Modular Ontology Modeling Meets Upper Ontologies: The Upper Ontology Alignment Tool

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Abstract. We provide an extension to the Protégé-based modular ontology engineering tool CoModIDE, in order to make it possible for ontology engineers to adhere to traditional ontology modeling processes based on upper or foundational ontologies. As a bridge between the more recently proposed modular ontology modeling approach and more classical ones based on foundational ontologies, it enables a best-of-both worlds approach for ontology engineering.

1 Motivation

Ontology modeling has become a primary approach to schema generation for data integration and knowledge graphs, in many application areas (e.g., [10,13]. The quest for efficient approaches to model useful and re-useable ontologies has over the years led to different proposals for ontology creation processes and tooling.

One of the most classic approaches is based on so-called upper or foundational ontologies [1,6,12]. Central to this paradigm is to utilize ontologies that are generic and/or large and as such cover a wide swath of domains, such as BFO [1], DOLCE [2], SUMO [5].[1] In this approach to modeling, a new (domain) ontology is created in accordance with the mindset or structure conveyed by these upper or foundational ontologies. Technically, *alignment* of the domain ontology classes and relations to the upper/foundational ontology entities – meaning creating appropriate sub-class and sub-property relationships so that relevant structure and/or axioms are inherited – play a prominent role.

Another, more recent approach to ontology modeling is based on an apparently quite different mindset: Modular ontology modeling [9] is based on the idea that an ontology may best be viewed as a collection of interconnected *modules*, each of which correspond to a key notion according to the terminology used by a domain expert. The approach is related to other recent proposals to approach ontology modeling in a *divide and conquer* fashion [7,11] and is a refinement

[1] There are many others, of course; in a sense e.g. schema.org [4] is such an ontology.

of the eXtreme Ontology Design methodology [8] based on Ontology Design Patterns [3]. In its original conception, and the corresponding tooling, in particular the CoModIDE Protégé plug-in [9], the approach de-emphasizes sub-class and sub-property relationships, and in particular does not account for upper or foundational ontologies.

However, it has been argued that there are advantages to either paradigm, which begs the question of whether they are compatible. In order to indeed show that they are, i.e. that it is possible to utilize a combination of both approaches depending on use-case requirements or the preferences of the ontology engineer, we have developed an extension of the CoModIDE tool which incorporates the specification of alignments with upper or foundational ontologies (or, in fact, any ontology). This enables an engineer to pick the best of both worlds. It has been developed keeping domain-level ontology developers or organizations dealing in ontology development in mind, which may get help in minimizing the tooling gap in order to unite paradigms and develop strong, flexible ontologies suitable to their needs.

2 Implementation Details

The Upper Ontology Alignment (UOA) tool is a view for Protégé.[2] The view's functionality, however, is dependent on CoModIDE (the comprehensive modular ontology design IDE), which is also a plug-in for Protégé, as it directly extends CoModIDE's functionality. CoModIDE is an interface for directly authoring ontologies by drawing a schema diagram on a graphical canvas. Classes are represented as cells and properties are represented as edges.

The UOA view allows a user to load an ontology – which may be an upper or foundational ontology – directly into the view (which is kept isolated from the ontology active in Protégé). The view extracts all of the classes and properties (excluding annotation properties) from the loaded ontology. The user then selects classes (cells) or object/data properties (edges) on the graphical canvas. The UOA tool then displays the pertinent entities depending on which glyph is selected on the graphical canvas. Figure 1 shows the view's interface when a class has been selected on the graphical canvas. By selecting, or un-selecting, the checkboxes next to these entities, the view will automatically construct and add the pertinent SubClass or SubProperty axioms to the ontology. CoModIDE detects these additions and will display the added relationships.

In addition, the view provides some supporting functionality for ease and clarity of use: the view will display the currently selected entity, automatically select checkboxes for axioms that are already present in the ontology (e.g. if some entity is already a subclass of the Perdurant class, that particular checkbox will be selected), allows for different ontologies to be loaded (i.e. a user is not limited to a single upper ontology), and provides descriptive logging in the case of failure.

[2] See `https://protege.stanford.edu`.

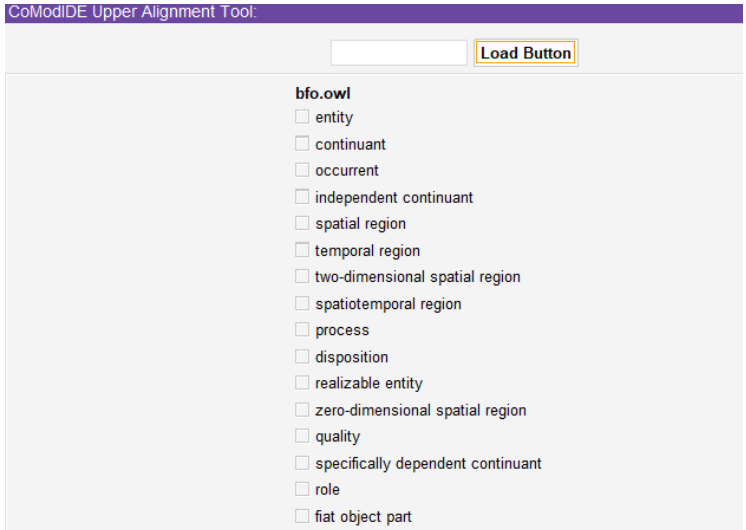

Fig. 1. Checklist for classes when a "cell" is selected in the graphical canvas.

Information on the implementation, installation, and use of these tools (including CoModIDE) can be found in our online portal.[3]

3 Demonstration

The anticipated demonstration consists of a walk-through of the entire process as the aim is to adapt the traditional approach of building ontology with modular ontology modeling. For the purpose of this demonstration, we are going to align the modular ontology model with an upper-level ontology GFO (General Formal Ontology). GFO is an upper-level ontology, designed such that it should be capable to describe upper-level categories that are common to domain ontologies explained by scientists in varying disciplines. We will start by having any pattern from the CoModIDE pattern library. GFO.owl file will be uploaded; we will prepare some other example OWL files as well, but an attendee may suggest their own. Then, we will demonstrate the steps for using the Upper Alignment Tool for "aligning" classes and properties present in the active ontology.Re-loading of ontology will be shown by uploading different ontology other than GFO. The material used for this demonstration can be found at the demo webpage at `https://daselab.cs.ksu.edu/content/upper-alignment-tool-demonstration-iswc-pd-2020`.

[3] See `http://daselab.org/content/modular-ontology-engineering-portal`.

4 Conclusion and Future Work

The Upper Alignment Tool provides the ontology engineer with the option of combining modular ontology modeling with modeling approaches based on upper/foundational ontologies. Possible extensions of this work include automatization or semi-automatization of upper alignments, provisions of more complex alignment capabilities beyond sub-classes or sub-properties, enhancement of namespace prefixes or labels, as well as validating its usefulness in a controlled user study.

Acknowledgement. This work was supported by the U.S. Department of Commerce, National Institute of Standards and Technology, under award number 70NANB19H094.

References

1. Arp, R., Smith, B., Spear, A.D.: Building ontologies with basic formal ontology. Mit Press (2015)
2. Gangemi, A., Guarino, N., Masolo, C., Oltramari, A., Schneider, L.: Sweetening ontologies with DOLCE. In: Gómez-Pérez, A., Benjamins, V.R. (eds.) Knowledge Engineering and Knowledge Management. Ontologies and the Semantic Web, 13th International Conference, EKAW 2002, Siguenza, Spain, October 1-4, 2002, Proceedings. Lecture Notes in Computer Science, vol. 2473, pp. 166–181. Springer (2002)
3. Gangemi, A., Presutti, V.: Ontology design patterns. In: Staab, S., Studer, R. (eds.) Handbook on Ontologies, pp. 221–243. International Handbooks on Information Systems, Springer (2009)
4. Guha, R.V., Brickley, D., Macbeth, S.: Schema.org: evolution of structured data on the web. Commun. ACM **59**(2), 44–51 (2016)
5. Niles, I., Pease, A.: Towards a standard upper ontology. In: 2nd International Conference on Formal Ontology in Information Systems, FOIS 2001, Ogunquit, Maine, USA, October 17-19, 2001, Proceedings. pp. 2–9. ACM (2001)
6. Oberle, D., Ankolekar, A., Hitzler, P., Cimiano, P., Sintek, M., Kiesel, M., Mougouie, B., Baumann, S., Vembu, S., Romanelli, M.: DOLCE ergo SUMO: on foundational and domain models in the SmartWeb Integrated Ontology (SWIntO). J. Web Semant. **5**(3), 156–174 (2007)
7. Osumi-Sutherland, D., Courtot, M., Balhoff, J.P., Mungall, C.J.: Dead simple OWL design patterns. J. Biomedical Semantics **8**(1), 18:1–18:7 (2017)
8. Presutti, V., Daga, E., Gangemi, A., Blomqvist, E.: eXtreme Design with content ontology design patterns. In: Blomqvist, E., Sandkuhl, K., Scharffe, F., Svátek, V. (eds.) Proceedings of the Workshop on Ontology Patterns (WOP 2009) , collocated with the 8th International Semantic Web Conference (ISWC-2009), Washington D.C., USA, 25 October, 2009. CEUR Workshop Proceedings, vol. 516. CEUR-WS.org (2009), `http://ceur-ws.org/Vol-516/pap21.pdf`
9. Shimizu, C., Hammar, K., Hitzler, P.: Modular graphical ontology engineering evaluated. In: Harth, A., Kirrane, S., Ngomo, A.N., Paulheim, H., Rula, A., Gentile, A.L., Haase, P., Cochez, M. (eds.) The Semantic Web – 17th International Conference, ESWC 2020, Heraklion, Crete, Greece, May 31-June 4, 2020, Proceedings. Lecture Notes in Computer Science, vol. 12123, pp. 20–35. Springer (2020)

10. Shimizu, C., Hitzler, P., Hirt, Q., Rehberger, D., Estrecha, S.G., Foley, C., Sheill, A.M., Hawthorne, W., Mixter, J., Watrall, E., Carty, R., Tarr, D.: The Enslaved Ontology: Peoples of the historic slave trade. J. Web Semant. **63**, 100567 (2020)
11. Skjæveland, M.G., Lupp, D.P., Karlsen, L.H., Forssell, H.: Practical ontology pattern instantiation, discovery, and maintenance with reasonable ontology templates. In: Vrandecic, D., Bontcheva, K., Suárez-Figueroa, M.C., Presutti, V., Celino, I., Sabou, M., Kaffee, L., Simperl, E. (eds.) The Semantic Web – ISWC 2018 – 17th International Semantic Web Conference, Monterey, CA, USA, October 8-12, 2018, Proceedings, Part I. Lecture Notes in Computer Science, vol. 11136, pp. 477–494. Springer (2018)
12. Smith, B.: Classifying processes: an essay in applied ontology. Ratio **25**(4), 463–488 (2012)
13. Vita, R., Overton, J.A., Mungall, C.J., Sette, A., Peters, B.: FAIR principles and the IEDB: short-term improvements and a long-term vision of OBO-Foundry mediated machine-actionable interoperability. Database **2018**, bax105 (2018)