The Epistemological-Ontological Divide in Clinical Radiology

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Abstract

Medical ontologies like GALEN, the FMA or SNOMED represent a kind of “100% certain” medical knowledge which is not inherent to all medical sub-domains. Clinical radiology uses computerized imaging techniques to make the human body visible and interprets the imaging findings in a clinical context delivering a textual report. For clinical radiology few standardized vocabularies are available. We examined the definitions given in the glossary of terms for thoracic radiology published by the Fleischner Society. We further classified these terms with regard to their definitions in terms of (a) describing visible structures on the image itself, (b) referring to ontological entities of the body (anatomical or pathological), and (c) terms imposing knowledge on structures visible on the image, epistemologically representing ontological entities of the body. Each ontological/epistemological definition was rated on a scale of vague/weak-sound/strong and put in context with the evaluation comments for the use of the terms given in the glossary itself. The result of this distinction shows that clinical radiology uses many terms referring to ontological entities valid for representation in a medical ontology. However, many epistemological terms exist in the terminology which impose epistemological knowledge on ontological entities. The analysis of the evaluation comments reveals that terms classified as sound (ontologically) and strong (epistemologically) are evaluated higher than terms bearing vague or weak definitions. On the basis of this, we argue that the distinction between ontological and epistemological definitions is necessary in order to construct epistemologically-sensitive application ontologies for medical sub-domains, like clinical radiology, where knowledge is fragmented in terms of description, inferred from a description, concluded on the basis of imaging, or other additional information with varying degrees of certainty.

Keywords:
Controlled vocabularies, medical ontology, clinical radiology, conceptual modelling

1. Introduction

With the development of medical ontologies such as GALEN [1], SNOMED-CT [2] and the Foundational Model of Anatomy (FMA) [3], medical knowledge from different medical sub-domains has been captured representing entities and relations between those entities. Knowledge modelling in a particular domain is based on the exploration of terms used in that particular domain and the definition of entities (universals) in a hierarchical structure. In the domain of clinical radiology this process is confronted by a difficulty: the large reliance on specifically epistemic and epistemically-qualified terms. When dealing with an image of the body, as in chest x-ray or computertomography (CT) for instance, we would like to claim that radiologists use the image on the film in order to describe clear and
distinct entities within the body directly. However, more often radiologists are required to
describe the complexes of shadows, densities and contrast enhancements subsequently
providing what amounts to the appearance of a body structure in a clinical context and what
those appearances represent in reality (anatomically as well as pathologically). Even if
interpretation of those appearances represents highly specialized medical domain
knowledge terms used in radiologic reports are of both kinds, ontological and
epistemological. The purpose of this paper is two fold. We here return to the Fleischner
Society’s “Glossary of Terms for Thoracic Radiology” [4] in order to:
• draw out the implicit ontological and epistemological commitments of these terms
and thereby making them explicit to the informatics community in order to aid the
development of “epistemic-sensitive” ontologies;
• investigate any possible relationships between these ontological and
epistemological commitments (previously unstated) and the explicit evaluations of
the terms proposed in the glossary itself.
We aim to demonstrate how these commitments, once they have been made explicit, may
increase the ability of these terms to satisfy the strict restraints in the development of
application-ontologies and to further propagate the use of this glossary among radiologists.

1.1 The Epistemological/Ontological Divide

Ontology has famously been defined as the “science of what is.” This philosophical
understanding of ontology will only underlie our discussion here insofar as it will serve to
make the epistemic/ontological divide clearer. Primarily, we will concern ourselves with
that notion of ontology employed by the various sorts of biomedical ontologies of the
medical informatics community such as GALEN, SNOMED or the FMA. Application
ontologies, of the biomedical sort such as these, are commonly designed around the
principle that there are pure and certain objectifiable classes (also called ‘universals’ –
organized according to the substumption/parent-child/IS-A relationships) with any number
of more specific relations that may be mapped between these classes, horizontally (i.e. is-
participant-of) and vertically (i.e. is-part-of). The idea being that any given particular
instantiation of these classes will invariably conform to these class mappings [5]
Epistemology, on the other hand, deals with questions of knowledge, certainty, and ways
we have of accessing those entities in the world [6]. In other words, questions of
epistemology encompass the various methods by which doctors and clinicians come to know
about those anatomical and pathological entities that are the focus of their discipline.
Epistemological questions are very rarely dealt with in the literature aimed at an informatics
audience, and understandably so. When designing an ontology it is rarely profitable to
introduce such questions as: “how do we know that’s a tumor?”, for however a particular
physician, dealing with a particular patient, comes to know a particular tumor, bears little
on the so-called ‘universal’ structures of tumors. That all tumors arise from a particular type
of cellular tissue, may be benign or malignant, may spread by metastasis, etc, is true
ontologically, regardless of whether there really exists a tumor in a particular instance.
However, such ontological commitments are difficult to achieve in radiology.

1.2 Imaging the Human Body

Clinical radiology uses different techniques like conventional x-ray, computertomography
(CT), magnetic resonance imaging (MRI) or ultrasound to deliver images of the human
body. Deciding on which imaging technique to use is crucial to getting the proper results,
on the basis of which a radiologist may make or exclude a particular diagnosis. The results
of an examination in clinical radiology are stated in a report, which yields a description of
the imaging findings and a conclusion. For the interpretation of imaging findings the individual perception, knowledge and experience about the appearance of anatomical or pathological structures with regard to the technique applied and the clinical information at hand is crucial. Radiology departments nowadays represent highly computerized environments where digital images are compiled, processed by software and stored in huge picture archiving repositories. Image interpretation is usually done on computer workstation where the findings are reported, in recent years utilizing speech and language recognition software.

1.3 Terms Used in Radiology and Concept Modelling

Despite the increasing use of computers in radiology, the content of radiology reports which serves as the basis for the communication of results of imaging examinations to colleagues, has not been affected by these technologies [7]. For the description of imaging findings and their interpretation no general standardized terminology is available. Some efforts have been undertaken to compose standardized vocabularies for specialized reporting tasks like the BIRADS classification for mammography reporting [8] or the glossary of terms for thoracic imaging proposed by the Fleischner Society. Some studies have extracted terms from radiographic reports to develop a concept model of the content of those reports [9, 10]. However, the integration of those terms in an application-ontology dealing with imaging domain knowledge has not been done.

2. Materials and Methods

Definitions stated in the “Glossary of Terms for Thoracic Radiology” published by the Fleischner Society were examined. The glossary of thoracic imaging contains definitions for 176 terms used in thoracic radiology. One term can have more than one definition. Each definition is classified by category, most frequent used categories are: Radiology, Radiology physics, Pathophysiology, Physiology, Pathology and Anatomy. If a term has the same definition in different categories, a composite category is used, e.g. Anatomy/Radiology. Few terms have definitions for which no category is specified. For most definitions an evaluation comment is given. The evaluation indicates whether the term is recommended or not, useful or not and whether the term represents an inferred or diagnostic conclusion.

2.1 Analysis

For this paper we focus on term definitions in the category of Radiology, for which we further specified the terms as purely ontological or epistemological. In a second step the ontological definitions were classified on an ordinal scale as vague, intermediate, or sound. Epistemological definitions were similarly classified as weak, intermediate, or strong, respectively. The evaluative comments were further classified as positive, negative, or not stated explicitly and the results were compared with regard to the ontological/epistemological distinction described above.

2.2 Ontological/Epistemological Classification

On the ontological level of the body we see terms, radiological as well as general anatomical, such as: “parenchyma. The lung exclusive of visible pulmonary vessels and airways,” as well as common radiological instruments and tools such as: “contrast medium. An agent administered to render the lumen of a hollow structure, vessels, or
viscus more or less opaque than its surrounding for the purpose of radiographic imaging.” For the most part, terms of this categorization were of the sound distinction and highly evaluated.

Those terms which properly isolate themselves to the ontological level of the image are termed “features of radiological anatomy,” elements which may serve to orient the radiologist but may not necessarily represent any bona fide entity within the body itself. Here we see such terms as: “posterior tracheal stripe. A vertically oriented, linear opacity ranging from the thoracic inlet to the bifurcation of the trachea and visible only in lateral radiographs of the chest. It is situated between the air shadows of the trachea and the right lung and is formed by the posterior tracheal wall and contiguous mediastinal interstitial tissue.” Terms at this level are generally categorized as sound.

The second category we call epistemological which represents those cases where an inference has been made from specific features of the image to specific entities within the body. Here we categorize term definitions such as: “coin lesion. A sharply defined, circular opacity within the lung, suggestive of a coin and usually representing a spherical or nodular lesion.” The term is further qualified however, “The term coin may be descriptive of the shadow, but certainly not of the lesion producing it,” and hence the evaluation, “A radiologic descriptor, the use of which is to be condemned. This term is categorized as weak epistemological. However, an example for a strong epistemological definition is: “pneumopericardium. The presence of gas within the pericardium; visible only where the gas shadow is seen in profile: laterally in the frontal view, anteriorly or posteriorly in the lateral projection.” Terms of this category are generally evaluated on the degree to which they are appropriately based on radiographic evidence. Those conclusions not appropriately based on radiographic findings alone are generally rated as weak (or intermediate if the term is cautioned against and its use restricted).

3. Results

166 definitions in the category of Radiology were classified. Table 1 shows the number of terms classified as ontological or epistemological with regard to the strength/soundness of the definition. Overall 109 terms were classified as ontological and 58 terms as epistemological. From terms classified ontological most terms were rated sound ontological (94). Few ontological terms were rated intermediate (12) and only three terms were rated vague (3). In contrast, terms classified epistemological showed moderate difference on the rating scale: 24 terms were rated strong, 23 intermediate and 11 weak.

Table 1 Number of ontological and epistemological radiologic definitions.

<table>
<thead>
<tr>
<th>Soundness/Strength</th>
<th>Ontological</th>
<th>Epistemological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound/strong</td>
<td>94</td>
<td>24</td>
</tr>
<tr>
<td>Intermediate</td>
<td>12</td>
<td>23</td>
</tr>
<tr>
<td>Vague/weak</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Sum</td>
<td>109</td>
<td>58</td>
</tr>
</tbody>
</table>

Evaluation comments given in the glossary by the authors are displayed in Table 2 with respect to the ontological/epistemological classification.
Table 2 Evaluation comments on ontological and epistemological definitions

<table>
<thead>
<tr>
<th>Evaluation comment</th>
<th>Ontological (%)</th>
<th>Epistemological (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>vague</td>
<td>intermediate</td>
</tr>
<tr>
<td>positive</td>
<td>0</td>
<td>8 (7)</td>
</tr>
<tr>
<td>Not stated explicitly</td>
<td>0</td>
<td>3 (3)</td>
</tr>
<tr>
<td>negative</td>
<td>3 (3)</td>
<td>1 (1)</td>
</tr>
</tbody>
</table>

Table 2 shows that most of the terms classified as ontologically *sound* or epistemologically *strong* had a *positive* evaluation comment. In contrast, none of the *vague* or *weak* ontological or epistemological classified terms was rated *positive* by the authors. However, ontological terms classified as *intermediate* were more positive evaluated as epistemological terms which frequently did no have an evaluation comment in the glossary.

4. Conclusions and Discussion

The glossary for thoracic radiology published by the Fleischner society is a valuable resource for terms used in thoracic radiology and a recommendation of their use in radiologic reports. Even if the distinction between ontological and epistemological terms is not given explicitly in the glossary, the definitions and the evaluation comments stated give a detailed view on the origin, the usefulness, and the value of each term in radiology.

Ontological considerations in medical information science leads towards a greater perspicuity in our definitions of body entities via a sound understanding of their place within a class hierarchy as well as the relationships that exist between these entities and others. This applies equally to radiology as to other medical domains like biology, anatomy or genomics. Clear ontological definitions of terms used in radiology would facilitate the exchange of information between radiologists and those reading their reports. Our study revealed that many terms used in radiology have a sound ontological definition independently of the entity they refer to, an entity on the image (e.g. posterior tracheal stripe) or the body itself (e.g. parenchyma). Additionally, most terms with sound ontological definitions were rated positive by the authors and their use is recommended. They represent valid entities for the construction of an imaging ontology or for incorporating into an existing ontology dealing with entities of the body (e.g. the FMA).

Terms with epistemological definitions are less frequent in the glossary but strong epistemological definitions were mostly rated positive, even if there were a remarkable high number of epistemological definitions which were intermediate ranked. While the epistemological status of many terms cannot be changed, it must be cleared up which epistemological terms are inferred, which terms are diagnostic conclusions and which are descriptors. This would not improve the precision of the terms itself but restrict their use to the appropriate context.

Terminology used in clinical radiology consists of both epistemological evidence and ontological entities. In particular, terms which deliver epistemological evidence about ontological entities seem to represent a large portion of terms used in radiology reporting. However, future medical ontologies with the aim of representing knowledge about certain medical sub-domains, like clinical radiology, have to find ways to integrate terms
containing epistemological evidence about ontological entities with varied levels of certainty.

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6. References


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