access and interactively explore the published media. Finally, the VMS technology provides a full set of interactive tools for the displayed object(s). As such, this service can be considered a valuable tool for the publication, exploration, and dissemination of CH.

[1] http://visual.ariadne-infrastructure.eu
[2] https://ariadne-infrastructure.eu

The VMS platform also allows users to browse through the resources uploaded by other users and set as publicly accessible. However, this option must not mislead: VMS is not to be intended as an archive or a repository. It is rather a platform to allow scholars/professionals to publish on the web large visual data and to share them with colleagues, supporting cooperative work.

VMS has been designed to give people working in the CH domain the opportunity to experiment with web publishing, offering them multiple possibilities, with multiple levels of access:

- **public vs. private publication:** content creators can decide if make their visual media accessible to anyone through the web platform, or whether to keep them private;
- **personal shareable link:** for sharing the uploaded media only with a selected group of end users;
- **iframe embedding:** for integrating the resulting presentation in the uploader's own web page;
- **viewer download:** to further customize it by working on the source code, and allow for self-publishing or offline, local use.

Therefore, the multiple levels of access are meant not just for the end-users, but also for content creators, depending on their software development skills. This democratizes the access to cutting-edge software solutions, that is one of the primary targets of VMS. In fact, VMS allows content creators to exploit high-performance lower-level software exposed in a shared environment through easy-to-use interfaces.

Particularly, VMS is based on:

- **3DHOP**[3] (Potenziani et al., 2015), an open-source framework for the creation of interactive web presentations of high-resolution 3D models;
- **Nexus**[4] (Ponchio & Dellepiane, 2015), a library for the creation and visualization of large 3D models online;
- **Relight**[5]**/OpenLIME**[6] (Ponchio et al., 2018), which are libraries to create and view on the web relightable images.

These solutions, all developed by CNR-ISTI Visual Computing Lab, are low or middle-level solutions. This means that users are generally required to write source code to make them work. Conversely, using the VMS platform, even a content creator with any

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[3] https://3dhop.net
[4] https://vcg.isti.cnr.it/nexus
[5] https://vcg.isti.cnr.it/relight
[6] https://github.com/cnr-isti-vclab/openlime

level of computer programming knowledge can exploit them interacting with simple interfaces developed ad-hoc, without the need for coding.

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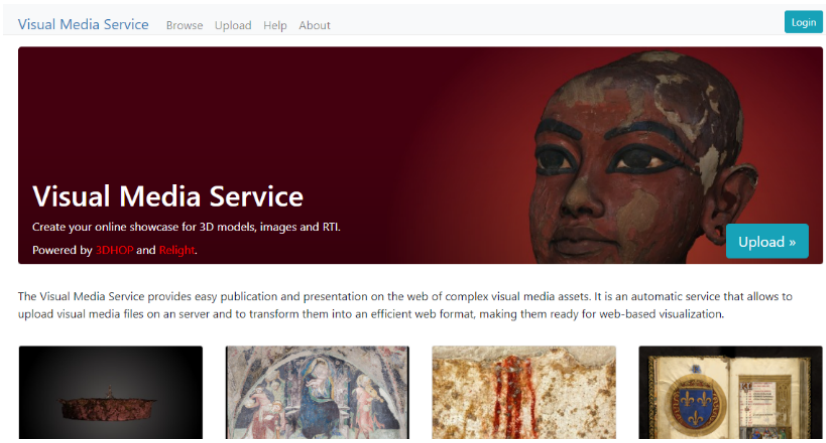

Figure 1 - The landing page of the Visual Media Service platform website.

The VMS can be considered an end-to-end solution, supporting content creators in each step of the publishing process, from login to presentation customization. The platform implements:

- **Multi-option login system**: to upload a visual media and create a presentation, a content creator has to log in to the platform. VMS supports 3 different login modes. Users can log in using a Google account, a D4Science account, or simply using an email address.
- **Informative data support**: when the content creator selects the visual media to upload, simple information about that media (title, description, and so on) can be provided. Since VMS does not aim to be a structured archive, currently informative data support is very simple. However, it is enough to provide minimal documentation and a tag-based search system for the uploaded resources.
- **Automatic server-side data processing**: when the content creator decides to upload a resource, the VMS server processes the selected visual media creating a web-friendly multiresolution version of it. Since data processing could take some time, it happens in background (so, in the meanwhile, the user can continue to navigate the platform). At the end of the processing the server sends to the content creator a message to notify that the processing is over.
- **Automatic creation of web presentations**: at the end of the processing, the platform also creates a basic web presentation of the chosen visual media. Note that by default the selected media is uploaded as a private resource. If the owner wants to make it publicly available, he/she has to manually change the default.
- **Assisted customization of web publication**: once the basic web presentation has been created, the content creator can configure it in a specific section. A configuration wizard process introduces to the user all the customization possibilities.

This last point represents the core of this work. Particularly, we focused on the configuration section for 3D models, which has been completely renewed, changing from a single-page simple editor with very few functionalities to a complete multi-step wizard able to guide the content creator through the publication process.

3D Configurator

The advent of modern 3D visualization technologies allows a wider audience access to digitized objects, enabling the possibility to appreciate these objects in previously unattainable ways. This is particularly valuable for objects that are fragile, have limited visibility, or restricted access, as often happens with Cultural Heritage (Wachowiak & Karas, 2009; Arnold & Kaminski, 2014). Finding a quick and easy way to enable 3D visualization of digitized artifacts is therefore essential. The configuration section for 3D models provided by the VMS tries to meet these needs.

The current 3D configurator is composed of 5 different configuration steps, appropriately divided according to the type of customization they provide: Alignment, Material & Light, Navigation, Interface, and finally Annotation.

Alignment: the first step allows the content creator to fix the model orientation (Figure 2). One of the more common issues arising from working with 3D models is that the model is often visualized with the wrong orientation. This happens because the 3D model has not been oriented correctly at the time of creation, or because the different tools composing the 3D working pipeline (data acquisition, editing, publication) use different reference systems. In any case, if the model is not in the correct orientation, in the alignment wizard the content creator can re-orient it using different commands:

- First of all, one can correct the model orientation rotating the model along an axis; there are 3 different sliders, one for each axis, and one can use them to independently rotate your model on a selected axis;
- Then, one can define the UP of the model; this is another very annoying issue that happens very often, since software used for creating 3D models follow different notations; so, UP vector can be defined in 2 different ways (Y-vertical, used mostly by Computer Graphics tools, and Z-vertical, used mostly by engineering and geographical tools), and this led to weird behavior in visualization; since is not possible knowing in advance what is the notation used for the given 3D model, in this panel with a simple button one can switch from a notation to the other;
- Finally, one can use advanced straightening to orient the model to match predefined views while directly interacting with the model in the 3D scene using a spherical trackball.

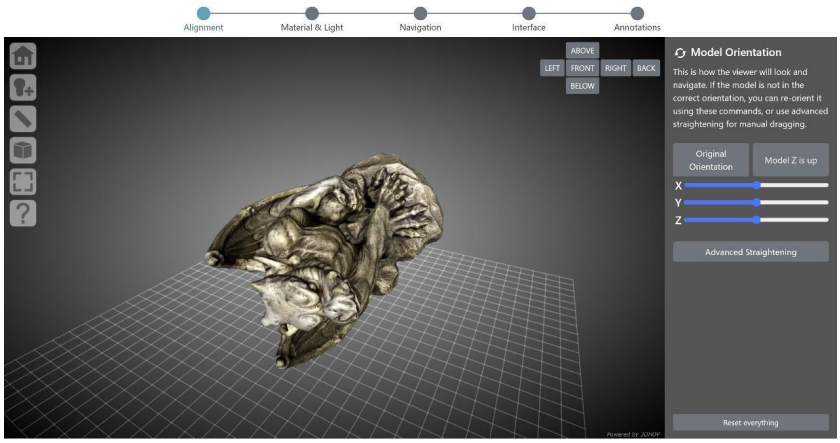

Figure 2 - The Alignment setup in the 3D configurator wizard. The panel on the right contains the controls for rotating the model along an axis, recalling the original orientation, setting the UP vector, accessing the dedicated panel for enabling advanced straightening. The 3D viewer on the left is updated in real time according to the customization in the right panel.

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Material & Light: the second step allows the content creator to set up the 3D model appearance (Figure 3). More specifically:

- the material wizard provides a set of tools to select the startup color of the 3D model (texture or solid color), define the solid color used, add or remove a toolbar button for switching between texture and solid color, and finally customize the glossiness level (dull, low, medium or shiny).
- the lighting setup provides a set of tools to define the startup lighting of the scene, add or remove a toolbar button for switching between enabled and disabled lighting, and finally add or remove a toolbar button for enabling the interactive control of light direction.

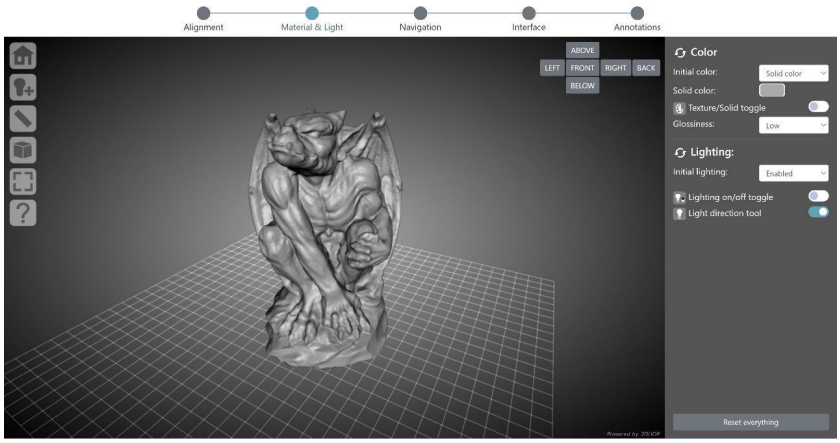

Figure 3 - The Material & Light setup in the 3D configurator wizard. The panel on the right contains the controls to set the initial appearance of the model, modify the solid color, add/remove the texture/solid color toggle button in the toolbar, define the level of model's glossiness, set the initial lighting of the scene, add/remove the lighting control button in the toolbar. The 3D viewer on the left is updated in real time according to the customization in the right panel.

Navigation: the third step allows the content creator to define the scene navigation setup (Figure 4). In particular, this wizard provides a set of tools to select the trackball paradigm used in the scene for manipulating the 3D model (turntable, that just allows a 2-axis manipulation, with vertical tilting and horizontal rotation of the model, preserving the vertical axis; or sphere, that enables full and free rotation on all axes), define the initial trackball position, customize the field of view angle of the virtual camera (using a slider or three different buttons with predefined values), specify the type of projection used by the camera at the startup (perspective or orthographic), and finally add or remove a toolbar button for switching between perspective and orthographic projection.

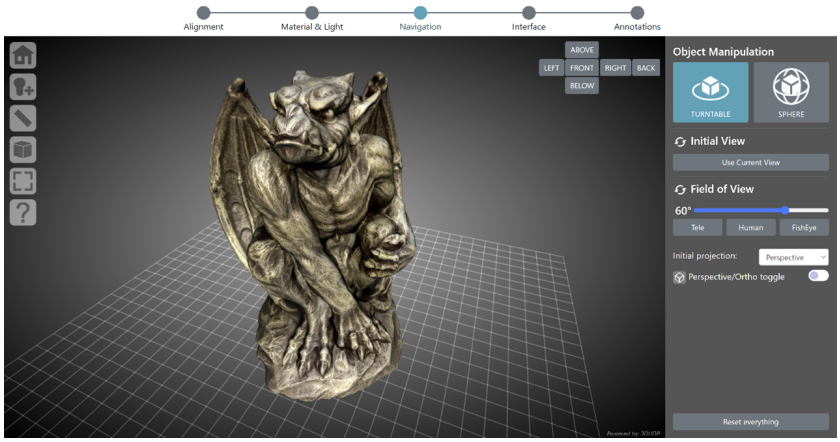

Figure 4 - The navigation setup in the 3D configurator wizard. The panel on the right contains the controls for changing the trackball, setting the initial view, modifying the FOV, defining the type of camera projection, adding/removing the camera projection button in the toolbar. The 3D viewer on the left is updated in real time according to the customization in the right panel.

Interface: the fourth step allows the content creator to customize the viewer interface (Figure 5). This specific wizard provides a set of tools to customize the toolbar skin (6 different themes are available: light, dark, minimal light, minimal dark, transparent light, transparent dark), add or remove tool buttons from the toolbar (lighting, light direction, measurement, point picking, sections, solid color, projection, full screen), define the viewer background (flat color, linear gradient, radial gradient, predefined images), and finally select which widget provide to the end user (base grid, compass, canonical views, navigation cube).

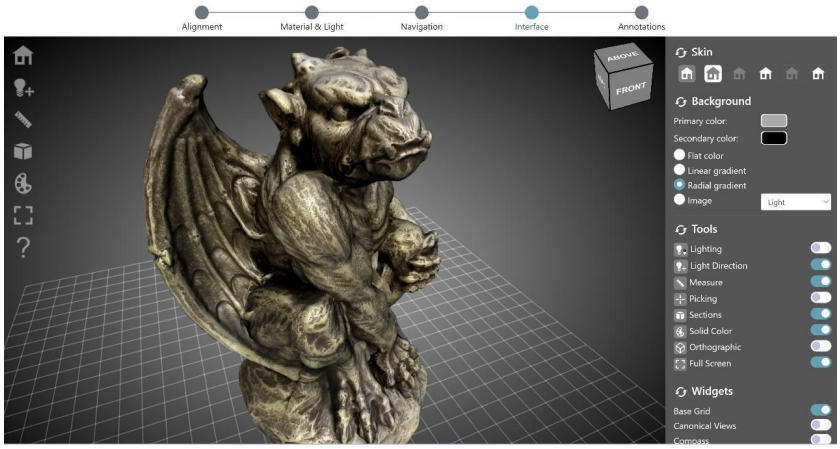

Figure 5 - The Interface setup in the 3D configurator wizard. The panel on the right contains the controls for changing the toolbar skin, setting the viewer background, selecting the tools to enable adding/removing the related buttons in the toolbar, choosing the navigation/orientation widget to add to the 3D scene. The 3D viewer on the left is updated in real time according to the customization in the right panel.

Annotation: the fifth step allows the content creator to add hotspots (points of interest highlighted by clickable geometries) to the 3D model and link them to some basic annotation (Figure 6). The annotations wizard provides a set of tools to add or remove custom hotspots to the 3D model, define the size and color of each hotspot, and finally edit the text information linked to the hotspot. Once at least one hotspot is defined, the wizard automatically adds a toolbar button to enable or disable the hotspot visibility. If hotspots are visible, moving the mouse cursor over their geometry triggers a panel (in the bottom left of the viewer) showing the text associated with that specific hotspot.

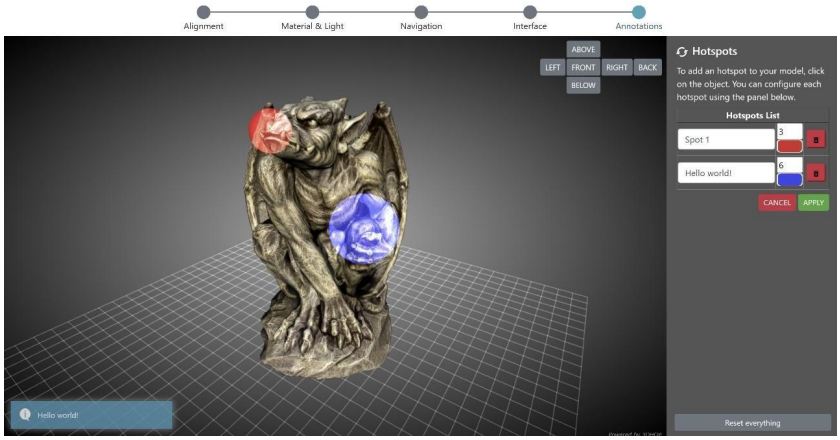

Figure 6 - The Annotation setup in the 3D configurator wizard. The panel on the right contains the controls for adding/removing spherical hotspots (in red and blue) to the 3D model, modifying the hotspots setup (radius, color), and editing the information linked to each hotspot. Moving the mouse cursor over one of the hotspots in the 3D scene recalls the linked information through a panel visible on the bottom left of the viewer.

Discussion

Released in early 2015, to date the VMS counts around 1500 visual media resources uploaded, processed, and visualized. Among these, around 1000 are still online, while the remaining have been removed. The number of content creators exploiting the platform over the years counts 460 unique users.

As mentioned before, in the VMS data owners can select between restricted or open access, which is an important option when data of ongoing, not yet published research is being managed and processed. The usefulness of this option is visible in the fact that, currently, only a subset of the material (around 30%) is publicly accessible. A similar deduction can also be drawn from the difference between the total object processed and the current number of available objects: users have exploited this service to put online, temporarily, restricted-access data, and then they removed it after having used it, or have used the VMS just to create the viewer, that has then been downloaded for private, local use.

These two types of use, are quite different from what is offered by other online services, have certainly contributed to the good results obtained so far, and to the penetration of the VMS in its target community. Indeed, currently the VMS is used by a number of cultural institutions. Among these, there are several universities (Florence, Milan, Turin, Rome, New York, Lincoln, Zacatecas, and many others) plus some research centers (INRAP, CNRS, CNR). Also, there is widespread use of the service in education, from university courses, (master's degree courses and Ph.D. courses). Finally, a few 3D scanning/processing companies use the VMS as a tool to test the 3DHOP library functions and its potential, to develop the interface, but rarely?? to preview or present 3D and RTI material to clients.

These examples of use, together with the figures mentioned above, show there is good interest in and appreciation for the VMS. Nevertheless, so far we have not?? received any news about a more systematic

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or structured use of the platform. The new configurator system aims at filling this gap, providing content creators with a set of customization options that have never been so extensive and easy to use. These new possibilities shouldn't just impact the mere publishing of content, but they also should be able to stimulate a discussion concerning the reproducibility/applicability of the proposed data publishing approach to different media (imagine applying the same configurator to other data), or even contexts (for instance, by configuring? the porting of the configuration wizard in similar data infrastructures).

Obviously, although the 3D configurator is 100% up and running, we are aware that, to date, for some aspects, it is still a demonstrator. And because of that, independently of the current limitations, due to its specialization, it cannot be considered a solution suitable for all eventualities.

For instance, since this 3D wizard is tailored to the specificity of 3D models, the same five configuration steps might not make sense with the other visual media supported by VMS (RTI & high-resolution 2D Images). On the other hand, since the same approach could also be replicated for these media, moving the RTI & high-resolution 2D Images configurators from single-page editors to multi-step wizard is on the road map of future developments. Future developments that are not limited to overcoming the configurator limitations, but also aiming at increasing and diversifying the publication possibilities provided to content creators.

The first step of this process is trying to go beyond the current single object visualization, for instance allowing content creators to upload objects as a collection of items, so as to visually organize their exploration in a dedicated section, but also to apply one specific configuration setup to the whole collection. This makes sense if one is publishing a collection of similar items, and could save the content creator a lot of time. A beta version of the tool for creating 3D collections has already been tested for a large set of lithic artifacts (Ardelean et al., 2022), and it is currently in the evaluation stage to be publicly released.

With collections you have multiple items grouped together, but each one will typically have its own viewer. However, one may want to have multiple objects in the same viewer. Actually, the VMS already supports this particular data organization, but currently this feature is restricted just to high-resolution 2D images. These particular collections of images are called **Image Sets** and are already online (it is possible to browse them on the platform website). Image Sets are very useful, for instance to keep all the pages of one book together, but they are a quite trivial example of multiple objects in the same viewer (because the final user can just visualize one item per time, jumping from a visualization of an item to the other).

For this reason, we are exploring the possibility to develop something more for 3D objects, designing a viewer able to load and display multiple objects together. Having more than one object in the same scene opens up various use scenarios: as a basic interaction, it would be possible to toggle the visibility of each component. However, to fully exploit the multiple objects, it will be necessary to add some more interaction with the objects. For this reason, the road map includes the release of various multi-object publication templates, each one with a specific built-in interaction, easily configurable.

Examples could include a two objects comparison template, in which a content creator uploads two objects, and the viewer lets the user toggle between the two models, apply cross-transparencies, or use a slider to switch from one to the other (Figure 6-A). Use scenarios: before/after restoration, display variants, artist's concept vs. actual statue. Another possible template is a sequence explorer, in which a content creator uploads multiple objects, each one depicting a "stage" of the same entity, and the user can follow the time sequence, see an "exploded" view, or display multiple stages with transparencies/sections (Figure 6-B). Use scenarios: archaeological excavations, evolution of a building/site).

Other development directions might aim at a more technical approach. Although usable in a technical environment, the VMS viewer is still more suitable as a tool for general public dissemination rather than as a technical instrument. For this reason the introduction of more advanced features, able to help professionals, is in the development road map. For instance, the current feature of hotspots authoring is useful, but still limited. Technical extensions could include: points/polylines/areas annotations, groups and layers of annotations, exporting functionality (Figure 6-C). Also, the introduction of more technical tools would give the possibility of exploiting the metric quality of the high-resolution visual media in the VMS. Advances in this regard could include: new measurement tools (e.g., angles), dimensioning, functionalities to export annotations/measurements.

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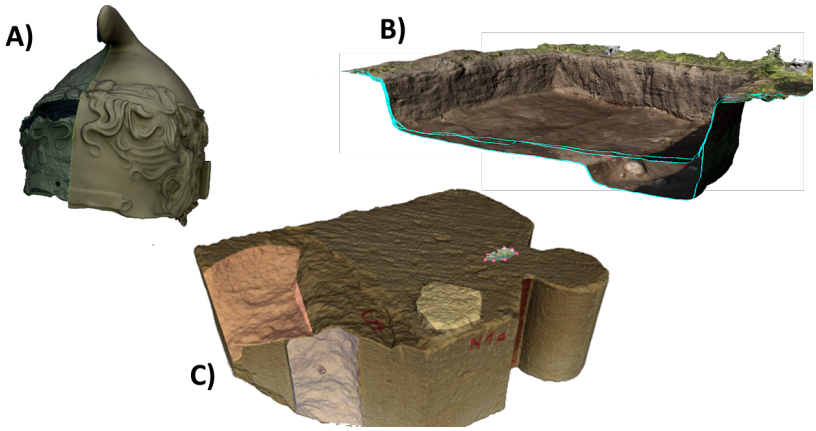

Figure 7 - Illustrative examples of possible future developments: A) two objects comparison template, in which a content creator uploads two objects, and the viewer lets the user use a slider to switch from one to the other; B) sequence template, in which a content creator uploads multiple objects, and the user can display multiple stages with transparencies/sections; C) technical viewer, providing more advanced features, such as points/polylines/areas annotations, able to help professional users.

Conclusions

We presented a multi-step wizard for customizing 3D model web presentations and for guiding the content creator through the publication process.

Composed of 5 different configuration steps (Alignment, Material & Light, Navigation, Interface, and Annotation), this 3D configurator system represents a significant step toward the assisted integration of complex visual media assets in the context of the archeological domain.

Initial testing started on selected datasets provided by ARIADNEPlus project partners led to positive feedback, indicating the proposed publishing approach may have a substantial impact on future research practices, as well as on data reuse.

All the planned developments, together with the continuous update and maintenance of all the software components of the VMS (3DHOP, Nexus, Relight/OpenLIME), aim at improving the already good results obtained by the service so far.

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Data, scripts, code, and supplementary information availability

Link to the Visual Media Service website: http://visual.ariadne-infrastructure.eu

Link to the ARIADNEplus website: https://ariadne-infrastructure.eu

Link to the 3DHOP website: https://3dhop.net

Link to the Nexus website: https://vcg.isti.cnr.it/nexus

Link to the Relight website: https://vcg.isti.cnr.it/relight

Link to the OpenLIME website: https://github.com/cnr-isti-vclab/openlime

Conflict of interest disclosure

The authors declare that they comply with the PCI rule of having no financial conflicts of interest in relation to the content of the article.

Funding

The research leading to these results has received funding from the European Union Horizon 2020 Programme (H2020-INFRAIA-2018-2020) under the Grant Agreement n. 823914 (H2020-INFRAIA-2018-1 "ARIADNEplus" project) and under the COST Action n. 18128 (CA18128 “SEADDA” Saving European Archaeology from the Digital Dark Age).

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