Ontology Merging with V-alignments in HETS

Liwei Deng*

1 Introduction

We review some recent work on ontology alignment; use the techniques presented in these to merge non-trivial ontologies and in the process analyse both the methods and the ontologies themselves.

We are interested in ontology management using a Category Theoretic framework; the origin of such an approach can be traced back to [1], which at the end outlines a work program for its realization. Progress on this will be reviewed here.

Before that, it will be useful to have a review of all the main ontology operation terms used by the papers cited in this report, since sometimes the same term is used by different authors to mean different things, and some authors give more precise definitions than others.

The techniques mentioned above will enable us to compute the merge of non-trivial ontologies, to give us an idea of how they work in practice. One of the merges will be from [1] and [4]. It seems to have some problems (pointed out in [4]) and is analysed further in an attempt to understand the cause of the problem, and possibly find remedies.

Another set of concrete ontologies, from a completely different source (a talk by Kai-Uwe Kuehnberger), besides being a good test for merging, can also be easily extended and refined, thus allowing for more rigorous tests of current techniques and tests of more powerful methods in the future.

*University of Edinburgh, UK, email L.Deng-2@sms.ed.ac.uk

2 Definitions of some ontology operations

A survey of ontology mapping [5], gives definitions to many ontology operation terms. However at least two of the papers cited in this report, [2] and [3], are published after [5]; they used old terms with similar meanings while introducing new, mostly related ones.

This ever growing collection of related ontology operations terms is on the threshold of becoming a non-trivial ontology in itself. They include mapping, translation, alignment, articulation, merging, connection, integration and refinement. It is useful, for both understanding what follows in this report and generally, to review these terms and explain their relations.

3 Ontology merging, V-alignment, HETS

In [1], an approach to ontology merging using Category Theory was presented; mainly, it gave a definition of the merge of two ontologies as the result of a pushout operation.

This is generalized and extended in [2] with the notion of a V-alignment, with a set of well defined operations for ontology merging and alignment operations.

The V-alignment is placed in a yet more general framework in [3] (though in this case not totally rigorously), through which it can be practically implemented in the Heterogeneous Tool Set (HETS) (see [6]).

4 Merging concrete ontologies

4.1 Concrete ontology merging in literature

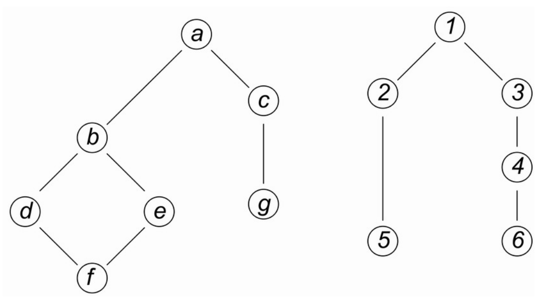
In the literature there seems to be relatively few examples of merging of concrete, non-trivial ontologies using the framework above (particularly the Category Theoretic one).

[2] gives a very simple example illustrating problems of using the V-alignment; [3] gives the specification of a W-alignment (see [2]), which is made out of V-alignments and is more difficult to automate, in the appendix.

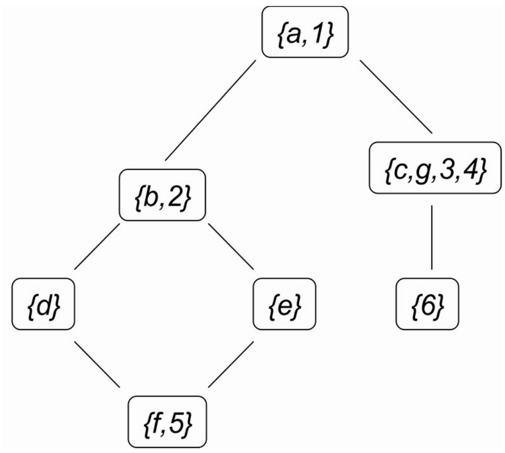
It seems natural to try out the more basic construction first, which is what we will do later. As already mentioned in the previous section, we will implement these examples in HETS, along the lines set out in [3].

4.2 A problematic example

[1] gave an example with the following two partial orders, with an ontology mapping of {(a,1), (b,2), (c,4), (f,5), (g,3)}. They are then merged with a pushout operation.



In [4], the elements in the example of [1] were instantiated by the author, which then obtained a merged ontology with the same structure. The merged ontology in [1] is shown below.



In the merged ontology there is an element, {c,g,3,4} that contained four elements of the original ontology (two from each); whereas intuition would suggest elements of the merged ontology should contain an equivalent pair of elements or singleton elements without equivalence, from the original ontologies.

This is pointed out in [4], where it's taken as evidence that this technique is deficient. We do not believe the problem lies with the technique, but rather the failure indicates a problem with either the original ontologies or the ontology mapping used to compute the merge. (This is in fact hinted at in [1] at the end of the 4^{th} step of the 'How to put our approach into practice' section, even though where the example was presented the authors didn't seem to think it was problematic.) This belief is investigated, with a view to fixing any errors detected.

4.3 A more complicated example

Finally, we finish with a more complicated example (this is from a talk by Kai-Uwe Kuehberger at University of Edinburgh). This example has the advantages of being natural and from a third party not directly concerned about ontology alignments and merging.

We note that there is an obvious analogy between an atom and the solar system (numerous small bodies orbiting a large core). At a crude level, the analogy works well and we expect ontologies formulated at this level to be very similar, and so the merge will be very similar to the originals.

But if we refine or extend the ontologies we will get big differences, with the intuitive merge more dissimilar to the original ontologies; so this provides a tougher test of the categorical techniques, and further techniques developed in the future.

References

[1] Pascal Hitzler, Markus Krtzsch, Marc Ehrig, and York Sure. What is ontology merging? - a category theoretic perspective using pushouts. In Proc. First International Workshop on Contexts and Ontologies: Theory, Practice and Applications (CO), pages 104107. AAAI Press, July 2005.

[2] Zimmermann, A., Krotzsch, M., Euzenat, J. and Hitzler, P. (2006). Formalizing ontology alignment and its operations with category theory. In Proceeding of the 2006 Conference on Formal Ontology in Information Systems, pages 277288, Amsterdam. IOS Press.

[3] Kutz, Oliver, Lucke, Dominik and Mossakowski, Till. (2008). Heterogeneously structured ontologies: Integration, connection, and refinement. In Knowledge Representation Ontology Workshop, KR-08, Sydney, Australia, volume 90 of CRPIT.

[4] Mijic, Roko. (2009). Representing knowledge about the real world: probabilistic, logical and categorical techniques. MSc thesis, School of Informatics, University of Edinburgh

[5] Yannis Kalfoglou and Marco Schorlemmer. Ontology mapping: The state of the art. In Yannis Kalfoglou, Marco Schorlemmer, Amit Sheth, Stephen Staab, and Michael Uschold, editors, Semantic Interoperability and Integration, number 04391 in Dagstuhl Seminar Proceedings. Internationales Begegnungs- und Forschungszentrum (IBFI), Schloss Dagstuhl, Germany, 2005.

[6] Mossakowski, Till, Maeder, Christian and Luttich, Klaus. (2007). The Heterogeneous Tool Set. In Grumberg, Orna and Huth, Michael, (eds.), TACAS 2007, volume 4424 of Lecture Notes in Computer Science, pages 519522. Springer-Verlag Heidelberg.