Universal-particular distinction in biomedical ontologies – Abstract

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Abstract

Biomedical ontologies are essential frameworks for organizing life science knowledge, from simple molecules to complex biological processes. However, the philosophical distinction between universals (concepts) and particulars (individuals) poses significant challenges. Standard ontology languages like OWL struggle to capture this subtlety, as object properties are intended to associate individuals. Consequently, universal concepts like *phosphorylation* — a pervasive process where a phosphate group is added to a molecule—are forced into the category of individuals to utilize properties. This leads to misuse of annotations; for example, in the BioPax Ontology, although phosphorylation is neither an explicit class nor an individual, the class *ModificationFeature* is annotated with *rdfs:comment* to provide instances like "A phosphorylation on a protein." These restrictions may disconnect the ontology from the underlying reality, hindering expressiveness and reasoning capabilities. Ontology Design Patterns (ODPs) have been developed to overcome certain limitations of languages like OWL, which support binary but not n-ary relations. One proposed ODP involves reifying numerical values with different aspects to represent n-ary relationships. For instance, *standard_water_boiling_point* can be decomposed into magnitudes and units of temperature and pressure. While *standard_water_boiling_point* is intended as a particular, it also demonstrates universal aspects. The notion of "standard" is arbitrary and context-dependent, varying with different definitions of standard pressure by organizations like IUPAC, EU REACH, and the EPA. How these differences can be represented, whether *standard_water_boiling_point* should be modeled as a universal or a particular, and whether reasoning can provide correct information remain open questions. This research aims to address this gap by exploring alternative approaches to representing universals and particulars in biomedical ontologies. Limitations of workarounds like annotation and punning in OWL warrant further investigation. Logical consistency checking might be emulated through instance-level constraint checking in languages like SHACL or ShEx. New conceptual modeling languages like ML2 or PURO, designed to accommodate this distinction, deserve assessment within the biomedical domain. Examining how ontologies represent entities in biological processes can provide insights into the universals-particulars distinction. By investigating these alternatives, this research can contribute to designing more refined ontologies. Accurate representation of universals and particulars will enable ontologies to better reflect reality and advance biomedicine. Enhanced expressiveness will support robust reasoning capabilities, leading to new predictions and discoveries that deepen our understanding of health.

Keywords

biomedical ontologies, universals, particulars, ODPs, entity representation, expressiveness, logical consistency

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