Supporting conservation and restoration through digital media modeling and exploitation - the example of the Acropolis of Ancient Tiryns

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***Abstract*—Open laboratories (OpenLabs) in Cultural Heritage (CH) institutions constitute an effective practice for providing visibility of all the processes that take place "behind the scenes", as well as for the promotion of documentation data, which the specialists of the domain collect and produce. However, a simple "presentation" of processes, or the absence of necessary further explanation and communication with the specialists, may be problematic in terms of what visitors eventually see and understand. The exploitation of digital media and their efficient management and interlinking to meaningful data and knowledge may contribute significantly to the dissemination of publicly available information and the support of OpenLabs. Considering all the above, the CAnTi (Conservation of Ancient Tiryns) research project aims to design and implement virtual and augmented reality interactive applications that will visualize the conservation and restoration (CnR) data of the Acropolis of Ancient Tiryns. The digital content of the applications will be modeled using Semantic Web (SW) technologies, providing cultural visitors with access to insight documentation data and media produced by CnR scientists. The applications will constitute a part of the OpenLab activities that will be carried out on the archaeological site, enhancing the visitors' experience regarding the CnR of the site's current practices and past.**

Keywords—openlabs, cultural heritage, digital applications, semantic modeling, conservation, restoration data

I. INTRODUCTION

During the last decades, an increasing number of Cultural Heritage (CH) institutions have used new practices and trends to enhance their offer and satisfy the preferences and requirements of potential audiences. More recently, such practices include the transformation of CH laboratories as *OpenLabs* in order to provide visibility of all the processes that take place "behind the scenes" [1]. During the operation of an *OpenLab*, certain artifacts are usually placed behind glass walls or display cases so that visitors may experience ongoing research, analyses, documentation, conservation and restoration (CnR) works.

Despite the initial intentions of CH institutions to adopt open science approaches and create unique experiences for attracting their audiences, due to specific limitations and risks involved in particular workflows of treating CH material remains and artefacts, they usually present to the public pre-designed experiments and workflows [2]. This perhaps explains why today, *OpenLabs* are found more often in closed and regulated environments, such as CnR laboratories and museums, and less frequently at open-air museums and archaeological sites. Also, during such displays, the audience has limited communication with the expert staff, while additional interpretative resources explaining what visitors actually see are not always in place. Such resources are produced by CnR specialists who collect and produce significant information during their work.

That information, called CnR documentation, includes both textual and visual records which: i) document the structure, the preservation state, as well as the environment of either movable or immovable CH, ii) document the previous and current processes regarding diagnosis-analysis and CnR of the conservation object, as well as their evaluation and iii) justify the choice (in terms of materials and techniques) of the interventions and other activities related to the preservation and promotion of conservation objects (e.g., preventive conservation, exhibition) [3, 4]. All this material is interesting not only for the specialists but also for non-expert CH communities and the public. It provides a better understanding of the preservation state, materials and construction technologies, as well as the CnR process itself, its value and occurring difficulties.

Similarly, the CnR documentation at the Acropolis of Ancient Tiryns is a continuous process that produces textual documents (e.g., reports regarding the interventions) and visual records (e.g., images, 3D models). Such documentation concerns the applied interventions in terms of their stages, methods, supplies and technologies used, as well as the preservation state and structure of the monument at the different stages of the interventions. However, the resulting records are usually inaccessible to expert and non-expert communities.

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Evidently, the current modus operandi of *OpenLabs* hinders both the openness of the scientific process and the visitor experience, while the rich CnR documentation is not exploited for dissemination. To address this threefold challenge, the CAnTi (Conservation of Ancient Tyrins) research project aims to support the operation of *OpenLabs* by designing and deploying a digital integrated approach. The latter is developed at the Acropolis of Ancient Tiryns, which presents a challenging case of an open archaeological site to the public with ongoing CnR works. The digital support includes virtual and augmented reality applications that will visualize conservation and restoration works. Also, the digital content of the applications will be modeled using Semantic Web (SW) technologies, providing cultural visitors with access to insight documentation data and media produced by CnR scientists. This research paper provides a brief overview of related work before the presentation of the project's innovative digital approach. Finally, the paper concludes by discussing the lessons learnt so far and steps forward.

II. Related work

A. Digital content supporting OpenLabs

The use of digital applications in the context of *OpenLabs* is not uncommon, depending on the goals of each operation and the level of engagement each institution wishes to achieve. A digital portal is commonly developed to provide information about how an *OpenLab* operates and what the visitor may experience; what types of processes - scientific or technical - have taken place in the past or currently take place based on a specific theme; and also, logistic information concerning the programme, ticketing, pricing etc.

On a few occasions, there is a provision for employing more advanced digital media, such as custom-designed digital applications and video presentations. For instance, at the Acropolis Restoration Service in Athens, Greece, in the context of the educational programme, Glauka, an online game, was developed to introduce children to the CnR works taking place at the Athenian monuments. Through role-playing, missions, challenges and rewards, the cultural visitors can learn about specific techniques and develop their newly acquired skills in CnR [5]. Online video 'tours' have also been employed in the case of ongoing excavations, where critical points of the excavation process and experts' interpretations are recorded and displayed on the research project website [6].

More rarely, digital presentations co-occur during *OpenLab* live demonstrations. One such case is the "Conservators on Exhibition" of the Benaki Museum, where video presentations and other activities were presented parallel to the "live" CnR processes [7]. This informative presentation complements ongoing research and technical processes, and better informs the spectator/visitor. Evidently, there is plenty of scope to build on previous work and develop novel digital approaches for attracting new audiences through the support of *OpenLabs*.

B. Semantic modeling of CH and CnR data

In terms of Semantic modeling, there is a plethora of work in the domain of CH, which is still underexplored in such contexts. To efficiently organize and interlink data and tackle interoperability issues (at a syntactic and semantic level), CH institutions and organizations have adopted SW technologies and, more particularly, ontologies. Different ontologies have been developed in this context to accommodate essential aspects of cultural information management, such as retrieval, integration, reuse and sharing [8, 9]. Accordingly, the CH subdomain of CnR exhibits increasing interest in ontologies to handle the highly heterogeneous and often secluded CnR information effectively.

A widely used top-level ontology for the CH domain is the International Committee of Documentation Conceptual Reference Model (CIDOC CRM) of the International Council of Museums (ICOM) [10]. CIDOC CRM provides the basic classes and relations that represent the various CH disciplines and is extended by ten modular models which cover documentation requirements of specific disciplines of the CH domain (FRBRoo, PRESSoo, CRMinf, CRMarchaeo, CRMsci, CRMgeo, CRMdig, CRMba, CRMtex, CRMsoc)[1]. The CIDOC CRM and its official extensions have been used for CnR data modeling through the years [11].

There are also ontologies which have been developed particularly for the CnR domain and have been used for specific services regarding CnR data management (most commonly data integration and data searching services). An example of those cases is the Ontology of Paintings and Preservation of Art (OPPRA), a semantic model specialized in the CnR of paintings [12]. Another example, which has been studied and reused in later ontology design and development, is the Monument Damage Ontology (MDO) [13]. MDO integrates, organizes and processes diverse information related to damage diagnosis and CnR interventions of historical buildings and eventually supports documentation and monitoring of damages and potential intervention planning/application [14]. Additionally, one more domain ontology is the PARCOURS semantic model, which aims to integrate CnR data from different sources to enable the querying of data in a unified way [15]. Finally, a semantic model that specializes in CnR of historical buildings, the *Conservation Process Model* (CPM), was developed to i) represent knowledge about the related CnR processes and ii) facilitate integration, mediation and interchange of heterogeneous CnR data at both the academic and the professional level [16].

Considering the existing practices and models, this research aims to exploit existing models and further extend them to fully represent data regarding the CnR of stone construction material, as well as the digitization of CnR processes and the products of the digitization. As we have already discussed, the data of the domain of interest could be potentially useful for systems and services for both specialists and the public.

III. Semantic modeling of CnR data of ancient tyrins

The development of the ontology was based on a first conceptual representation which was formed during the study and analysis of the data and documents produced during CnR practice of the CnR specialists of the Acropolis of Ancient Tiryns. For the development, Protégé[2] was used (version

[1] https://www.cidoc-crm.org/collaborations

[2] https://protege.stanford.edu/

5.5.0, for desktop), open-source software for ontologies development.

After constructing the taxonomy at a conceptual level, the alignment of the concepts and relations of the ontology with the conceptual model CIDOC CRM[3] (version 6.2.1) followed. Furthermore, the CRMdig[4] (version 3.2.1) model has been reused, which is a compatible model of the CIDOC CRM, specializing in the representation of methods and products of digital representations of movable or immovable CH. Additionally, the SKOS model has been reused for modeling individuals of the ontology, which expresses types of different basic concepts (e.g., types of materials, types of Acropolis parts, types of interventions). To be used as a thesaurus, independent of the ontology, the individuals were initially organized in a different file and then merged into the ontology.

The ontology conceptually represents the wider CnR domain and documentation of stone building material. The number of classes, object properties, data properties and individuals of the ontology (including the extra entities based on the alignment of the ontology with the CIDOC CRM and SKOS ontologies) is presented in Table 1. The classes, properties and individuals which constitute the ontology have been translated into Greek and English.

Table 1: Number of classes, properties and individuals of the CAnTi ontology.

Class count	140
Object Property Count	364
Data Property Count	27
Individual Count	111

The reuse of the classes of CIDOC CRM and CRMdig was accomplished in two ways: first, if the concept is a specialization of a CIDOC CRM/CRMdig class and, second, if the concept is equal with a CIDOC CRM/CRMdig class in terms of its meaning. In the first case, a new class was added, which was also a sub-class of one CIDOC CRM/CRMdig class. In the second case, the equal class of the CIDOC CRM/CRMdig has been recognised and noted for future CnR data modeling.

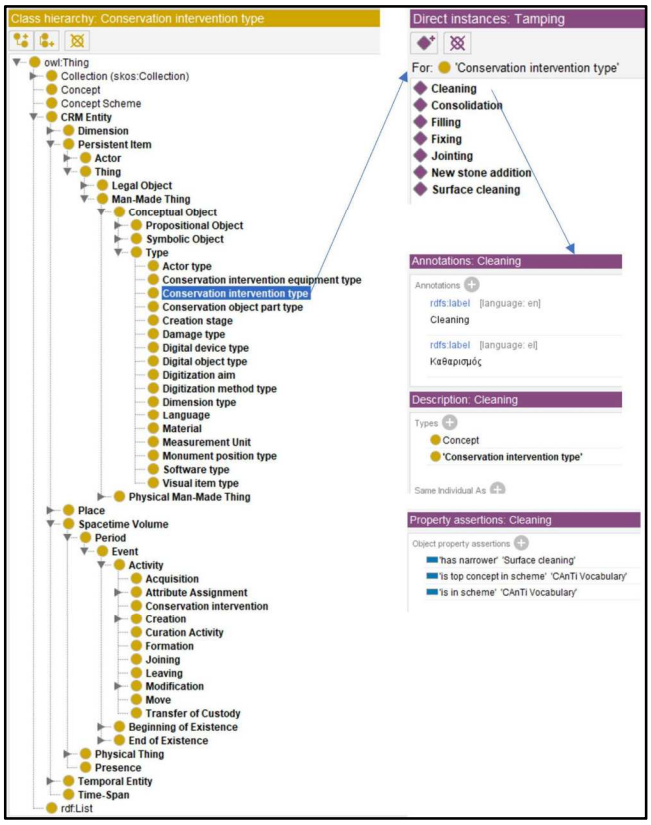

Figure 1. Screenshot of a part of the taxonomy of CAnTi ontology and an example of the individuals of interventions' types (using CAnTi ontology and SKOS for their modeling).

IV. APPLICATIONS FOR OPENLAB OF CNR

In this section, we will present the applications and services that are being developed as part of the *OpenLab* activities at the Acropolis of Ancient Tiryns and aim to enhance the cultural visitors' experience and familiarisation with the CnR processes.

First, an online portal has been developed, which CnR specialists will use to create and manage all the necessary content (e.g., videos of interventions, documentation - text, images, 3D models). At the same time, the public will be able to access the portal before and after visiting the monument.

As we have already discussed (see Sections I and II), the case of the *OpenLab* at the Acropolis of Ancient Tiryns presents significant limitations due to the nature of the interventions. For example, the intervention locations are not easily accessible by the public, while the construction site has specific provisions in place for the number of people allowed each time. Moreover, the audience's presence during the interventions is dangerous, and it will be difficult to secure the desired time for discussion with the specialists. For the aforementioned reasons, the design of a synchronous to the CnR works presentation program is preferable when it includes the presentation of some less dangerous, less complicated and pre-planned interventions.

[3] https://www.cidoc-crm.org/sites/default/files/cidoc_crm_v6.2.1-2018April.rdfs

[4] https://cidoc-crm.org/crmdig/sites/default/files/CRMdig_v3.2.1.rdfs

Since the public will be able to register in a presentation program and get familiar with only a limited part of CnR practice, digital applications will be exploited in order to enrich the visit and provide further interpretation of historical and ongoing CnR works. The applications (Augmented Reality and Virtual Reality) will be available to use during or after the actual visit to the monument or independently from the visit.

More particularly, with the Augmented Reality (AR) application for mobile phones, visitors will be able to navigate inside the monument and see points of interest related to CnR interventions. Also, visitors will be able to see visual and textual material for the periods before, during, and after interventions, as well as any additional documentation information. Through the Virtual Reality (VR) application, cultural visitors can experience a series of interventions in the monument in a three-dimensional (3D) virtual world, comprehend the many stages of its restoration, and see the final aesthetic outcome, all from a mobile or stable device. In addition, cultural visitors can interact with the 3D model to recreate the process.

In the context of the *OpenLab*, activities with a physical presence will be examined experimentally in tandem with digital applications and connect with the project's stated aims. Figure 2 below illustrates the nature and the specific roles of the *OpenLab* applications and activities.

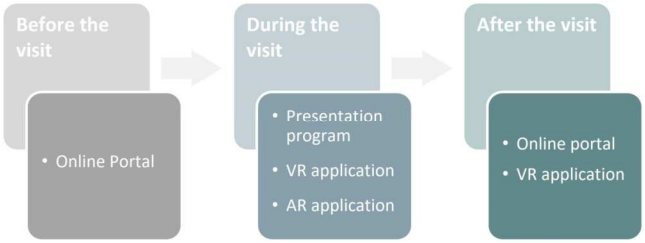

Figure 2. OpenLab applications and activities

V. DISCUSSION

The current research work aims to support the operation of *OpenLab* of the Acropolis of Ancient Tiryns with the design and deployment of a digital integrated approach. The approach exploits SW, AR and VR technologies, making accessible to the public interesting CnR documentation material, both textual and visual, and eventually addressing certain limitations of *OpenLabs*. The limitations of the particular case include i) the presentation of complicated CnR processes in a non-controllable, open-space site and ii) the efficient explanation of CnR processes and their results to the public.

At this point, the ontology, which will be used to model CnR data, has been developed. Additionally, the development of the applications which will support *OpenLab* is in progress.

The next steps of this work include the finalization of the applications development and their evaluation in four basic axes: i) the engagement of the public with the CnR domain through the OpenLab, ii) the comprehension of the information material about CnR interventions presented, iii) the user-friendliness and the efficiency of the applications and iv) the satisfaction of the specialists in terms of their communication with the public. Therefore, we will better understand at which level the proposed approach can facilitate the presentation of the CnR data on behalf of the specialists and improve the overall visitors' engagement and experience.

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