Alternative Approaches to Representing Part Whole relations in OWL

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Pat whole relations are problematic to represent in description logics generally and OWL-DL in particular. In general we wish to capture at least four general rules

1. Subdivisions and wholes must have the same dimensionality – *e.g.* subdivisions of the liver must be three dimensional
2. The laterality of parts must correspond to the laterality of the whole, if the whole has a laterality..
3. Faults of and procedures on the part are faults of or procedures of the whole – *e.g.* that diseases of the aortic valve are diseases of the heart.
4. That components of subdivisions are components of the whole, but that subdivisions of components are not subdivisions of the whole – *e.g.* that ligaments of the elbow are components of the upper extremity, but that the distal third of a ligament of the elbow is not a subdivision of the upper extremity.
5. Layers of subdivisions of the whole are subdivision of the corresponding layers of the whole – *e.g.* the skin of the hand is a subdivision of the skin of the upper extremity.

None of these rules can be captured in simple OWL axioms, because they all require more than one variable – the ability, for example, to say "same laterality as". All such statements fall outside the DL fragment of logic which is a fragment of logic with just two variables.

However, some can be captured relatively easily by axiom schemas – *e.g* by having separate axioms for left and right literalities; one, two and three dimensional objects, etc.

Of these, rules 1) and 2) can be captured relatively easily by such axiom schemas in OWL. Rule 5 is effectively impossible to capture in any representation that scales beyond a few body parts.

Case three is the best known and most studied and there are at least four approximations:

a) Use of SEP triples of primitives as advocated by Schulz and Hahn [1, 2]
b) Composition construction of SEP triples in OWL itself [3]
c) Use of property axioms outside of OWL but for which tractable algorithms for description logics are known to exist [3]
d) Use of the role hierarchy to gain an approximation that makes being a part of a kind of being located at.

Similarly, the same set of four techniques applies, with variations, to case four.

The authors have recently performed simulations on most of the examples above testing their scaling and examining the practical requirements rewriting and intuitive understanding.

A set of simple examples along with working ontologies will be presented for all of those options which can be expressed in standard OWL-DL, along with the results of these studies.

1. Hahn, U., Schulz, S. and Romacker, M., Partonomic reasoning as taxonomic reasoning in medicine. in *Proc. of the 16th National Conf. on Artificial Intelligence & 11th Innovative Applications of Artificial Intelligence (AAAI-99/IAAI-99)*, (Orlando FL, 1999), AAAI Press/MIT Press, 271-276.
2. Hahn, U., Schulz, S. and Romacker, M. Part-whole reasoning: a case study in medical ontology engineering. *IEEE Intelligent Systems and their Applications*, *14* (5). 59-67.
3. Rector, A., Analysis of propagation along transitive roles: Formalisation of the GALEN experience with MedicalOntologies. in *2002 International Workshop on Description Logics (DL2002)*, (Toulouse France, 2002), CEUR-Proceedings 53, http://sunsite.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-53/Rector-DL2002-propagates-via-final.ps.