Measuring Similarity between Ontologies

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Abstract. Ontologies now play an important role for many knowledge-intensive applications for which they provide a source of precisely defined terms. However, with their wide-spread usage there come problems concerning their proliferation. Ontology engineers or users frequently have a core ontology that they use, e.g., for browsing or querying data, but they need to extend it with, adapt it to, or compare it with the large set of other ontologies. For the task of detecting and retrieving relevant ontologies, one needs means for measuring the similarity between ontologies. We present a set of ontology similarity measures and a multiple-phase empirical evaluation.

1 Introduction

A core purpose for the use of ontologies is the exchange of data not only at a common syntactic, but also at a shared semantic level. Especially on the WWW more and more ontologies are constructed and used, beginning to replace the old-fashioned ways of exchanging business data via standardized comma-separated formats by standards that adhere to semantic specifications given through ontologies. Thus, in the near future more and more ontologies will be made available on the WWW. With this upswing and beginning widespread usage of ontologies, however, new problems are incurred. Ontology engineers or users frequently have a core ontology that they use, e.g., for browsing or querying data, but they need to extend it with, adapt it to, or compare it with the large set of other ontologies. For the task of detecting and retrieving relevant ontologies, one needs means for measuring the similarity between ontologies on a canonical scale (e.g., the reals in $[0, 1]$).

So, how may we measure the similarity of ontologies or of ontology parts? One could make use of the formal structures of ontologies and try at the unification of ontologies or ontology parts (which is essentially subgraph matching). The drawback here would be that all real-world ontologies that we know of do not only specify its conceptualization by logical structures, but to a large extent also by reference to terms that are grounded through human natural language use. For instance, modeling that MAN

A. Gómez-Pérez and V.R. Benjamins (Eds.): EKAW 2002, LNAI 2473, pp. 251–263, 2002.

and WOMAN are subordinates of PERSON suffices for many purposes even without any further differentiae. Two ontologies that contain these parts agree on their semantics only to a small extent by formal means, but to a larger extent by reference to common terminology. Furthermore, missing structures need not be problematic. For instance, if one ontology comes with concepts referred to by VEHICLE, CAR, SPORTSWAGON and the other with VEHICLE and SPORTSWAGON only, the semantic exchange of data may still be rather easy, even though the second ontology lacks the two taxonomic links from VEHICLE to CAR and to SPORTSWAGON.

Looking at these requirements, we have found a lack of comprehensive methodological inventory to measure similarity between real-world ontologies, as well as practical, reproducable experiences with measuring similarity between ontologies. Firstly, this paper is about introducing the necessary inventory. We break down the overall task and propose a set of measures that capture the similarity of ontologies at two different levels, the lexical and the conceptual. In general our similarity measures describe the extent to which one ontology specification is covered by the other — and *vice versa*. Secondly, this paper is about providing some practical experiences and results with the proposed measures. Five subjects, four novices and one ontology engineering expert, have modeled ontologies in three different phases about a commonly well-known domain given some additional background knowledge in form of domain texts. The ontologies generated by the different subjects then served as input to an empirical evaluation study of our similarity measuring framework.

In the following, we first prepare the ground for our proposal and our empirical evaluation study by formally specifying the ontology structure and its semantic we refer to subsequently. In the two sections thereafter, we propose measures for describing the similarity of different ontology parts at the lexical and conceptual level. In Section 5, we describe the empirical evaluation study and the results we achieved there, before we relate to other research and conclude the paper with an outlook on future challenges.

2 A Two-Layer View of Ontologies

In order to compare two ontologies and measure similarity between them (or between parts of them), one may consider different semiotic levels. The two levels that we can focus on (abstracting from an actual application) are: First, at the lexical level we may investigate how terms are used to convey meanings. Second, at the conceptual level we may investigate what conceptual relations exist between the terms.[1] For this investigation we define a simple notion of ontology and some auxiliary functions in six steps.

Definition 1 (Concept Language). *Our simple concept language is defined starting from* atomic *concepts and roles.* Concepts *are unary predicates and* roles *are binary predicates over a domain $\mathcal{U}$, with* individuals *being the elements of $\mathcal{U}$. Correspondingly, an interpretation $\mathcal{I}$ of the language is a function that assigns to each concept symbol (taken from the set $\mathcal{A}$) a subset of the domain $\mathcal{U}$, $\mathcal{I} : \mathcal{A} \mapsto 2^{\mathcal{U}}$, to each role symbol (taken from the set $\mathcal{P}$) a binary relation of $\mathcal{U}$, $\mathcal{I} : \mathcal{P} \mapsto 2^{\mathcal{U} \times \mathcal{U}}$. Concept terms and role*

[1] Further studies could look at the pragmatic and the social level and try find out about the application of terms in concrete applications and social contexts.