A Digital Data Curation-Based Photogrammetric Acquisition Methodology for Cultural Heritage, expanded with CIDOC CRM Compatibility: protocol BeA-PG

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Abstract

The increasing digitalization of cultural heritage assets and the exponential expansion of digital repositories have created new opportunities for archaeological documenting, preservation, and dissemination. Photogrammetry, a survey approach that uses photographic acquisitions to construct highly detailed 3D models of objects, buildings, and landscapes, is one of the most promising techniques in this field. The effectiveness of the photogrammetric process, however, has still limitations due to a lack of experience sharing and data interoperability, which have resulted from the singularities of the techniques in both process and data format.

To address this issue, this paper proposes a novel workflow for the photogrammetric process, called BeA-PG, developed for the BeArchaeo archaeological project. BeA-PG implements two relevant features for improving the effectiveness: on the one hand, sharing is improved by widening the scope of the process representation from the specific archaeological context to the broader cultural heritage context, by adopting the Digital Data Curation process abstraction; on the other, it improves the interoperability by describing the process with a shared ontological vocabulary, namely the CIDOC-CRM model.

The paper introduces the major features of the photogrammetric process, its description through the abstract flow of the Digital Data Curation process, and its encoding through the CIDOC-CRM vocabulary. We illustrate the BeA-PG workflow and its experimental application in the practical setting of the BeArchaeo project.

1. Introduction

Digital imaging technologies have revolutionized archaeological documentation and analysis. From photogrammetry to LiDAR and Structure from Motion (SfM), these methods offer efficient and accurate recording of archaeological contexts, artifacts, and landscapes. They produce spatially-referenced outputs, such as orthophotos and digital elevation models, that facilitate research, digitization, and public outreach. Various digital acquisition techniques are utilized in contemporary cultural heritage analysis, such as Laser Scanners, LiDAR, and ground-penetrating radar. Laser Scanner has proven effective in archaeological structures at construction sites [FFA⁺¹⁶⁺], LiDAR can reveal hidden architectural archaeological information beneath vegetation [SG⁺¹⁴⁺], and ground-penetrating radar has the capacity to conduct extensive surveys on archaeological structures, even in urban areas where excavation is impossible [BCN⁺⁰⁰⁺].

In digital imaging for archaeology, there have been some efforts in interdisciplinary settings: the use of unmanned aerial vehicles (UAVs) to rapidly document and analyse built cultural heritage applied to record and interpret two surface water cattle tanks constructed by Texas cowboys in the mid-1880s [HJCFC⁺²¹⁺]. On the same path the case of the Mouseion Topos, which thanks to the use of the HERMES methodology, has allowed the reorganization of the digital material concerning traditional local settlements situated at three Aegean islands. In the first case, we have a classic example of the use of digital imaging technologies, in the second a representation of the solutions offered in relation to the organization of already produced data [CNV⁺²¹⁺].

Photogrammetry, one of the main techniques in digital imaging in archaeology, involves the use of specialized software to process photographs or digital images to produce measurements and reconstructions of significant sites, artifacts, and structures [CLO⁺¹⁰⁺]. While new techniques attempt to bridge various approaches and develop novel solutions [BBFB⁺²²⁺, KNT⁺²₂⁺], photogrammetry has emerged as the most widely used technique. It’s because that photogrammetry is also cost-effective compared to other instruments, such as laser scanners, making it an attractive option for cultural heritage professionals. However, it is a survey technique that is not included in a single instrument but is broken down into various software and hardware components (the camera, processing software, and modeling software) and produces a large amount of data. Consider for example the survey of the Sanctuary
of the Great Gods on the island of Samothrace, where, even consid-
ering the adoption of a specific acquisition protocol, the exact num-
ber of photographs is not known but the estimate is around 5000
photographic acquisitions per 1000 square meters of the archaeo-
logical site [BPW21]. These numbers tend to increase dramatically
to the extent that the archaeological context presents characteris-
tics of strong morphological irregularity or complexity of the ele-
vations.

The vast amount of data generated during the photographic ac-
quision process needs effective data organization and manage-
ment to ensure the long-term preservation and accessibility of the
data. Metadata on the accuracy of photogrammetric acquisition is
critical for the proper interpretation and use of data [Rem11]. Meta-
data relating to the camera model, the type of lens of the instru-
ment, the processing software used, the point cloud densification
algorithm, and the reconstruction algorithm are all important. Al-
though mentioned in the literature, they are often detached from the
3D model and then lost, invalidating the scientific legitimacy of the
3D model. The intrinsic modular nature of the photogrammetric ac-
quision, in relation to the large amount of data produced, has led
scholars to start working on structuring a unique acquisition proto-

col. To name just a few of the more recent examples Guidi et al.’s
work on Donatello’s “Maddalena” statue [GBA04]. In this case, we
are presented with a detailed description of the technical aspects
of acquisition, focusing on specific and irreplaceable instruments.
The entire protocol centers around the definition of a specific sur-
vey, providing specific details even on the processing and modeling
machines for the 3D model. While this path is detailed, it offers no
room for generalization and abstraction of the process. Another ex-
ample is Sebar et al.’s work on an abstract acquisition protocol that
outlines defined acquisition paths [SAG*20]. This protocol outlines
a sequential approach to survey activities, encompassing acquisi-
tion and modeling phases. However, it does not allow for the inte-
gration of processes in progress or the inclusion of material from
projects that follow different protocols. It is constrained to scanning
processes that strictly follow a step-by-step progression, limiting its
adaptability to incorporate diverse protocols or ongoing work from
other projects.

Although we observe the design of different acquisition and pro-
cessing protocols that do not share guidelines or lack a unique on-
tological and formal system that allows for metadata comparison
and the challenges regarding interoperability in cultural heritage
have already impacted the research field [KFH09] also making it
difficult to collect information for those projects whose purpose
is precisely to bring together the information collected from dif-
ferent projects, such as the case of the project ARIADNE, an e-
infrastructure that integrates archaeological datasets from various
institutions and achieves interoperability through the use of con-
trolled vocabularies, thesauri, gazetteers, and ontology [RFG16].

Therefore, if we consider ontology and a modular process
marked by fundamental steps for the intercommunication of data
and metadata, as well as the importance of creating and adopting a
methodology that can be understood both by humanists and com-
puter scientists, it seemed clear to us to turn to already existing
and widely shared ontologies, vocabularies and abstractions which
could be the basis for structuring the BeA-PG workflow.

The effort to which it tends is in fact that of not creating an ac-
quision and processing path that works within the research project
that generated it but which on the contrary proves to be adaptable
to different archaeological contexts and which can also act as a tool
of communication and interpretation of existing protocols. For this
reason we turned to Digital Data Curation to produce an abstrac-
tion of the phases, and to CIDOC-CRM as regards ontology and
vocabulary or, more specifically, Digital Data Curation, for stan-
dardizing digital processes related to cultural heritage [MSMJ19],
and CIDOC-CRM, for providing a shared formal encoding of pro-
cesses and data, to create a shared database schema [BCG17].

As we are about to illustrate, the working hypothesis of this pa-
per is to develop the description of processes and data for the case
of photogrammetric acquisition from these general frameworks.
We illustrate here the main tenets of a protocol, named BeA-PG,

erased on the fundamental assumptions of Digital Data Curation
and CIDOC-CRM models. We start with the abstraction of the
photogrammetric case in the sense of the Digital Data Curation,
to exploit the constraints and formats that have been developed for
the general case of cultural heritage and then provide a formal encod-
ing by exploiting the terms provided by the CIDOC-CRM model.
The goal is to make a protocol abstraction that can provide a com-
parison base for the protocols in the field.

The paper is structured as follows: state of art of general frame-
works for photogrammetric acquisition in archaeology, a brief in-
troduction to Digital Data Curation and CIDOC-CRM, the preli-
mary development of a BeA-PG in the context of the abstraction
of Digital Data Curation and the encoding of CIDOC-CRM, and
conclusions. This line of research is still ongoing but hopes to be
able to allow for the development of a shared formal description of
processes and data, creating a shared schematic database.

2. State of the art

Magnani et al. and Howland et al. have analyzed the role of pho-
togrammetry in contemporary archaeology, highlighting its use-
fullness as a rapid and economical tool for digitization and pub-
lic outreach. However, despite its widespread use as a visual aid,
in both studies, they show how its analytical potential remains
underdeveloped [MDS*20]. Nevertheless, photogrammetry advan-
tages, including speed, precision, cost-effectiveness, and adaptabil-
ity, have made it a successful tool in archaeology. Techniques de-

ived from photogrammetry, such as LiDAR and Structure from
Motion (SfM), have expanded its capabilities in creating GIS out-
puts, while low-altitude aerial photography can facilitate the pro-
duction of 3D models [CSRG19]. Photogrammetry has also shown
the ability to replace outdated or expensive mapping tools, as
demonstrated in Cleverger’s study [Cle27].

In addition to its advantages, the widespread use of photogram-
mety in archaeology and cultural heritage has led to a vast amount
of data and raises concerns regarding the management of large
virtual archives [AE09]. The storage, structuring, and appropriate
management of territorial data obtained through these techniques
remains challenging and is limited by the capabilities of spatial
database management systems [OEW019]. As a result, scholars of-
ten focus on technical issues related to digital space management,
theorizing new solutions for its management, but tend to neglect
the theoretical and methodological aspects or place them in a sub-
ordinate function to hardware issues [MMF+23]. Such confusion in
data set management poses the risk that, once the project produc-
ing the data and metadata is completed, the absence of a reusable
or compatible ontological storage methodology may result in the
abandonment of project data and the subsequent loss of informa-
tion [FKK+13].

The adoption of standardized formats represents the most effec-
tive solution to address the fragmentation of digital archaeological
data [KS22]. Standardization allows data to be harmonized and
 interoperable across multiple platforms, enabling integration and
the development of advanced analysis and visualization tools.
However, the implementation of standard formats requires a com-
mon understanding and agreement within the archaeological com-
unity. Nevertheless, the benefits of standardization outweigh the
effort required to implement it, offering greater opportunities for
knowledge sharing and collaboration in the field of digital archaeol-
ogy [Zh021]. Recognizing the significance of abstract methodolo-
gies in developing photogrammetric protocols, we propose that an
ontology-driven and methodologically grounded protocol can serve
as a valuable tool for both new and existing projects. Such a proto-
col would encompass common categories found in other workflows
and provide a framework for incorporating specific terms from dif-
f erent contexts into a shared ontology. By embracing a shared on-
tology, protocols can extend beyond their original scope and effec-
tively address the semantic construction of protocols, as demonstr-
ated by the Inception Protocol. This approach not only offers a
functional tool for project implementation but also promotes co-
erence and interoperability across diverse photogrammetric work-
flows. [GMP+17]. Other projects have focused on specific proto-
cols for particular categories of objects [RMK20], while some research has not focused on structuring a protocol but on evaluat-
ing acquired three-dimensional models [NMR14]. These protocols,
subjected to a verification and recognition of the shared substantial
contents hidden under the surface of a formal difference, could com-
 municate with each other.

3. Abstract models and the application to photogrammetry

As we have observed, in the context of digitalization in archaeol-
yogy, it is crucial to have a more shared view at some abstract level,
even up to employing a standardized vocabulary. The abundance of
data generated by digital technologies presents challenges in man-
aging large archives, leading to the risk of losing valuable infor-
mation if there is no standardized methodology for archiving and
managing data. Using an ontological and methodological approach
can offer not only a functional tool for new projects but also pro-
vide a framework for integrating previous protocols developed in
other projects. By adopting a shared vocabulary and ontology, we
can ensure compatibility and coherence between different projects
and facilitate the reuse of data. Therefore, a common vision and a
standard vocabulary and ontology are essential for advancing digi-
talization in cultural heritage, enabling a more comprehensive un-
derstanding of the objects and their contexts. In order to provide
a shared vocabulary we need first to produce an abstraction from
the specific approach and describe it in some general terms. This is
why we have approached Digital Curation framework.

Digital Data Curation is the practice of managing, preserving,
and adding value to digital data throughout its lifecycle. This in-
volves ensuring that data is stored in a secure and accessible man-
ner, while also adhering to ethical and legal obligations. Curation
activities may include organizing and describing data, selecting ap-
propriate storage and backup methods, creating metadata, and en-
suring long-term preservation through digital archiving [Hig08].

The field of Digital Data Curation has become increasingly im-
portant as the amount of digital data produced continues to grow
rapidly, particularly in the context of cultural heritage institutions.

Digital Data Curation requires a deep understanding of both the
technical and scholarly aspects of the data being managed, as well as
a commitment to ensuring that the data remains usable and ac-
cessible over time. Despite the success of Digital Data Curation,
only a few projects in photogrammetry make reference to it [LL23].
Among these, we can cite the CuFOTO project, which refers exclu-
sively to religious architectural structures [GMS+17]. Generally,
with few exceptions [KLD+20], Digital Data Curation is not a refer-
ence for the digital archaeological field. In 2019, Fernandez wrote
about the relationship between photogrammetry and digital cura-
tion, referring to it as a "Digital Drama" [Fer19].

On the other hand ontologies and thesauri play a fundamental
role in the development of shared terminological vocabularies for
digital databases in various domains, including cultural heritage.

These tools provide a standardized and structured approach for
organizing and defining the concepts and relationships within a par-
cular domain, enabling a more efficient and effective search and
retrieval of information from multiple sources. The CrossCult
project, funded by the EU, uses semantic technologies to model
and semantically link disparate pieces of cultural heritage infor-
mation, aiming to change the way European citizens appraise his-
tory [VBKM+17]. Freire et al. assess the usability of ontologies
by crawlers operating on the data web [FdV19], while Doerr’s re-
fection attempts to represent and define ontologies in cultural her-
itage from a point of view of classification and absolute ontolog-
ical value [Doel99]. Because the use of ontologies and shared vo-
cabularies has the potential to facilitate interoperability, data in-
tegration, and data reuse, which are crucial for the preservation
and dissemination of cultural heritage great effort has been de-
voted to the development of these shared ontologies and vocabu-
laries. That commitment has led, in the field of cultural heritage,
to the creation of the CIDOC Conceptual Reference Model (CRM)
that has emerged as the main reference ontology for the manage-
ment of databases and information in cultural heritage [BCG17].

This ontological model for cultural heritage data has been de-
veloped by a specific committee of the International Council of Mu-
seums (ICOM). It provides a formal structure for describing and
linking cultural heritage information, such as objects, events, ac-
tors, and their relationships. The CRM is a high-level ontological
model that provides a common vocabulary and a framework for
integrating data from different sources, enabling interoperability
and data exchange between different systems. It is designed to be
domain-independent, flexible, and extensible, allowing the model-
ing of complex cultural heritage information. CRM is widely used
in the cultural heritage domain and has been adopted by many insti-

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tutions and projects worldwide. It is continuously maintained and updated by the CIDOC CRM Special Interest Group, which ensures its relevance and adaptability to new challenges and requirements in the field of cultural heritage [BCG17].

While the CIDOC-CRM has been used in previous archaeological projects, these have been limited to highly specific cases. For example, the GROPLAN CIDOC-CRM is employed to increase compatibility with the Java programming language [BCG17]. The VENUS European project also utilized the CIDOC-CRM to structure ontology for training an artificial intelligence in underwater photogrammetry [DMH*15]. In both cases, we observe an exceedingly specific utilization of CIDOC-CRM, maintaining a high level of class, domain, range, and property usage. However, the focus is excessively limited to the particular use case, rendering the abstraction intended for method transmission impracticable at this level. Despite the theoretical emphasis on cultural heritage and the existence of initial efforts to implement the CIDOC-CRM in a holistic vision that addresses ontological needs and overcomes practical obstacles in organizing digital data within a project [LKG22, LDKM20], research on the application of CIDOC-CRM in relation to photogrammetry has predominantly remained abstract. There is a lack of established position that bridges the gap between specific protocols and the broader theoretical application. It is necessary to develop a framework that mediates between the theoretical foundations of the CIDOC-CRM and the practical challenges encountered in organizing digital data, in order to effectively utilize this tool in photogrammetric applications [CSPD10]. In conclusion, there is a need for a more balanced approach that considers both the theoretical and practical applications of the CIDOC-CRM in photogrammetry.

4. BeA-PG workflow and CIDOC-CRM encoding

The BeA-PG workflow is a photogrammetric acquisition method designed for archaeological object surveying. Developed in the context of the BeArchaeo project, it comprises five main phases: Acquisition, Processing, Modelling, Exporting, and Archiving, each further divided into subphases that detail the methodological actions to be taken for successful completion (Figure 01). The pre-archiving system, which generates a unique code for each 3D model, involves creating a folder structure that includes folders for photographs and model data. The entire protocol is built upon the logical categories established by Digital Data Curation, and although not identical in name, the two systems overlap to a significant extent. Efforts are currently focused on making the BeA-PG model encoded with CIDOC-CRM. While the protocol has been used in specific contexts, such as the archaeological project BeArchaeo, its implementation is highly adaptable and can be applied in diverse contexts to enhance the accuracy and completeness of archaeological surveys. The ultimate goal of the BeA-PG protocol is to improve data interoperability and promote collaboration across diverse projects.

The BeA-PG protocol was initially conceived with a phased structure that aligns with the ontological representation of entities, ensuring compatibility with the CIDOC-CRM vocabulary. The emphasis was placed on identifying intersections between the original framework and the classes and entities provided by the CIDOC CRM, facilitating seamless integration. The central focus of the scheme is the E24 Physical Human-Made Thing, which represents the archaeological object and the 3D digital model. The survey activity, referred to as E12 Production, acts as the intermediary between the physical and digital representations of the archaeological object. To fully understand the scheme, it is essential to appreciate its expanding nature. The production of the survey can be broken down into various activities, including acquisition, processing, modelling, exportation, and archiving. Each of these activities produces physical components of the 3D model. These components comprise the Texture, Point Cloud and Mesh, all of which are also expressed as E24 Physical Human-Made Things. However, the scheme is designed to describe a unique case, that of an individual archaeological object. A process of abstraction becomes necessary to move from the production of a single object to the acquisition protocol, which is expressed as an E29 Design and Procedure (Figure 02).

In order to accurately classify and analyze operational sub-phases, it is necessary to establish a connection between these sub-phases and their corresponding. Typologies for this reason the protocol was re-designed to identify commonalities between the original scheme and the classes and individuals offered by the CIDOC CRM, with a focus on the E24 Physical Human-Made Thing, which represents both the archaeological object and its corresponding 3D digital model. The E12 Production serves as a vital intermediary in the protocol, facilitating the conversion of the archaeological object into a virtual representation, the 3D model. This transformation not only makes the 3D model an integral part of the protocol but also establishes it as a virtual manifestation of the original archaeological object. The decision to assign the 3D model the status of a Physical Object rather than an Information Object was carefully considered. Within the BeA-PG protocol, the 3D model serves a functional purpose that requires it to be treated and managed based on broad and complex properties, which would be limited if considered solely as an Information Object. Moreover, in the context

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**Figure 1:** Representation of the general scheme of BeA-PG. The main phases are distinguished: Acquisition, Processing, Modeling, Export, and Archiving.
of manipulating the 3D model, it is more practical and functional to treat it as a Physical Object rather than an Information Object. In fact, the CIDOC manual itself suggests treating virtual objects as Physical Objects since they are human-made.

The BeA-PG production process is broken down into various activities, including acquisition, processing, modeling, exportation, and archiving, each producing physical components of the 3D model, such as Texture, Point Cloud, and Mesh, which are also expressed as E24 Physical Human-Made Things.

However, the protocol is designed to describe a single case, that of an individual archaeological object. Abstraction becomes necessary to move from the production of a single object to the acquisition protocol, which is expressed as an E29 Design and Procedure.

To accurately classify and analyze operational sub-phases, it is essential to establish a connection between these sub-phases and their corresponding. Typologies, as expressed in the E55 Type property. This can be achieved through the use of the "P67 refers to" property, which enables the relocation of each protocol phase with each previously described activity. The relationship between E7 Activity, P2 Type, E55 Type, and E29 Design and Procedure allows each activity to be classified based on its corresponding Typology and designated a specific sub-phase in the overall procedure.

The establishment of clear and concise connections between sub-phases and Typologies is crucial to ensure accurate identification and classification of each phase and activity. The CIDOC has demonstrated its effectiveness in accurately defining the temporal relationships between different stages and sub-stages, which is crucial in the development of 3D models using the BeA-PG photogrammetric acquisition protocol. This allows researchers to discern interrelated stages and sub-stages and identify crucial dependencies required for progression. The temporal scan is also vital for identifying phases that follow a logical but not necessarily sequential relationship and those that are strictly sequential in nature.

The CIDOC thus plays a crucial role in facilitating thorough research and the effective development of sophisticated 3D models. Figure 02 provides an overview of the protocol, while Figure 03 depicts the relationship between E7 Activity, P2 Type, E55 Type, and E29 Design and Procedure. Figure 04 and Figure 05 illustrate how the CIDOC accurately defines temporal relationships between different stages and sub-stages, providing researchers with a comprehensive understanding of the complexities and nuances of the 3D model being produced. Specifically, we observe how the archaeological object (Archaeological Object 01) undergoes the Survey process, resulting in the creation of the 3D model (Physical Human Made Object). The 3D model is then decomposed into its physical components, namely the Texture, Mesh, and Point Cloud. From there, we can examine how these components are generated through the various phases of the protocol, which are represented in Figure 01 but categorized according to the classes and properties of the CIDOC CRM (Figure 02 and subsequent).

5. Application of the BeA-PG methodology and the CIDOC CRM in a case study: project BeArchaeo

We use them to represent a case study extracted directly from the BeArchaeo project. The Be-Archaeo project focuses on the archaeological excavation of the Tobioticsuka Kofun in Soja City, Okayama Prefecture, along with the study of other Kofun burial mounds and related archaeological material in the ancient Kibi and Izumo areas (present-day Okayama and Shimane Prefectures). The project aims to explore rituals, regional relationships, and the formation of ancient states in Japan. Collaborating archaeologists from Europe and Japan, together with a diverse team of archaeometry experts (including chemists, physicists, biologists, geologists, petrographers, veterinary surgeons, and soil scientists), conduct advanced research on this significant period of Japan's early history.

Within this project, a considerable amount of archaeological artifacts from the Okayama area and the Tobioticsuka site needed to be photogrammetrically recorded. The 3D models generated constituted part of the metadata, combined with archaeometric analyses and observations from archaeologists, which were then incorporated into the Omeka-s database. Additionally, a portion of the
that refers to the same artifact, providing us with the following information: Description, Archaeological Finding Record, Object definition, and directly related object, initially found in, chronology.

Currently, a copy of the card that is present in the database can be used to access the information on the BeA-PG protocol’s card via an interlink that is present in the database card. In addition to making the data more readily accessible, the coincidence between the BeA-PG protocol and CIDOC CRM aims to archive and store more data in an organic way, enhancing the archival fusion between the BeA-PG protocol’s output and the data kept in the Omeka-S-based database. In order to assess the outcome, we have therefore retrieved the schema created thus far and added the AF MNM 005 artifact to it.

5.1. The BeA-PG protocol applied to other protocols

One of the most important aspects of the BeA-PG protocol is that it does not seek to replace other protocols designed in different contexts, but rather to function as a means of communication with other significant protocols in order to increase interoperability and contribute to the enrichment of the metadata they produce, with a view to the eventual integration of the information into a coherent database. The case of Colonia Dacica Sarmizegetusa by Adriana Antal et alii presents itself as an acquisition protocol focused on the final rendering of three-dimensional models in the context of an interactive virtual presentation for a museum. By applying the BeA-PG protocol, we can begin with the interactive itself (which is situated in the Archiving phase as the endpoint), deconstruct the implementation process, and break down all the various parts that make up the interactive, cataloging the 3D models and breaking them down into their essential parts, such as texture, mesh, and point cloud, and associating them with the informative metadata present in the final interactive. From the various components, the production processes of the models will be deduced, thus returning to the base of the Acquisition phase and merging a new organic arrangement of all the material related to this project into
a database that communicates with the CIDOC-CRM, thereby allowing the project to obtain all the systematically produced original information. In the case of the Inception Protocol [GMP16], since it is already a sequenced protocol for phases aimed at digital acquisition, we can imagine an ontological coincidence between the various phases of the Inception Protocol and those of the BeA-PG protocol in order to achieve adaptability to CIDOC and thus to a possible final database. Action 01 of the Inception Protocol (Common Framework for cataloging methodology) coincides with the first sub-phases of the Acquisition phase, which are of an analytical nature, and already in this first phase, we can organize reorganization and other speculative activities on the artifact so that the metadata produced, from the acquisition path to the actual acquisition, are organized while imagining the Space and Time factors already provided by the Inception Protocol to which we add the Typology voice provided by the BeA-PG protocol's archiving. As for Action 02 (Integrated data capturing), it converges in the second group of sub-phases of the BeA-PG Acquisition phase, distributing and organizing not only the data and metadata derived from the actual survey and potential analyses of the archaeometry on the artifacts but also punctually managing the *consecutio temporum* of the survey phases. At this point, Action 3 (Semantic Model for cultural heritage) no longer becomes a detached process but is pre-announced by the preceding phases, with all the data prepared for their insertion into a semantic database and following step by step the Elaboration phase, guiding the manipulation of the model in the Modeling phase and in which each step is recorded, thus directing it towards Action 04, which is no longer the insertion into an Inception platform but a broader database based on the principles of CIDOC-CRM and thus communicable with any database of the same type, preserving this relationship between data and metadata even in the final Archiving phase in which both Action 04 and Action 05, Deployment and Valorization, coexist. Ultimately, the comparison and application of the BeA-PG workflow in relation to the Inception protocol demonstrate that there is no need to envision a specific ontology for each project or invent a separate ontology for digital surveys. The shared ontology and vocabulary are already embedded within the BeA-PG survey protocol. This organization of ongoing materials showcases the potential of utilizing the BeA-PG workflow to establish communication with other existing protocols and methodologies.

6. Conclusions

In conclusion, this paper presents an experimental encoding of photogrammetry for digital documentation, preservation, and dissemination of cultural heritage assets. The BeA-PG workflow aims to represent the process in the specific archaeological context and extend it to the broader cultural heritage context using a shared ontology, particularly the CIDOC-CRM framework however always taking into account the conceptual guidance provided by Digital Data Curation services as a methodological and conceptual guide for the entire protocol.

The case study demonstrated the effectiveness of the BeA-PG workflow in decomposing every single component of a photogrammetric survey of an object and preserving all related metadata, which can lead to new data and sources of inspiration for big data management. This method has been shown to reconcile time and cost needs with survey activities and facilitates interoperability and sharing across several photogrammetry protocols, enabling the integration of data from various sources. The BeA-PG workflow provides a promising approach to photogrammetry and contributes to the efficient digital documentation and preservation of archaeological assets. In the next future, we are going to validate the workflow in further projects and yield a stable version of the protocol, to be widely applied to the large realm of archaeological projects.

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