A Vocabulary of Culturally Relevant Relationships to Interlink Digital Heritage Objects over the Web Using LOD Technologies

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Abstract. In recente years many cultural heritage institutions such as archives, libraries, and museums are publishing their collection as digital objects over the Web. Since ever such institutions have the mission of the curation and safeguarding of the memories of societies. The patrimonialization and curatorial processes developed by heritage institutions are continuous value-adding processes based on consolidated methodologies. The representation and publication of cultural heritage records as digital objects using LOD—Linked Open Data—technologies are new steps in this patrimonialization and curatorial processes. Many collections are thematically superimposed, complementary, and have synergy. Frequently these collections present culturally relevant relationships between their objects, like a book about a painting or a draft or sketch of a famous painting, etc. This research aims at characterizing such culturally relevant relationships, compiling an inventory, and organizing them in a vocabulary. The implementation of culturally relevant relationships as semantic links using LOD technologies can achieve interoperability between digital collections and improve their usability.

Keywords: culturally relevant relationships, vocabularies, digital collections, heritage institutions, linked open data, semantic links, interoperability.

1 Introduction

Since the end of twentieth century heritage institutions are publishing their collections as digital objects over the Web. Archival, library, and museum collections are still dependent on catalog systems and technologies that do not allow full integration between their own data and with another resources available throughout the Web. LOD technologies enable digital records from different archives, libraries or museum collections to be directly published over the Web. The potentialities of such collections increase as they constitute a distributed linked data archive [12]. Proposals are also made to discover and improve links between such collections [13]. What are the relationships between digital objects originated from collections of different heritage institutions? What are the relationships between Cervantes Saavedra's Don Quijote de La Mancha and several etchings by Pablo Picasso on this theme?

The representation and publication of cultural heritage records as digital objects using LOD technologies is a whole new step in the patrimonialization and curatorial processes developed by cultural heritage institutions. LOD technologies enable direct publication of digital collections and thus their integration into the mainstream Web. Many of these collections are thematically superimposed and complementary, having synergies not yet explored.

Frequently these collections present culturally relevant relationships between their objects, like a book about a painting, a draft or sketch of a famous painting, a letter from an author commenting a book or an artwork, or a contract to commission a sculpture or artwork, etc. What types of culturally relevant relationships may exist between digital objects of collections in archives, libraries, and museums? How can such relationships be discovered and identified? How can LOD technologies be used to implement such relationships as semantic links? How could such relationships be useful for art, history, or culture curators to annotate sets of digital heritage objects?

This paper reports new results of ongoing research [9] that aims at discussing and characterizing such culturally relevant relationships, compiling an inventory of such relationships, organizing them in a vocabulary, and discussing how semantic links expressing them should be derived from the databases of catalog systems. The implementation of semantic links using LOD technologies can achieve interoperability between digital collections and improve their usability, thus empowering heritage institutions. The paper is organized as follows: after the introduction, section 2 describes the materials and methods used and the assumptions made related to precisely characterizing what objects we are relating and what their digital representations are; section 3 develops a framework for the analysis of the relationships collected; section 4 presents the relationships found; and section 5 provides final remarks and conclusions.

2. Material and Methods

Use cases or examples of relationships between objects of different heritage collection are suggested by curators, or collected in literature, and used as examples of possible relationships. Conceptual models such as the FRBR, the CIDOC CRM, the EDM, the RiC-CM were also examined as sources of possible relationships.

A framework to analyze and organize the collected relationships was developed, based on the top-level relationship schema between entities of Groups 1, 2, and 3 of the FRBR model.

Access through the Web to collections of heritage objects presupposes their representation in digital formats. The digital objects that are published and interlinked throughout the Web using LOD technologies are indeed artifacts, even if the original object it is based is a natural object [9]. In this sense, they are social creations [11] created based on archives, libraries, and museum descriptive methodologies and

standards. They are complex digital objects, here called HO—digital heritage object—identified by a unique persistent identifier, along with metadata that provides context, access points, and enables their management in the digital environment. These metadata sets are associated with digital images of the physical object.

3. A framework to analyze relationships between cultural heritage objects

A framework to analyze the suggested relationships was developed. It consists of a table cross-relating heritage objects (HOs) according to the type of heritage institution: archives, libraries and museum heritage objects. To these HOs "monuments" (monHO) was also added, as there are several suggested use cases that include relationships between archives, libraries, and museum objects with monuments. Such objects are related to other objects, namely Agents (FRBR Group 2 Entities), Concepts, Processes, Time and Place (FRBR Group 3 Entities). The table is shown below.

Table 1. Relationships between heritage objects

	aHO	lHO	mHO	monHO	Agents	Concepts	Events	Time	Place
aHO	*11*	*12*	*13*	*14*	15	16	17	18	19
lHO	*21*	*22*	*23*	*24*	25	26	27	28	29
mHO	*31*	*32*	*33*	*34*	35	36	37	38	39
monHO	*41*	*42*	*43*	*44*	45	46	47	48	49
Agents	51	52	53	54					
Concepts	61	62	63	64					
Events	71	72	73	74					
Time	81	82	83	84					
Place	91	92	93	94					

Each table cell may contain a direct relationship – a semantic link - from the entity represented by the specific line (its *domain*) to the entity represented by the specific column (its *range*). For example, cell 23 represents a relationship between a library Heritage Object (lHO) and a museum Heritage Object (mHO). As we ask for heritage institution curators to suggest cases of relationships between objects in collections of different heritage institutions, the framework developed reflects relationships where domain and range are objects in archives, libraries, and museum collections. Archives, libraries, and museum objects may be further specialized in different types of objects as is usual in archive, library, and museum collections management. The table is an analytic device that will enable a synthesis to be achieved. All relationships are also types of the *associative relationship*, largely used in thesaurus theory and construction.

"Dependence" is a fundamental criterion to analyze and classify relationships. Are there several types of dependence? Following Guarino and Welty [3], [4] on "existential dependence" and IFLA [6] on "referential" and "autonomous" relationships, we question if any of the relata in the relationships found is existentially dependent on the other? Are any of them dependent on the other in any other sense? Searle [11] discusses "subjective judgments," "observer-relative features" of reality, and features

that are "ontologically subjective." Are both relata independent? Do any of the relata depend on a subjective judgment from their creator or from a third party agent: a curator, a literary critic? Hessen [5] notes that any knowledge is always knowledge of something, knowledge is a relation between an agent and an object, the agent is *intended for* the object. Dahlberg's [2] concept theory, suggests the existence, among the formal relationships, of *intersections relationships*, such as those relating objects that share at least one property.

To analyze and evaluate possible relationships provided by use cases or collected, each relationship is assigned a label, is described, examples are given, and questions are asked as follows: do any of the relata existentially depend on the other? Is there an inverse relationship? Are there other types of relationships between the two types of objects? Are there similar relationships in other conceptual models, vocabularies, or ontologies?

4. Results

What are culturally relevant relationships? For the purposes of this work, those are conceptual relationships that contextualize and enhance the cultural comprehension of a heritage object. They may be *Direct* relationships, such as between a book and a painting inspired on it (e.g., the work *Don Quijote de La Mancha* and the aquatint by Picasso portraying Don Quijote and Sancho Panza[1]), or *External* relationships. Such are relationships between HO and external entities as Agents, Concepts, Events, Time and Place. Such relationships, provided in the FRBR model, for example, the relationships between a painting by Claude Monet and the concept (subject) Impressionism art movement or between heritage objects that share the same author (the FRBR Group 1 relationships to Group 2 and 3 entities).

Culturally relevant relationships may be *automatically derived* from records in catalogs, such as between two works with common properties, such as the title in the previous example of Don Quijote, or between a work and its author. Yet they can also be *authorial:* different cultural experts and curators, such as art and literary critics, historians, educators, journalists, scholars, etc., discover, illuminate, evaluate, relate to, interpret, and show different points of view about historical facts or processes, historical characters, and artifacts, etc. While doing their job, these experts may find or propose authorial relationships between such entities not previously perceived by anyone else. We plan to develop such distinction in future works.

4.1. Criteria for analyzing the relationships.

From the theoretical bases used and from this inventory of relationships, emerged an initial set of criteria for the organization of the relationships found. Such criteria are something like what Guarino and Welty [3] call "meta-properties."
- *Cultural association (CA)*: when there is a relationship between two HOs established not by the creator of any of them, but by a third-party agent, for example, by a

[1] See https://www.moma.org/collection/works/68157

curator, a literary or art critic. Cultural association means that the two HOs are existentially independent.
- *Cultural dependence (CD)*: when two HOs have a relationship established by the creator of one of them; the creator of one HO *intended for* the other HO; the two HOs are both artifacts.
- *Cultural independence (CI)*: when two HOs have a relationship established by the creator of one of them, the creator of one HO *intended for* the other HO, but only one of the HOs is an artifact, whereas the other one is originally a natural object.
- *Existential independence (EI):* when the two HOs exist independently of each other.
- *Existential dependence (ED):* when the existence of one HO in a relationship is dependent of the existence of the other HO in the same relationship. It is the inverse relationship of EI.
- *Intersection (IS)*: both HOs share at least one common property.

Another criterion that seems to define the way two HOs are related is the type of *expression form*, or how each object is expressed or manifested. In this sense and according to previous research [9], the following types of expression forms exist:

- (originally) natural objects
- artifacts
  - image
    - -iconographic (paintings, drawings, etchings, photographs)
    - moving image
  - textual
    - one-copy textual (documents, letters, deeds)
    - -various-copy textual (books, manuscripts or print copies)
  - sound
  - objects (images of three-dimensional objects).

4.2. Relationships identified.

Direct relationships (between two HOs):
Based_on relationship between different types of HOs. It presupposes an original, previous work and another based_on work. It encompasses all kinds of pragmatic replicas or artistic copies, re-creations, revisits, and re-readings of a work; it is concerned directly with works in the FRBR model sense. A work is based on another if the based-on work carries at least one property of the base work: -a book (lHO) which is based_on another (lHO): cell 22; -an artwork (mHO) which is the base for another (mHO): cell 33; -a monument (monHO) which is the base for another (monHO): cell 44.
-Example: many literary works are *based_on* Shakespeare Hamlet's[2], such as *Hamlet for Kids (Shakespeare Can Be Fun!)* by Lois Burdett; the design of Federal Hall in New York City is *Based_on* the design of the Parthenon in Athens[3]; the different

[2] See https://en.wikipedia.org/wiki/Literary_influence_of_Hamlet
[3] See https://en.wikipedia.org/wiki/Federal_Hall

Based_on versions of Da Vinci's *Mona Lisa* by artists such as Dali, Botero, Andy Warhol, etc.
-Criteria: CD, IS; both HO share the same expression form.
-Do any of the objects depend on the other? Existentially, both objects do not depend on each other but (we suggest), from a cultural standpoint, the *Based_on* works would not have existed if the original work did not exist.
-Inverse relationship? Yes, the *Base_for* relationship.
-Other types of relationships between the two types of objects? The *Design_or_Procedure_for* relationship.
-Are there similar relationships? *crm:P15 was influenced by (influenced)* and *frbr:is a transformation of, has adaptation, has an imitation* relationships.

Design_or_Procedure_for relationships: -between architectural plans (aHO) and a monument (monHO): cell 14; -between an artwork (mHO) and their preparatory sketches (mHO): cell 33.
-Criteria: CD.
-Example: the architectural plans of MAC Niterói and the monument itself; the preparatory sketches and *Guernica* by Pablo Picasso; the preparatory sketches and the "War and Peace" panels by Brazilian artist Candido Portinari at the United Nations headquarters in New York.
-Inverse relationship? Yes, the *Design_or_Procedure* relationship: cells 11 and 33.
-Similar relationships? The *crm:E29 Design or procedure entity*, used with the *crm:P69 has association with* relationship.
-Other types of relationships between the two types of objects? No.

Documents relationship between a field notebook (aHO) and the objects it documents (mHO): cell 13.
-Example: Darwin's Beagle's expedition field notebook[4] and the species collected by him.
-Criteria: CI; the range HO has the form expression *textual*.
-Inverse relationship? The species in a museum *is_Documented_by* a field notebook: cell 31.
-Are there other types of relationships between the two types of objects? No.

Has_as_Subject relationships: -between a painting or drawing (domain mHO) that has as subject a book (range lHO): cell 32; -between a book (lHO) which has as subject letters (aHO): cell 21; -between a book (lHO) which has as a subject a book (domain (lHO); -between a book (lHO) which has as subject a monument (monHO) cell 24; -between a letter (domain aHO) commenting on or describing a book and the book itself (range lHO): cell 12; -between a letter (domain aHO) commenting or describing an artwork and the artwork itself (range mHO): cell 13.
-Criteria: CD; the range HO has the form expression textual.
-Example: La Joconde : essai scientifique / sous la direction de Christian Lahanier[5], as many other books, has as a subject, or describes, or analyses, Da Vinci's *Mona*

[4] See http://darwin-online.org.uk/EditorialIntroductions/Chancellor_fieldNotebooks.html
[5] See https://lccn.loc.gov/2008456582.

Lisa; a letter from Brazilian writer Machado de Assis to his colleague Joaquim Nabuco commenting on the idea for a future book, *Memorial de Ayres* [7]; the book *Brunelleschi's Dome: The Story of the Great Cathedral in Florence* [8] has as subject the construction of Brunelleschi's Dome of Santa Maria del Fiori cathedral;
-Inverse relationship? The *Is_Subject_of* relationship between a painting or drawing (mHO) which has as subject a book (domain lHO): cell 32; or between a monument (monHO) which is the subject of a book (lHO): cell 42.
-Similar relationships? The "is the" relationship *frbr:has_as_subject*, or *edm:P120 is about (is subject of).*

Influenced relationship: -between a work which influenced the creation of another work *according to someone*.
-Example: according to several literary critics, the work Don Quijote by Cervantes Saavedra *influences* many others; any of the two HO is intended for the other.
-Criteria: CA, EI.
-Inverse relationship? The *Influenced_by* relationship.
-Similar relationships? The *dbpedia:influenced* relationship.
Inspired: Relationship -between a book (domain lHO) which inspired a painting or drawing (range mHO): cell 23; -between an artwork (domain mHO) and a book (range lHO): cell 32.
-Example: the previously mentioned book *Don Quijote de La Mancha* by Cervantes Saavedra and an aquatint by Picasso portraying Don Quijote and Sancho Panza; or the romance *Iracema* by the Brazilian writer José de Alencar and a painting with the same title by José Maria Medeiros[6]; or the Da Vinci's *Mona Lisa* and the romance *Mona Lisa Overdrive* by William Gibson[7], among many others.
-Criteria: CD; the two HO have different expression forms.
-Inverse relationship? The *Inspired_by* relationship.
-Other types of relationships between the two types of objects? The *Has_as_Subject* relationship between a book (domain lHO) which has as subject a painting or drawing (mHO) or the *Is_Illustrated_by* relationship between a book (domain lHO) which is illustrated by a painting or drawing (mHO, of type iconography).
-Similar relationships? The relationship *wikim:inspired.*

Is_Illustrated_by relationship: -between a book (domain lHO) that is illustrated by a painting or drawing, (range mHO, of type iconography): cell 23.
-Example: the Aristophane's *Lysitrata* edited by the Limited Editions Club, which is illustrated by six signed etchings of Pablo Picasso; James Joyce's *Ulysses* 1935 edition illustrated by Henri Matisse's rare etchings.
-Do any of the objects depend on the other? In this case, it seems to apply the FRBR (IFLA, 1998, 66) *referential* relationship. Matisse's etchings are components of the Ulysses edition, they would not have existed if the edition did not exist.
Criteria: CD, domain lHO has the expression form textual, range mHO has the expression form iconographic.
-Inverse relationship? The *Illustrates* relationship.

[6] See https://pt.wikipedia.org/wiki/Ficheiro:Iracema_hi.jpg.
[7] See https://en.wikipedia.org/wiki/Mona_Lisa_Overdrive.

-Other types of relationships? The *frbr:Has_as_Subject* relationship between a book (domain lHO) which has as subject a painting or drawing (mHO); the *Inspired* relationship between a book (domain lHO) which inspired a painting or drawing (range mHO).
-Similar relationships? *crm:P65 shows visual item* or *crm:P46 is composed of (forms part of).*

Portrays relationship: -between an artwork (domain mHO) of type iconography and a monument it portrays (range monHO): cell 24.
-Example: several paintings made by French Impressionist artist Monet portraying the Rouen Cathedral[8].
-Criteria: CD; range mHO has the expression form iconographic.
-Inverse relationship? The *Is_Portrayed_by* relationship: cell 43.
-Other types of relationships? No.
-Similar relationships? The *crm:P62 depicts (is depicted by)*.

External relationships.
Such are relationships between HOs and external entities: Agents, Concepts, Events, Time and Place. Taking the FRBR model as a basis such relationships may be *thematic relationships* (*has as subject relationships*), or various other kinds of specific relationships (*is_created_by*, *is_realized_by*, *is_produced_by*, *is_owned_by* FRBR relationships Group 1 to Group 2 relationships). There are also other kinds of relationships between HOs and external entities not provided for in the FRBR model, those that provide context to HOs, as the *crm:P8 took place on or within (witnessed)*, between a *Period* and a *Physical Object*, and *crm:P12 occurred in the presence of (was present at)*, between an *Event* and a *Persistent Item*.

The following kinds of relationships are found.

Has_existential_participation relationship: - between HO (domain) to which an Agent (range) contributed to its existence (domain): cells 15, 25, 35, and 45; or between HO (domain) to which an Event (range) contributed to its existence (domain): cells 17, 27, 37, and 47;
- Example: the book *Don Quijote de La Mancha* (domain: lHO) and Cervantes Saavedra (range: Agent); the Monalisa (domain: mHO) and Da Vinci (range: Agent); the Dome of Santa Maria del Fiori Cathedral (domain: monHO) and Brunelleschi (range: Agent); the work Isagoge (domain: lHO) by Porfírio and its translator, Boethius (range: Agent); also a volcanic stone sample (mHO) and the eruption of Vesuvius volcano (range: Event).
Criteria: ED.
-Inverse relationship? Existential_participation relationship: cells 51, 52, 53, and 54; cells: 71, 72, 73, and 74.

Has_physical_proximity_or_contact relationship: - between an HO (domain) which at any moment was physically close or has contact with an Agent (range): cells 15, 25,

[8] See https://en.wikipedia.org/wiki/Rouen_Cathedral_(Monet_series)

35, and 45; or between an HO (domain) which at any moment was physically close or has contact with an Event (range): cells 17, 27, 37, and 47.
- Example: the Rosetta Stone (domain: mHO) and the French Scientist Jean-François Champollion (range: Agent); or the pen (domain: mHO) with which Princess Isabel signed the law of the abolition of slavery in Brazil (range: Event).
Criteria: EI.
-Inverse relationship? *Physical_proximity_or_contact* relationship: cells 51, 52, 53, and 54; cells: 71, 72, 73, and 74.

An initial proposal of a schema is as follows:

- Associative relationships
  - HO HO relationships
    - Cultural affinity relationships
      Based_on, Has_as_Subject, Influenced, Inspired
    - Descriptive/Referential relationships
      Documents, Is_Illustrated_by, Portrays
    - Genetic/Planning/Sketch relationships
      Design_or_Procedure_for
  - HO external entities relationships
    - Thematic relationships
    - Contextual relationships
      - Has_existential participation relationships
      - Has_physical proximity_or_contact relationships
      - Time_context
      - Place_context

5. Conclusions

This is an ongoing research, the results presented and the schema proposed herein are provisional and a starting point to be discussed, tested and enhanced.

The publishing of digital collections over the web opens new opportunities to heritage institutions. It enhances access, enables reuse, and achieves full integration of collections to the mainstream Web, thus enlarging their reach and synergies. Such synergies can be exploited as culturally relevant relationships are established between the digital objects of these collections implemented as LOD links. The interlinking of resources from different institutions provides rich contexts not available by OPAC technologies [10]. The reciprocal implementation of LOD links between heterogeneous and distributed digital collections requires cooperation, coordination and curatorial activities on a new level. It can also achieve interoperability across the boundaries of cultural heritage institutions, and improve usability between collections, thus empowering and reshaping heritage institutions.

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[9] http://cnpq.br/.