Ontological Patterns for Modeling Art Exhibitions: An Initial Investigation

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Abstract. Exhibitions play a crucial role in shaping art history by defining artistic movements and promoting visual canons. However, current models fail to capture their complex dynamics, especially in terms of contingency and participation. This study proposes a framework for modeling catalog-derived and database-derived exhibition data, by employing a bottom-up approach based on two major datasets: the Artl@s BasArt project (catalog-derived) and the MoMA Exhibition Index (database-derived). Developed using CIDOC-CRM, a de-facto standard ontology in the heritage domain, the model specifies ontological patterns for documenting key aspects of exhibitions, such as their temporal duration, spatial extension, mereological structures, source of knowledge, the role of its participants and the function of the artwork exposed. The adoption of the proposed model facilitates the integration and analysis of diverse exhibition data, enabling a comprehensive and richer understanding of the spatial, temporal, and participatory dimensions of each exhibition, helping to contextualize their reach and impact within the global artistic milieu, and enabling better data-driven studies in digital art history and cultural analytics.

Keywords: Ontology · CIDOC-CRM · Exhibitions · Cultural Heritage · Digital Art History

1 Introduction

With the increasing availability of digital museum resources researchers can now potentially explore the circulation of art and artists across the globe. Catalogues raisonnés and exhibition catalogs provide crucial information on what has been produced by an artist as well as where and when it was exhibited. However, studying exhibitions reveals more than just what was exhibited and by whom. Exhibitions have also played an important role in shaping art. They have mediated the history of forms through the circulation of ideas, images, and works. They are a primary medium for the construction [30] and reinforcement [1,2] of the artistic canon. They bear witness to developments in the artistic field, and "highlights the connections between art and other realms, such as commerce, and they reveal politics and policies of an institution" [8]. The datafication of exhibition information opens the door to novel methodologies (e.g., distant reading)

M. Sfakakis et al. (Eds.): MTSR 2024, CCIS 2331, pp. 256–267, 2025.
https://doi.org/10.1007/978-3-031-81974-2_22

to study exhibitions, overcoming the limitations of the single case study, and helping investigate at global scale phenomena such as the (i) geography of art, (ii) the development of the artistic milieu, (iii) the process of patrimonialization, and (iv) the impact of the curatorial discourse. However, the integration of exhibition datasets presents complex ontological challenges that heavily restrict the possibilities for transversal studies of exhibition history. Interconnecting scattered collections through a shared conceptualization is, therefore, a matter of urgency, specifically given the rise of data-driven studies in fields such as Digital Art History and Cultural Analytics [16,22]. This contribution focuses on the development of an initial ontological model for integrating and analyzing different types of exhibition data (catalog-derived and database-derived). The article investigates the ontological nature of exhibitions, and how to express and/or harmonize its diverse characteristics, specifically with respect to the expression of contingency and participation patterns. The purpose is to create a framework, based on CIDOC-CRM, for the conceptualization and formalization of key aspects found in exhibition data. After an initial literature review (Sect. 2), the article expands on the identity criteria and ontological requirements for modeling exhibitions, listing in 3.2 seven important characteristics to consider: Objects in events, Participation, Temporal duration, Spatial extension, Contingency relationships, Mereological structure, Knowledge Source. Section 4.1 introduces the strategy used and the two datasets employed for guiding the development of the model (Artl@s BasArt and MoMA). Finally, Sect. 4.2 discusses challenges and limits of current ontological patterns and presents the results.

2 Literature Review

Linked data have been used in the cultural heritage sector [9] to provide access to museum catalogs [10,28], architectural reconstructions [17,23], photo archives [14], or iconographical objects [3,6]. Even if the use of computational data for studying exhibitions has widely been recognized [15], and numerous exhibition datasets have recently become available via *ad-hoc* interfaces[1] or data export[2], not much work has been done to develop ontological models for exhibition documentation. Rodríguez-Ortega and her team have developed a new ontology for the description of art exhibitions [27], specifically focusing on the annotation of their discursive and social layers.

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[1] To cite a few: Artl@s (https://artlas.huma-num.fr/en/artlas-bases-de-donnees-en-acces-public/), Database of Modern Exhibitions (https://exhibitions.univie.ac.at/), Salons (https://salons.musee-orsay.fr/).

[2] To cite a few, the MoMA dataset mentioned in the article, the Zürich Kunsthaus (https://github.com/KunsthausZuerich/exhibitions), the Cooper Hewitt, Smithsonian Design Museum (https://github.com/cooperhewitt/collection).

3 Functional Requirements

3.1 Information Analysis

Exhibition information typically originates from two primary sources: catalogs and databases. Catalog-derived data generally result from the automatic or manual extraction of the content of an exhibition catalog, a publication aimed to describe and document the exhibition for the general public. Catalogs record the title of the exhibition, when it was held, where it was held, who participated, and with which artworks. Additional information may pertain to the presence of a committee, of illustrations representing a specific work, the address where to contact the artist, his availability to sell the presented artwork, a small artist biography, and his relation to existing and affirmed artists. Database-derived data generally result from the extraction of a selection of records from an internal database or database-like application. These records document the exhibition for management purposes, serving the institution's internal audience. For this reason, the focus is on the organizational machine behind the exhibition itself. These records tend to describe in detail who organized the exhibition and in which role.

3.2 On the Nature of Exhibition

We can define a few characteristics that a model for documenting exhibitions must consider.

Objects in Events. The objects exhibited may be present for the complete duration of the exhibition, or just for a smaller temporal segment (temporary presence). The role of the object in the exhibition may be generic or specific. An example of the latter is the use of a specific object to promote the exhibition itself. Objects may be owned by the organizers of the exhibition or by an external entity (e.g., a private owner, or another institution). An exhibition may display material objects, digital/virtual representations as well as host performances.

Participation. Exhibitions can be collaboratively developed within an institution. A model should differentiate between the degree of involvement of the various agents (e.g., constant/temporal), as well as be capable of formalizing their role (e.g., artist, curator, arranger) within the exhibition (e.g., direct/mediated).

Temporal Duration. Exhibitions always comprise a temporal component (start/end date) which may be known/unknown or precise/imprecise. Temporal relationships should be able to express our knowledge about the event no matter the granularity of information available (year, day, decade, century). We should be able to order exhibitions based on absolute and relative temporal information (e.g., before, after).

Spatial Extension. Exhibitions unfold in space, such as in specific museums or galleries. They may take place in a room within an institution or within multiple rooms. The same exhibition can be held at multiple places (different institutions) at the same time (e.g., virtual exhibitions) or at different times (e.g., traveling exhibitions). Multiple exhibitions can occur in the same space, for example in the same room at the same museum/gallery.

Contingency Relationships. The model should differentiate between activities performed prior to the exhibition, which are directly linked (CAUSE) to the creation of the exhibition itself (e.g., curation), and activities that are key to its development, hence they aid (ENABLE) its creation (e.g., loans) [31].

Mereological Structure. Exhibitions may be documented as having multiple parts/stages. It is the case of traveling exhibitions, which are designed to be moved and displayed at multiple locations at different times or, at the same time. Each identified stage of a traveling exhibition may have its own starting and ending date.

Knowledge Source. Exhibitions are documented through internal database-archival records or using one or more media, such as catalogs, videos, images, and advertisements.

4 Data Modeling

4.1 Strategy

To provide a model able to sustain documentation and analysis of catalog-derived and database-derived exhibition information, it is paramount to analyze the characteristics of an exhibition and how they can be documented. Generally, the source used for answering such a query can be retrieved by studying a domain (top-down) or by analyzing how exhibitions are described in existing information structures (bottom-up). Both methods have their advantages/disadvantages. Bottom-up approaches adhere to the concreteness of the data and encourage a culture of reuse, but result in the proliferation of details that make it difficult to integrate datasets. Top-down approaches help create artifacts reusable across diverse application scenarios but restricted in scope [12]. This contribution integrates the two approaches, developing a set of requirements and characteristics (see 3.2) based on the domain and its source, while at the same time iteratively refining and comparing the theoretical requirements with information present in two major exhibitions datasets: BasArt[3] and the MoMA Exhibition Index[4].

BasArt is a collaborative database of exhibition catalogs [20]. At the time of this writing, it documents 5653 exhibitions from the 19th century to the

[3] https://artlas.huma-num.fr/map/.
[4] https://github.com/MuseumofModernArt/exhibitions.

present day. Part of the Artl@s project, BasArt provides researchers access to a wealth of information beyond the traditional European and North American sources. Every exhibition in the database is recorded using a comprehensive set of descriptors including temporal information about the exhibition, artwork exhibited and by whom, as well as many details of the artists involved. The recorded data focus mainly on four entities, the exhibition itself, its participants (artists), the artwork exhibited, and the source used for the description (catalog). The diversity of the catalogs recorded in BasArt, and its global reach make it the perfect use case for developing a model for catalog-derived exhibition information.

MoMA Exhibition Index Dataset documents 1.788 exhibitions held at the Museum of Modern Art in New York from 1929 to 1989. The dataset, released in 2016, has been compiled as part of the Exhibition History, a project of the Museum of Modern Art Archives. For every exhibition held during the documented period at MoMA, we may retrieve a series of descriptors focusing on who organized (and in which role) and who participated in the exhibition. The focus on the dataset on the recording and documentation of the internal activities of a single modern and exemplary memory institute makes it the perfect use case for developing a model for database-derived exhibition information.

The work presented here not only provides mappings of the data described in these two sources but also analyzes the underlying characteristics of the information (a summary of how the characteristics in 3.2 apply to each analyzed dataset is available in Table 1). These information requirements will then be mapped onto CIDOC-CRM ontological structures, illustrating deficiencies and pinpointing aspects that need to be enhanced or integrated into the ontology to better fulfill the described use case. Additionally, this analysis aims to lay the informational groundwork for potential future expansions of the model by incorporating new requirements that are presently unaddressed because of limitations in data extraction technologies.

4.2 Model and Analysis

We model exhibitions as perduring entities, i.e. they happen or occur in time. Thus, they exist as temporal entities, the same as events or activities. Their identity is not linked with a fixed list of artworks, as the works of art exposed at the beginning of an exhibition may differ from the ones exposed at its end. While this may appear ontologically odd at first, it is not that very different from describing a fighting army that moved from point A to point B. It is clear to every reader that such a statement does not imply that all the participants moved, or all the participants indeed survived [24]. What is clear is that the identity of the army does not change from A to B. The spatial coordinates where an exhibition took place cannot be used as identity criteria either, as an event may occur in several places at different times. Similarly, several temporal events can occur in the same place. Space is not a criterion of identity for events, because events have a spatial projection but no spatial dimension [18]. The identity of an Exhibition is temporal and it may be composed of several shorter segments or phases $(p_1, p_2 ... p_n)$

temporally defined in that they can occur parallelly or sequentially and at different locations [11]. Exhibitions result from extensive work by diverse actors in different roles. This type of work starts to take place prior to the starting date of the exhibition and may last until the exhibition is finished. These activities can be modeled as part of the exhibition itself or as a separate part. Choosing one approach over the other is highly contingent on the available data and the aims of the modeling process. The proposed modeling presents the exhibition as composed of two parts: (x) the exhibition itself (identified by the opening/closing temporal boundaries) and the (y) exhibition management, which involves all the coordination, design, and implementation activities that bootstrap the exhibition and, in some cases, continue until the exhibition end. Using this modeling we can precisely document the agency, work, and role of each of the exhibition participants. Different ontologies can sustain these modeling choices, including DOLCE, Event-Model-F, and FARO [4,25,26,29]. Due to its popularity within memory institutions, the data has been modeled using CIDOC-CRM, a standard ontology developed under the aegis of ICOM (International Council of Museums) to aggregate information about cultural objects and activities. CRM is actively developed, and it features several official/unofficial extensions that help formalize a diversity of statements about cultural heritage objects and practices [5]. CRM has the advantages of being an event-centric model and information is represented through events. As mentioned above, exhibitions are perdurant, therefore we can model them in CRM as a single activity (`crm:E7_Activity`). Among the formalized classes and properties in CRM (and its extensions), there are a few particularly interesting ones for the documentation of exhibitions, specifically with respect to the requirements outlined in Sect. 3.2.

Table 1. Summary of the diverse information characteristics present in the model and how they are reflected in the analyzed datasets.

Model Characteristics	BasArt	MoMA
Objects in events	Tangible objects	Tangible objects
Participation	Full involvement	Full and partial involvement
Temporal duration	Precise temporal information	Precise temporal information
Spatial extension	Address or city information	N/A
Contingency relationships	During	Pior and during
Mereological structure	Travelling exhibitions and pavillions	N/A
Knowledge Source	Catalog	Associated documents

Objects in Events. Exhibitions can display tangible objects, born-digital artworks, and host performances. We can link each of these exhibited items to their respective owner using the property `crm:P52_has_current_owner`. It is possible to document the display of a material object using `crm:P16_used_specific_object`. Using the CIDOC-CRM extensions LRMoo[5] (formerly FRBRoo) and CRMDig[6], it is also possible to document the presence of performances (`lrmoo:F31_Performance`) as well as digital objects (`crmdig:D1_Digital_Object`). We can even define the specific role each of these items/performances plays within the exhibition, for instance, documenting that "a photo of the artwork β was used for advertising the exhibition x". It is possible to formalize such a statement using the n-ary constructs available in the CRM properties of properties (.1 pc extension). However, this solution is only partially satisfactory, as the resulting pattern is quite complex (a total of five triples, and three of them are used only for the n-ary construct).

Mereological Structure. The ontology does not formalize explicitly the notion of phase. However, each activity can be composed (`crm:P9_consists_of`) by different temporal segments. We can use this pattern to model traveling exhibitions, where each move/stage can be modeled as a single segment of a larger activity (Fig. 1). We can use the same pattern to document the temporary presence of artworks within the exhibition. This parthood relationship makes it possible to record the different stages of the exhibited collection, instantiating multiple `crm:E7_Activity` as the number of documented stages. Therefore, if fifty artworks are present across the whole exhibition, but twenty are present for only half the time, we can instantiate two (`crm:E7_Activity`) sub-activities, one representing the temporal segment where fifty artworks are exhibited, and a second one representing the segment when seventy are present.

Temporal Duration. Temporal relationships between the documented exhibition segments can be specified using time and time-relationships properties. The latter are extensively documented in CRM (e.g., `crm:P183_ends_before_the_start_of`), and the scope note of the properties do specify their equivalences to Allen operators. One of the advantages of using CRM is the availability of both precise and imprecise temporal properties. While a larger discussion on how to model precision is surely needed [7], the ontology features two types of temporal statements, `P81a/P81b` and `P82a/P82b`, that help define the level of precision of the recorded temporal statements.

Spatial Extension. The level of detail in the spatial information linked to an exhibition is a matter of encoding rather than modeling. CRM leaves to the user the specifications of the exact type of place where an activity occurred. This information can be encoded using reference resources (e.g., a vocabulary entry) or using WKT (`crm:P168_place_is_defined_by`). The use of WKT is particularly beneficial as it defines the precise point or polygon that represents the geographical area where the exhibition took place. These approaches can be combined using an external vocabulary to qualify the status of the WKT coordinates (e.g., city/address/building).

Contingency. CRM includes two properties that express contingency relationships between events: `crm:P17_was_motivated_by` and `crm:P20_had_speci`

[5] https://cidoc-crm.org/lrmoo/.
[6] https://cidoc-crm.org/crmdig/.

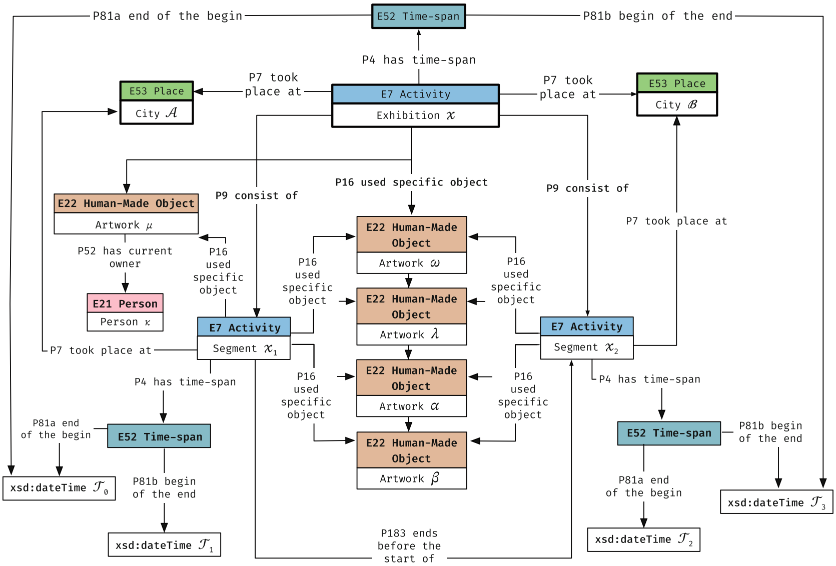

Fig. 1. Graphical Representation of the modeling of a travel exhibition. We can document the exhibitions in City $\mathscr{A}$ and City $\mathscr{B}$ as two distinct (but linked) stages (called x_1 and x_2) of the same exhibition x occurring in different places and at different times. The modeling showcases the possibility of documenting the diverse artworks displayed at the different stages of the exhibition. In the example, segment x_1 is linked with artwork μ while segment x_2 is not. The two exhibition stages have specific and different temporal boundaries and are further linked together by a relative temporal statement (crm:P183_ends_before_the_start_of).

`fic_purpose`, with `P17` being the closest property for indicating causation. However, the scope note of the latter does mention that it describes "items that are regarded as a reason for carrying out the instance of E7 Activity", which does not express exactly that the outcome of one activity leads to the occurrence of another. P20 instead expresses the "relationship between a preparatory activity" and a subsequent event. While there is no direct causation, this property expresses a type of temporal dependency [13]. Quality change dependencies in events [19,21] are not yet present in CRM at the moment of this writing. Due to this reason, the final modeling can only rely on P20 to express the causal relationship between the management activity ($E7_y$) and the resulting exhibition ($E7_x$). Additionally, some activities may have been conducted prior to the exhibition that, even if unsuccessful, do not change the existence of the exhibition itself (DESPITE according to [31]). It is the case of refused loans, which are recorded internally. Negative actions are quite difficult to translate into CRM. Recently, the CRM-SIG worked on the development of an extension for the formalization of plans: CRMAct[7]. Currently under development, and not yet formalized in

[7] https://www.cidoc-crm.org/crmact/.

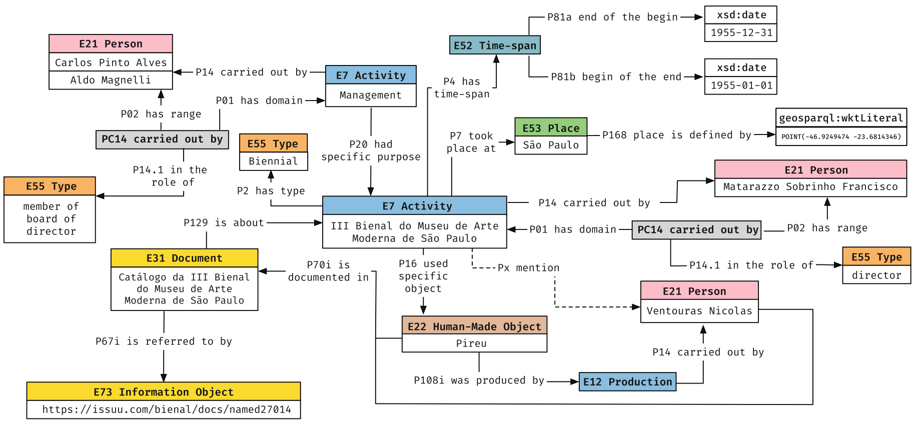

Fig. 2. Graphical Representation of the modeling of the III Bienal do Museu de Arte Moderna de São Paulo. By separating the management stage from the exhibition itself, it becomes easier to classify the contributions of different agents, specifically preparation and direction. The roles of the different agents in each event are expressed using a combination of .1 properties and internal vocabularies. The catalog is modeled as the primary source of historical knowledge, documenting the presence of artworks (and their authors) in the catalog

RDF, the extension uses the concept of Activity Plan and Event Template to define "not yet happened" activities, such as proposals for conservation work. However, CRMAct is about future activities and plans and, therefore, cannot be used to document unsuccessful past plans.

Knowledge Source. The source of the recorded information can be annotated in CRM by linking (`crm:P70_documents`) an entity with the source or document (`crm:E31_Document`) that attests its existence and accuracy. In the context of exhibitions, the catalog usually serves as the main source, and it is linked to the location where it can be retrieved (e.g., URL; archive).

Participation. Currently, CIDOC-CRM lists only two properties for defining types of participation: `crm:P11_had_participant` (involvement in the event) and `crm:P14_carried_out_by` (implies causal or legal responsibility). Differentiating involvement from responsibility is crucial, but participation can be specified with a few new sub-properties. For example, the nature of a curator's participation in the creation of an exhibition differs from that of an arranger, particularly in terms of directness and causality. However, in CRM we would use the same property, leaving the comprehension of the differences in participation a matter of external knowledge, as such distinctions are not captured within the property's semantics. This problem arises also in the case of agents who act indirectly upon an exhibition, by approving it or making it financially possible. In this instance, the use of P14 does not tell us very much about the action. To specify this type of information we would have to create a specific sub-activity documenting it. While possible, the most effective solution would be to use directed/mediated participation properties, such as the ones formalized in BFO. Moreover, the properties used by DOLCE of constant participation (participation during the whole temporal extension of the activity), and temporary participation (participation only during a segment of temporal extension of the activity) [4,26] should also be considered, as they help specify the type of participation of an agent in an activity. Each of these novel participation properties may be formalized as sub-properties of `P14` or `P11`. There is another important problem linked with participation, and it relates to artists. Do artists participate in the exhibition? Some of the exposed artwork may not have a living creator, thus we may say that artists are only present and involved through their artworks and are not direct participants. Using CRM, we can document that an artwork, created in a production event by an artist, is used by an exhibition. However, theoretical accuracy can sometimes obscure the work's practical objectives. This is not a very pragmatic solution, specifically because analyses of exhibitions tend to focus first and foremost on the artists who participated. The absence of a direct property to list them is quite inconvenient. While it is possible to use `P11`, it may suggest that a deceased individual is involved in events taking place after his death, potentially leading to significant issues if automatic data enrichment processes are in use. If participation in an exhibition does not involve presence, surely it involves a type of mediated or indirect contribution or at least a direct reference.

The requirements outlined above have been mapped into a CIDOC-CRM model[8] (illustrated using an example in Fig. 2). The proposed framework, while rooted in established CRM patterns, provide a pragmatic solution that balance the existing capabilities of the ontology and the nuanced demands of exhibition representation.

5 Conclusion

This paper presents an initial investigation of the ontological requirements for modeling art exhibitions, addressing both catalog-derived and database-derived information. Leveraging CIDOC-CRM, the study develops a model that accommodates the complex nature of exhibitions, including their temporal, spatial, and participatory dimensions. The research underscores the limitation in expressions of current ontologies, specifically with respect to contingency and participation patterns, and advocates for the improvements of ontological models to better capture the multifaceted nature of exhibitions. The proposed model formalizes the established requirements using core concepts and relationships of CIDOC-CRM while illustrating their deficiencies and pinpointing the aspects that need to be enhanced to better match the intended meaning of the data.

Despite the identified limitations in capturing the data nuances by CRM's class and properties, the proposed model was successfully used to (i) transform

[8] Given the limitation of the paper a full version of the model is available on GitHub:https://github.com/ncarboni/Exhibitions.

a large subset of information from the BasArt database, as well as (ii) transform the MoMA Exhibition dataset in RDF. This work made it possible to query and analyze two major sources of exhibition information, enabling the use of distant reading methods for analyzing artistic exchanges across the Atlantic in the 20th century. These practical applications highlight the model's potential, particularly as a flexible foundation for the further ontological developments required in order to attain a comprehensive documentation of exhibitions.

Disclosure of Interests. The author has no competing interests.

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