SUGOI: Automated Ontology Interchangeability

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Abstract. A foundational ontology can solve interoperability issues among the domain ontologies aligned to it. However, several foundational ontologies have been developed, hence such interoperability issues exist among domain ontologies. The novel SUGOI tool, *Software Used to Gain Ontology Interchangeability*, allows a user to interchange automatically a domain ontology among the DOLCE, BFO and GFO foundational ontologies. The success of swapping varies due to differences in coverage, and amount of mappings both between the foundational ontologies and the alignment mappings between the domain and the foundational ontology. In this demo we present the tool, and attendees can bring their preferred ontology for interchange by SUGOI, and will be assisted with the analysis of the results in terms of 'good' and 'bad' entity linking to assess how feasible it is to change it over to the other foundational ontology.

1 Introduction

Since over ten years, foundational ontologies (FOs) have been proposed as a component to facilitate interoperability among domain ontologies on the Semantic Web, because they provide common high-level categories so that domain ontologies linked to them are also interoperable [7]. Multiple FOs have been developed in the meantime, however, such as DOLCE, BFO [7], GFO [1], SUMO [9], and YAMATO [8]. This created the problem of semantic conflicts for domain ontologies that are linked to different FOs—if those FOs are indeed really different on crucial components—and raises new questions for ontology engineers, including:

1. If domain ontology O_A is linked to FO O_X, then is it still interoperable with domain ontology O_B that is linked to FO O_Y?
2. Is it feasible to automatically generate links between O_A and O_Y, given O_A is linked to O_X?

To answer these two questions, we developed SUGOI, a *Software Used to Gain Ontology Interchangeability*, which automatically interchanges the FO a domain ontology is linked to. The current version can swap between DOLCE, BFO, and GFO (their mappings have been studied in detail [3, 5]); it easily can be extended to handle other FOs, as only new mapping files will have to be provided. SUGOI and a video capture demo demonstrating the online and offline versions of the tool are accessible from the FO library ROMULUS at `http://www.thezfiles.co.za/ROMULUS/ontologyInterchange.html`. The remainder of this paper outlines the design of SUGOI, provides an example and implementation and demo details.

2 Design of SUGOI

SUGOI interchanges domain ontologies between DOLCE, BFO, and GFO, which are all stored as OWL files. This requires mappings between the selected FOs, for which we use the results obtained by [3, 5]: its equivalence and subsumption mappings between entities in the three different ontologies have been investigated in detail, are logically consistent, and are available as machine-processable OWL files from the ontology repository ROMULUS [4].

Several ontology files are being used in the interchangeability being:

- The *Source Ontology* (${}^{s}\mathcal{O}$) to be interchanged, comprising the *Source Domain Ontology* (${}^{s}\mathcal{O}_d$) and the *Source Foundational Ontology* (${}^{s}\mathcal{O}_f$), and any equivalence or subsumption mappings between entities in ${}^{s}\mathcal{O}_d$ and ${}^{s}\mathcal{O}_f$.
- The *Target Ontology* (${}^{t}\mathcal{O}$) that has been interchanged, comprising the *Target Domain Ontology* (${}^{t}\mathcal{O}_d$), the chosen *Target Foundational Ontology* (${}^{t}\mathcal{O}_f$), and any equivalence or subsumption mappings between entities in ${}^{t}\mathcal{O}_d$ and ${}^{t}\mathcal{O}_f$.
- *Mapping ontology*: the mapping ontology between the ${}^{s}\mathcal{O}_f$ and the ${}^{t}\mathcal{O}_f$.
- *Domain entity*: an entity (class or property) from ${}^{s}\mathcal{O}_d$ or ${}^{t}\mathcal{O}_d$.

The SUGOI algorithm accepts a ${}^{s}\mathcal{O}$ consisting of a ${}^{s}\mathcal{O}_d$ linked to a ${}^{s}\mathcal{O}_f$ and interchanges it to a ${}^{t}\mathcal{O}$ with a different ${}^{t}\mathcal{O}_f$. SUGOI has twenty consistent mapping files [3] pre-loaded to interchange between DOLCE, BFO and GFO modules, and accesses the remainder of the ontology files either by loading the ontology from the online URI, or from an offline file, depending on the version in use (see below). After the interchange process, all the domain entities from the ${}^{s}\mathcal{O}_d$ are present in the ${}^{t}\mathcal{O}_d$. SUGOI links domain entities from the ${}^{s}\mathcal{O}_d$ to the ${}^{t}\mathcal{O}_f$ by mapping a domain entity's superentity in the ${}^{s}\mathcal{O}_f$ to its corresponding superentity in the ${}^{t}\mathcal{O}_f$ using the mapping ontology. If the domain entity's superentity does not have a mapping entity, SUGOI then looks for a corresponding mapping entity at a higher level up in the taxonomy. Thus, eventually, the domain entity from the ${}^{s}\mathcal{O}_d$ is mapped with on-the-fly subsumption.

The source and two output ontologies are shown for sao:Membrane Surface from the SAO ontology in Fig 1, interchanged to DOLCE and GFO. The next example illustrates the process in sequence for the DMOP ontology [2].

Example 1. The basic steps of the algorithm for interchanging between DOLCE to GFO are as follows, using the data mining DMOP ontology [2] as an example:

1. Create a new ontology file, a ${}^{t}\mathcal{O}$: `dmop-gfo.owl`.
2. Copy the entire ${}^{t}\mathcal{O}_f$ to the ${}^{t}\mathcal{O}$: copy the GFO ontology into `dmop-gfo.owl`.
3. Copy the axioms from the ${}^{s}\mathcal{O}_d$ to the ${}^{t}\mathcal{O}$: e.g., consider the axioms, axiom1: dmop:DecisionBoundary $\sqsubseteq$ dolce:abstract and axiom2: dmop:Strategy $\sqsubseteq$ dolce:Non PhysicalEndurant which exist in the ${}^{s}\mathcal{O}$ DMOP. We add these axioms to the `dmop-gfo.owl` ${}^{t}\mathcal{O}$ and they are referred to as 'new' axioms.

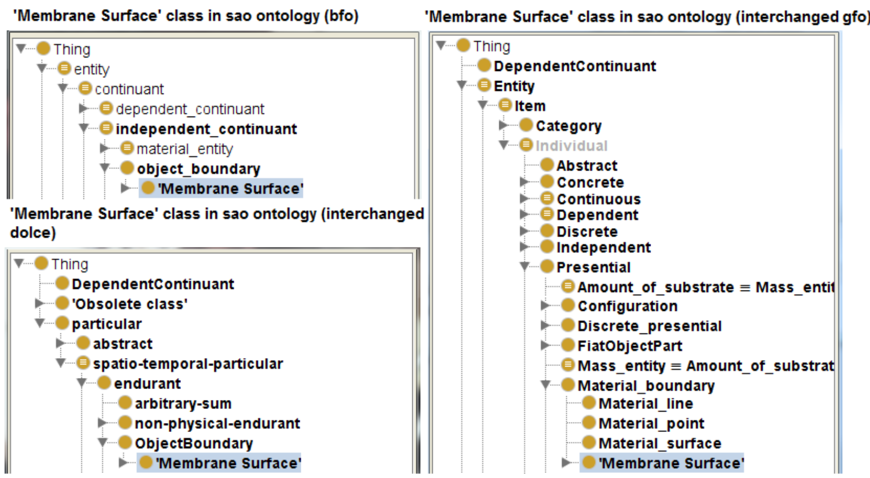

Fig. 1. The position of the sao:Membrane Surface class in source and target ontologies.

4. Change the 'new' axioms to reference ${}^{t}\mathcal{O}_f$ entities, if mappings exist: for axiom1, there is an equivalence mapping between `gfo:Abstract` and `dolce:abstract`, hence we change axiom1 dmop:DecisionBoundary $\sqsubseteq$ dolce:abstract to dmop:DecisionBoundary $\sqsubseteq$ gfo:Abstract. For axiom2, there is no equivalence mapping between dolce:NonPhysicalEndurant and GFO entities; we skip this step.
5. If a mapping does not exist, perform on-the-fly subsumption: For axiom2, dolce:NonPhysicalEndurant has a superclass dolce:Endurant and the mapping ontology has dolce:endurant $\equiv$ gfo:Presential, so dolce:NonPhysicalEndurant $\sqsubseteq$ gfo:Presential is added to `dmop-gfo.owl`.
6. Delete entities that exist in the ${}^{t}\mathcal{O}$ that are from the ${}^{s}\mathcal{O}_f$ but do not appear in an axiom with entities from the ${}^{t}\mathcal{O}_d$, resulting in the final ${}^{t}\mathcal{O}$, `dmop-gfo.owl`. Delete the dolce:abstract entity from `dmop-gfo.owl`.

There are currently three platform-independent versions of SUGOI:
1. Applet: an online web version integrated into the ROMULUS repository [4].
2. Desktop online version: a platform independent jar file to be executed on a local machine, but requires internet connectivity.
3. Desktop offline version: a platform independent jar file to be executed on a local machine, and is bundled with foundational and mapping ontology files.

SUGOI was developed in Java using the OWLAPI v3.5.0 in Netbeans IDE 8.0. The Applet of SUGOI is deployed online within any browser that has the Java TM Platform plugin installed and activated. The desktop versions of SUGOI are platform independent jar files with dependencies (all bundled together) that require minimal disk space, and Java runtime components installed. For future work, we consider creating a SUGOI Protégé plugin.

SUGOI generates not only a target ontology annotated with its provenance (that it automatically linked to a FO by SUGIO), but also a log file with the changes that have been made and a *raw interchangeability* measure. This measure factors in the so-called 'good target linking' and 'bad target linking', where the former counts direct alignments to a ${}^{t}\mathcal{O}_f$ and the latter that some entity of the ${}^{s}\mathcal{O}_f$ was needed as intermediary, indicating how successful the interchange was. For instance, the raw interchangeability for the afore-mentioned SAO to DOLCE is 50% and to GFO was 55% and for DMOP to GFO it was 12% (rounded) [6]. We conducted an evaluation with 16 ontologies that were aligned to a FO, which are described in [6].

3 Demonstration of SUGOI

In the demo session, we will show the easy use of the tool and elaborate on analysis of the output data. Attendees also can bring their own ontology, or some other that they are interested in, that is aligned to either DOLCE, BFO or GFO, and use SUGOI to change its FO. The resulting ontology will be inspected and analysed to see what has changed for this particular instance, which can be augmented on the spot with the deeper analysis involving the mappings among the FOs that are used by the algorithm.

References

1. Herre, H.: General Formal Ontology (GFO): A foundational ontology for conceptual modelling. In: Theory and Applications of Ontology: Computer Applications, chap. 14, pp. 297–345. Springer, Heidelberg (2010)
2. Keet, C.M., Lawrynowicz, A., d'Amato, C., Hilario, M.: Modeling Issues, Choices in the Data Mining OPtimization Ontology. In: Proc. of OWLED'13. CEUR Workshop Proceedings, vol. 1080. CEUR-WS.org (2013), Montpellier, France, May 26-27
3. Khan, Z., Keet, C.M.: Addressing issues in foundational ontology mediation. In: Proc. of KEOD'13. pp. 5–16. SCITEPRESS – Science and Technology Publications (2013), Vilamoura, Portugal, 19-22 September
4. Khan, Z., Keet, C.M.: The foundational ontology library ROMULUS. In: Proc. of MEDI'13. LNCS, vol. 8216, pp. 200–211. Springer (2013), September 25-27, Amantea, Calabria, Italy
5. Khan, Z., Keet, C.M.: Toward semantic interoperability with aligned foundational ontologies in ROMULUS. In: Proc. of K-CAP'13. ACM proceedings (2013), 23-26 June, Banff, Canada. (poster/demo)
6. Khan, Z., Keet, C.M.: Feasibility of automated foundational ontology interchangeability. In: Proc. of EKAW'14. LNCS, Springer (2014), 24-28 Nov, Linköping, Sweden. (accepted)
7. Masolo, C., Borgo, S., Gangemi, A., Guarino, N., Oltramari, A.: Ontology library. WonderWeb Deliverable D18 (ver. 1.0, 31-12-2003). (2003), http://wonderweb.semanticweb.org
8. Mizoguchi, R.: YAMATO: Yet Another More Advanced Top-level Ontology. In: Proceedings of the Sixth Australasian Ontology Workshop. pp. 1–16. Conferences in Research and Practice in Information (2010), Sydney : ACS
9. Niles, I., Pease, A.: Towards a standard upper ontology. In: Welty, C., Smith, B. (eds.) Proc. of FOIS'01 (2001), Ogunquit, Maine, October 17-19, 2001