Universal-particular distinction in biomedical ontologies – **Abstract**

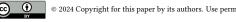
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Biomedical ontologies are essential frameworks for organizing life science knowledge, from simple molecules to complex biological processes. However, the philosophical distinction between universals (concepts) and particulars (individuals) poses significant 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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¹⁵th International Conference on Biomedical Ontologies 2024, July 17-19, 2024, Enschede, The Netherlands *Corresponding author.

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