A Parthood Approach for the conceptual modelling of Tangible Objects Composition (TOC) - an application on Cultural Heritage (CH)

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Abstract. Several semantic web approaches tend to address and solve the problem of integrating multidisciplinary rich content using Linked Open Data. Cultural heritage (CH) is a multidisciplinary domain that contains a massive heterogeneous content that varies distinctly by types and properties and is managed by different organizations. Various semantic web approaches have been proposed in the context of CH, and at multiple integration levels (local, national, international). These approaches focus on metadata schemata integration but give no significant importance to the representation of a tangible cultural heritage object, as an entity and the different parts that compose it. Knowing that the preservation and restoration of CH artifacts is an important goal in the CH field, we aim at modeling the content of this domain by representing the composition of a cultural heritage object and studying its evolution with time and space. In our present work, we illustrate the first part of the approach which is a parthood approach for the conceptual modeling of the composition of a tangible object in general, with the application on CH objects in particular. To do this, we introduce some parthood concepts and properties that are used for representing the composition mechanism. We limit the possible cases of part-whole relations in tangible objects to 7 cases and choose a corresponding logical/ontological part-whole relation(s) for it. This resulted in introducing also a hierarchy of tangible object types. We plan to build and implement our approach using OWL2 as the ontological language for our linked open data approach.

Keywords: Conceptual modeling · Composition relations · Part-Whole relations · Cultural heritage.

1 Semantic web approaches in Cultural Heritage (CH)

Cultural heritage is the legacy of physical artifacts and intangible attributes of a group or society that is inherited from past generations [1]. It includes a wide range of studies for the restoration and preservation of the physical pieces of evidence of the past. Although this content varies distinctly by types and properties, it is semantically richly interlinked.

Several semantic web approaches have been proposed, built and implemented at multiple integration levels (local, national, and international). Examples of approaches are the Europeana data model [2] (aiming at greater flexibility and expressivity for designing a metadata schemata), the CIDOC CRM [3] (focusing on the possible types of objects and 3 main composition relations), FRBRoo [4] (establishing a formal ontology to represent the underlying semantics of bibliographic information), cultural heritage integrated into the framework of INSPIRE [5] [6] (creating an abstract model of 3 main parts: legal, documentary and cultural, and representing a cultural material/non-material entity), ABC Ontology [7] (to research models and methods for describing the variety of content that is increasingly populating the web and digital libraries, and out of which is the CH content), CultureSampo [8] (a prototype system for integrating the context of the Finnish culture on a Finnish national level).

Problem statement One of the main problems in cultural heritage is the schema integration problem [9]. Most approaches tackle the problem of schema integration focusing on constructing the metadata schemata. However, they give no importance to the cultural heritage object itself, the descriptions of its parts, its composition, history, preservation, and restoration.

2 Our approach

Our approach addresses the goal of studying the representation of a tangible cultural heritage object and its evolution with time to build the necessary information needed for its preservation and restoration.

For the representation part, we model the composition of a tangible object using part-whole relations between entities. The idea furthermore is to offer rich top-level semantic contextualization for the representation of the composition elements using part-whole concepts and properties in general, with an application to cultural heritage objects in particular. This is done in a way to enable complex semantic and spatial operations on these objects by building a language of tangible object composition using description logics. For the evolution part, we plan to model changes that alter tangible objects, taking into consideration its composition, concerning spatial and temporal constraints.

In this work, we present the components of the first part of our approach, which is a parthood approach for modeling tangible objects composition (TOC) with some examples from the cultural heritage field.

Part-whole relations The study of part-whole relations between entities has been an active area of research several domains [15]: conceptual and object-oriented modeling [10] [11], knowledge representation and reasoning about objects, spatial representations [12] [13], cognitive sciences, linguistics, and philosophy [14]. Here in our proposed approach, we plan to use a combination of part-whole relations based on Winston's part-whole relations taxonomy and properties [14], Varzi's ontological/logical aspect using mereology [10], Bittner's and Donnelly's ontological/spatial aspect [12] along with RCC8, the qualitative spatial aspect [13]. The choice is based on the context's needs and the part-whole relations that would best represent it.

3 Components of the TOC approach

To model the composition of a tangible object using part-whole relations, we present the components needed:

1. Parthood concepts, presented in a hierarchical graph, and their formal definitions. First, we have the two main concepts in parthood science: Whole W and Part P. Then, we differentiate conceptually, at a concept distinction level, between 3 subconcepts of W and P: Absolute-Whole AW (is a whole and not a part i.e. has entities that are parts of it but itself is not part any other entity), Part-Whole PW (is a whole for a certain entity and is a part for another entity) and Absolute-Part AP (is a part and not a whole i.e. itself is a part of a certain entity but does not have any entities that are part of it). After that, we differentiate at a property distinction level between 2 types of wholes according to their part entities: Basic-Whole BW (whose part is an absolute whole) and Non-Basic-Whole NBW (whose part is a part-whole). Last, we have the 4 combinations of whole concepts according to the concept and property distinction levels: Basic-Absolute-Whole BAW, Non-Basic-Absolute-Whole $NBAW$, Basic-Part-whole BPW, Non-Basic-Part-Whole $NBPW$.
2. Parthood properties (hierarchical manner) and their formal definitions.
3. TOC automaton to represent the composition of a tangible object. This graph representation uses nodes and arcs, to represent the parthood concepts and properties, respectively.
4. The 7 cases of part-whole relations in tangible objects, including 5 part-whole relations from Winston's taxonomy [14] (area/place, collection-member, object-stuff, integral object-component, and mass-portion) and 2 proposed additional ones (area-object and sequence-element), 3 properties of part-whole relations from Winston's taxonomy [14] (functional F, homemerous H and separable S) and 1 additional proposed property for relations (Existentially Dependent E), and a hierarchy for tangible object types.

4 Next Setps

Combining all that preceded in one TOC model by building the TOC ontology that encompasses all the TOC components in one complete approach, based on the best practices and principles of the Semantic Web and Linked data efforts, using OWL2.

Modeling Changes that alter a CH object using the TOC model, taking into consideration the different composition levels of the object. Also, linking the changes semantically according to a cause and effect relation, that is, for every change, a pre-change and post-change can occur.

Spatiotemporal modeling of the composition of a tangible object, including all the changes that altered it, with the space and time constraints. Also, we will be able to inference and reason new knowledge about the changes that altered an object.

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