Ontological Semantics
An Attempt at Foundations of Ontology Representation

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Abstract

The original and still a major purpose of ontologies in computer and information sciences is to serve for the semantic integration of represented content, facilitating information system interoperability. Content can be data, information, and knowledge, and it can be distributed within or across these categories. A myriad of languages is available for representation. Ontologies themselves are artifacts which are expressed in various languages. Different such languages are utilized today, including, as well-known representatives, predicate logic, subsuming first-order (predicate) logic (FOL), in particular, and higher-order (predicate) logic; the Web Ontology Language (OWL) on the basis of description logics (DL); and the Unified Modeling Language (UML). We focus primarily on languages with formally defined syntax and semantics.

This overall picture immediately suggests questions of the following kinds: What is the relationship between an ontology and the language in which it is formalized? Especially, what is the impact of the formal semantics of the language on the formalized ontology? How well understood is the role of ontologies in semantic integration? Can the same ontology be represented in multiple languages and / or in distinct ways within one language? Is there an adequate understanding of whether two expressions are intensionally / conceptually equivalent and whether two ontologies furnish the same ontological commitments?

One may assume that these questions are resolved. Indeed, the development and adoption of ontologies is widespread today. Ontologies are authored in a broad range of different languages, including offering equally named ontologies in distinct languages. Much research is devoted to techniques and technologies that orbit ontologies, for example, ontology matching, modularization, learning, and evolution, to name a few. Ontologies have found numerous beneficial applications, and hundreds of ontologies have been created, considering solely the context of biomedical research. For us, these observations increase the relevance of the stated questions and close relatives thereof, and raise the desire for solid theoretical underpinnings. In the literature of computer and information sciences, we have found only few approaches that tackle the foundations of ontologies and their representation to allow for answering such questions or that actually answer them.

We elaborate an analysis of the subject as the first item of central contributions within this thesis. It mainly results in the identification of a vicious circularity in (i) the intended use of ontologies to mediate between formal representations and (ii) solely exploiting formal semantic notions in representing ontologies and defining 'ontology-based equivalence' as a form of intensional / conceptual equivalence. On this basis and in order to overcome its identified limitations, we contribute a general model-theoretic semantic account, named *ontological semantics*. This kind of semantics takes the approach of assigning arbitrary entities as referents to atomic symbols and to link syntactic constructions with corresponding ontological claims and commitments. In particular, ontological semantics targets the avoidance of encoding effects in its definition. Therefore we argue that this semantic account is well suited for interpreting formalized ontologies and for defining languages for the representation of ontologies. It is further proposed as a fundament for envisioned novel definitions of the intensional equivalence of expressions, in potential deviation from only being formally equivalent under set-theoretic semantics. The thesis is defended that a particular usage of a formalism and its respective vocabulary should be accompanied by establishing an ontological semantics that is tailored to that *use of the formalism*, in parallel to the formal semantics of the language, in order to capture the ontological content of the formal representation for adequate reuse in other formalisms. Accordingly, we advocate ontological semantics as a useful framework for justifying translations on an intensional basis. Despite all deviations of ontological semantics from its set-theoretic blueprint, close relationships between the two can be shown, which allow for using established FOL and DL reasoners while assuming ontological semantics.