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An Ontology Design Pattern for Modeling Experimental Paradigms

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Abstract. We present an ontology design pattern for modeling scientific experiments and examinations conducted in a clinical research study. Integrating heterogeneous data into a common ontological model is a challenge, redoubled if we want them to be explored later. In order to facilitate the development of dedicated ontological modules, this design pattern relies on invariants, is centered on the event of the experiment, and keeps the link to the original data.

Keywords. Ontology Design Pattern, Biomedical Ontologies, Biomedical Research.

1. Introduction

The PsyCARE project[2] aims to improve early detection and intervention in psychosis, and to offer personalized therapeutic programs. Different studies are implemented in the project, the main one being multicenter. The data collection platform is the single point of access for end-users to the data submitted by the data producers. The conceptual model of the data collection platform is provided by a modular ontology whose domain modules correspond to the heterogeneous data collected: clinical, brain imaging, biology and molecular biology [3], speech analysis [7], motor assessment [8] data. The role that ontologies can play in data integration and exchange by enabling semantic interoperability is well established [2]. In order to facilitate the integration of these data into different dedicated ontological modules, the preservation of provenance metadata, the exploration of the data and their subsequent reusability, we propose in this paper an ontological design pattern centered on experimentation events that can be broadly applied to experimental paradigms from different disciplines.

2. Methods

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The data we have just mentioned are heterogeneous by the context in which they are produced, by the scientific models that underlie them, by the formatting and exchange practices that apply to them, and even by the lexicon developed by each field to designate its objects and methods.

2.1. Common elements

However, we can point out common elements to these data production processes: the *object of study*, the *carrying out of an experiment* - experiment that obeys the same *protocol* for the different objects of study and that first generates a *concrete product* from which *measurements* or assessments are made. The protocol, prior to the realization of the experiments, necessarily provides an *instrument* for the capture of the concrete product, and implies possibly a conditioning (that will be referred to as "*instructions*") of the object of study or of the agent performing the experiment, allowing to ensure the comparability of the results obtained, as well as one or several *stimuli* to condition the phenomenon studied - in order to refine the observation.

2.2. Ontological commitment

The ontological modules developed for the different data sources are part of a modular ontology for which a foundational ontology and a core ontology for medical data have been developed previously. *ontoPOF* is a foundational ontology that preserves strong compatibility with endurantist foundational ontologies (e.g. BFO[3] or DOLCE[4]), but opens up possibilities for representing the temporal dynamics ("change") of entities [5]. *ontoDOME* is a core ontology for the health domain that models knowledge as it is exchanged or described in medical documents, rather than as it would exist in the minds of medical experts. This choice, based on a view of ontologies as digital artifacts that extend the human cognition of those who store and those who explore large amounts of data, promotes data traceability. These ontological commitments lead us (i) to preserve a parallelism between the protocol and the experiment that realizes it - in order to be able to compare the project and its realization; (ii) to interpose, between an experiment and the measures to which it gives rise, the generated data (Fig. 1), and this at different levels of granularity (study, visit, examination, data collection, data collection stage).

2.3. State of the art

An ontological design pattern is a model that can be used to solve a recurring ontological design problem [6]. The identification of such a pattern is based on the observation of invariants in data, objects, processes and relationships. Ontological design patterns (OPs) can be of several types [4]: structural, reasoning, correspondence, presentation, lexico-syntactic, and content OPs. The latter, which propose models concerning the content of a particular domain, correspond to what we propose here. A keyword search on the website of the *Association for Ontology Design & Patterns*[5] (ODPA) does not give any result for the subject we are dealing with. But some ontologies propose models of

[3] Basic Formal Ontology

[4] Descriptive Ontology for Linguistic and Cognitive Engineering

[5] http://ontologydesignpatterns.org/

scientific experiments or clinical examinations. *EXPO*[6] proposes a methodological characterization of scientific experiments in order to annotate them and situate them in the field of science [9]. *CogPo* aims at describing paradigms in cognitive psychology [10] and contains most of the elements mentioned in section 2.1. Like EXPO, it characterizes a paradigm in a scientific domain rather than modeling an experiment in action, which generates data. The *Ontology for Biomedical Investigations* (OBI) is a very detailed ontology for clinical and biomedical studies [1]. Its objective is to provide an ontological model that a biomedical study will instantiate. It already addresses many use cases and will likely be extended to others. Our approach is different: we propose a minimal structure, leaving the domain modules to model the domain in more detail. Furthermore, levels of granularity of study events, the data they generate, and the corresponding protocols are only marginally considered in OBI.

3. Results

We chose to consider a mereotopological relation of composition between the paradigm and the conditions, reflecting the mereotopological relation between the events (time of the session, which has as parts the times of the different conditions), rather than a relation of abstraction by generalization. The figure 1 shows the results at the condition level: stimulus, instruction and captation tool for the condition protocol are specified as inputs to the project represented by a protocol (which is carried out for each experiment carried out by a subject). The design pattern resides only in the relations that are indicated. If some elements (i.e. instances) present a strong ontological proximity, such as subjects, events, protocols, which can lead to foresee classes to represent them in the taxonomic part of the ontology, others can cover a strong ontological diversity, or appear under different aspects according to the context. This design pattern[7] was used on the different domain modules (clinical psychiatry, brain imaging, biology, speech analysis and motor assessment modules) implemented in the data collection platform by the industrial partner of the project[8]. It has enabled us to orientate the modelling by pushing us to identify the elements to be integrated into the dedicated ontologies in the various data sources. An application of our ontological design pattern to the module dedicated to dexterity and psychomotricity, as well as SPARQL queries illustrating the data mining possibilities offered, are available[9].

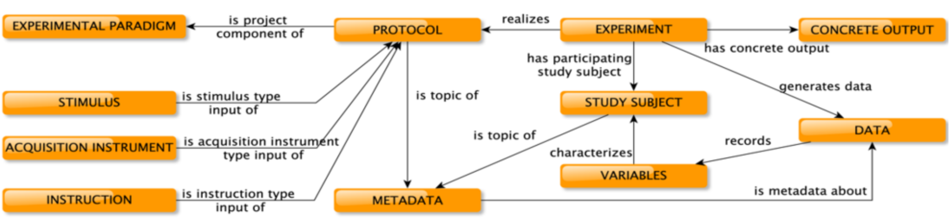

Figure 1. An Ontology Design Pattern for experimental paradigms

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[6] Ontology of scientific EXPeriments

[7] which has been submitted for review on the ODPA website :
http://ontologydesignpatterns.org/wiki/Submissions:ExperimentalParadigmData

[8] Fealinx - http://www.fealinx.com/

[9] https://framagit.org/ jacqueshilbey/ontodext-op

4. Discussion and conclusion

A few caveats need to be raised: (i) depending on the data sources, the design pattern we present must be adapted (for example when some conditions are passed in the same sequence and the resulting data, average or subtraction between results obtained in each condition, must be linked to the event realizing a paradigm); (ii) this pattern is meant to be comprehensive and depending on the cases, all the elements presented in section 2. 1 are not necessarily instantiated; (iii) the use of this design pattern does not exempt from a precise identification of the different levels of granularity of events/data according to the different domains (looking for what remains invariant: subject, place and time, scientific domain, paradigm, condition); (iv) some relationships are redundant but shorten the path in the knowledge graph, depending on the desired mode of exploration.

Once these points are taken into account, this ontology design pattern facilitates the development of domain modules, the preservation of the link to the original data and their exploration.

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