The ontological challenge of laterality

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1 ABSTRACT

The concept of laterality is not sufficiently solved in ontological systems, because the information "X is a paired structure" refers to the existence of the subconcepts "left X" and "right X". We propose three layers, such that classic ontology is valid in each layer and the relations between the layers are well defined.

2 INTRODUCTION

A modern hospital information system should offer intelligent choices when the user wants to select an anatomical location. For the measurement of intra-arterial blood pressure, for example, the primary choice should be like ABDOMINAL AORTA, RENAL ARTERY, THORACIC AORTA …. And only when the user chooses RENAL ARTERY an additional choice of LEFT/RIGHT is shown – not when he chooses ABDOMINAL AORTA. Also, it would not be acceptable if the system shows RENAL ARTERY, RIGHT RENAL ARTERY, LEFT RENAL ARTERY parallel in one menu. **Handling of laterality in the FMA**: The Foundational Model of Anatomy (FMA) (University of Washington, 2012) does not list the renal arteries as parts/branches of the AORTA, so lets use the INFERIOR PHRENIC ARTERY as an example when looking at the FMA. There, all three: INFERIOR PHRENIC ARTERY and its subconcepts LEFT INFERIOR PHRENIC ARTERY and RIGHT INFERIOR PHRENIC ARTERY are listed equally as parts/branches of the ABDOMINAL AORTA, without difference.
So, a dynamic GUI generator can not rely directly on the FMA for anatomical information.

3 PAIRED STRUCTURES

In general, it seems that the topic of laterality is still not sufficiently solved in ontological systems. In human language, things seem easy. Everybody would agree to the following statements:

(1) "RENAL ARTERY *is-a* ARTERY"

(2) "RENAL ARTERY *is a* PAIRED STRUCTURE"

(3) "LEFT RENAL ARTERY *is-a* RENAL ARTERY"

Obviously, *is-a* can not be understood as a transitive relation in this context. These seem to be three different *is-a* relations. "PAIRED STRUCTURE" seems to be a mental concept which refers to the existence of RIGHT and LEFT concepts:

(4) "Every concept which *is-a* PAIRED STRUCTURE has two incarnations: a right and a left copy of itself".

4 THREE LAYERS OF CONCEPTS

A pragmatic approach is to divide the anatomical knowledge base into three layers.

1. "Types" –non-instantiable concepts like ORGAN.
2. "Abstract Objects" – non-instantiable concepts of which the information 'paired' or 'singular' is meaningful, like HAND (best thought of as mental abstractions).
3. "Concrete Objects" – can be used to e.g. annotate an anatomical atlas, they are the instantiable 'left' and 'right' incarnations of the abstract objects in layer 2.

Layers 2 and 3 contain the same information. The concepts PAIRED STRUCTURE and SINGULAR STRUCTURE in Layer 2 govern the structure of Layer 3 – they can therefore be called 'Structure classes'.
There are regular *is-a* relations within Layer 1 (FLAT BONE *is-a* BONE), between Layer 2 and Layer 1 (HAND *is-a* BODY PART) and between Layer 3 and Layer 1 (LEFT HAND *is-a* BODY PART). Relations between Layer 3 and Layer 2 can be called *is-lateral-incarnation-of* (LEFT HAND *is-lateral-incarnation-of* HAND), then it can be defined which properties and relations can be inherited along this relation and which not.
Relations between objects are meaningful in Layer2 (ARM *has-part* HAND) and correspond to relations in Layer3 (LEFT ARM *has-part* LEFT HAND). An additional challenge are the cross-side relations in Neuroanatomy (see also Niggemann *et al*., 2008). By the way: Other 'repeated' objects like fingers (of one hand), although they are similar, can not be described by this approach – they are not symmetrical to each other. Their similarity is best described by a standard base class ("Finger").

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REFERENCES

University of Washington. *Foundational Model Explorer*.[Online].(2012) [cited Apr 2012]. Available from: URL:http://fme.biostr.washington.edu/FME/index.html

Niggemann JM, Gebert A and Schulz S. (2008). Modeling functional neuroanatomy for an anatomy information system. *J Am Med Inform Assoc.,* **15**(5), 671-678