Metonymies in Medical Terminologies. A SNOMED CT Case Study

Markus Kreuzthaler, MSc¹, Stefan Schulz, MD¹²

¹ Institute for Medical Informatics, Statistics and Documentation, Medical University, Graz, Austria; ² Institute of Medical Biometry and Medical Informatics, University Medical Center, Freiburg, Germany

Abstract

Metonymies are language phenomena, in which one expression is used to refer to a related one. Whereas there are many examples in medical discourse, it has been controversially discussed to what extent metonymic phenomena also matter in medical terminologies like SNOMED CT, where they could hamper their proper use. We investigated this by analyzing all SNOMED CT single word fully specified names containing the suffixes “-itis” and “-ectomy”. Using a combination of string and concept matching, we harvested definitional phrases from the Web and contrasted them with the terms and their logical definitions as stated in SNOMED CT. Whereas metonymic phenomena are very rare in the collection of surgical terms (two out of 138), they were found in 16 terms (about 12 percent) in the collection of inflammation terms. Web mining retrieved useful phrases for 11 of these terms. Most metonymies found corresponded to the “whole for part” and “general for specific” pattern.

Introduction

Metonymy is a linguistic phenomenon in which an expression is used to refer to the referent of a related expression. Examples are “to count heads” (instead of “to count people”), “the White House declares war on fox news” (instead of “the president who inhabits the White House declares war...”) or “topless beach” (instead of “beach where bathers dispense of the top of their bikini”). Metonyms may violate semantic constraints, if interpreted literally: a house cannot speak, a beach has no top, etc. However, this is not a strict criterion: one can count heads, even if what is really meant is that people are counted, as the interest is not in the head but in the person. Metonyms were found to be rather frequent, and they are systematic to follow certain patterns, like place for event, whole for part, part for whole etc.¹

Are metonymies common in medical terms?

We had identified one case for “whole-for-part metonymy” in the SNOMED CT definition of gastritis. According to the logical interpretation of the axiom which fully defines the SNOMED CT concept Gastritis, every disorder that has an associated morphology Inflammation and which has the Finding site Stomach structure would then be defined as gastritis. Obviously, this definition was derived from the literal meaning of the word “gastritis”, with the word stem “gastr” meaning stomach, and the suffix “-itis” meaning inflammation (see Figure 1). According to this, the (rare) case of abscess in the stomach wall² would then also be classified as Gastritis.

![Figure 1: SNOMED CT concept definitions for Gastritis.](image-url)

In the study here presented we will explore the significance of metonymies in biomedical terminologies using the
SNOMED CT finding and procedure hierarchies. We will do it semi-automatically, by a combination of expert inspection, semantic analysis and web mining.

Materials and Methods

Our processing workflow uses a combination of text analytics and expert assessment. The basic idea is the following: SNOMED CT concepts from the disease and procedure hierarchies, with a single-word fully specified name that corresponds to certain morphological patterns, are selected. We used the suffixes “-itis” (inflammation) and “-ectomy” (removal). A medical expert inspected each name on whether it is suspicious for metonymy. Independently, the ontological definition is analyzed on whether the meaning conveyed by the description logics axioms (restricted to reference to anatomy) corresponded to a literal interpretation of the name. This is juxtaposed to a list of text snippets mined from the World Wide Web and analyzed whether these snippets convey a different (text) definition of the concept as suggested by the wording and the formal axioms. Example:

As stated in the introduction, the term “Gastritis” would be identified by the medical domain expert as a metonymy, as long as he/she knows that the exact location of a gastritis is the gastric mucous membrane, i.e. the inner lining of the stomach. The SNOMED CT concept Gastritis is fully defined. As the relation Finding site, is filled by the target concept Stomach structure, one could deduce that not only inflammatory processes in the mucous membrane but also in other parts of the stomach wall should be classified as gastritis. Therefore the reference to the target anatomy concept would be considered an underspecified reference (see Figure 1). The web mining results, yielded by the methodology as explained below, returns the following suggestions:

1. stomach lining: 44 matches
2. lining of the stomach: 22 matches
3. lining of your stomach: 3 matches
4. lining of stomach: 1 match

On the top rank we have the correct suggestion stomach lining in contrast to the SNOMED CT definition Stomach structure. For fulfilling this workflow the following resources are needed conducting and interfacing the different parts within a Java environment:

SNOMED CT. Version 20110131 was used as well as we expanded this version having morphological normalized word stems of the Concepts_Core and Relations_Core tables using semantic indexing.

Bing Search Engine. Bing is a Web Search Engine developed by Microsoft. Its API Version 2.0 lends itself for web mining as it offers an open interface to their retrieval engine. It allows at the moment free access as long as a frequencies of seven queries/second is not exceeded. Results are returned in JSON format.

Morphosaurus Semantic Indexer. The MorphoSaurus Semantic Indexer includes a morphologic parser that extracts, using a large multilingual repository of medical terms and term fragments, the minimal meaning-bearing elements from each word and maps them to semantic identifiers. The relation persistence framework Hibernate was used for accessing SNOMED CT.

The routine we implemented is a simple pattern-based question answering approach. It takes a SNOMED fully specified name of the format X & SUFFIX to mine the web for definitional phrases of this term. We therefore developed a processing chain that evaluates the following string matching criteria applied to the JSON attribute field web:Description returned from the Bing Sarch Engine.

\[^{a}\]http://www.bing.com/developers/s/APIBasics.html
\[^{b}\]http://www.hibernate.org/
Criterion 1. (Very strict). The substring “X-itis” is immediately followed by “is an inflammation of the” in the returned BING result. The result is preserved in case there are more than $treshold_1$ positive hits, otherwise Criterion 2 is tested.

Criterion 2. (Strict). “X-itis” precedes “is an inflammation of the” at any position in the same text snippet in the returned BING result. The result is preserved in case there are more than $treshold_2$ times positive hits, otherwise Criterion 3 is tested.

Criterion 3. (Fuzzy). “X-itis” precedes “inflammation of the” at any position in the same text snippet in the returned BING result. The result is preserved.

If $treshold_n$ number of rules were successfully applied in a processing step we build up a simple map, counting the number of occurrences of right syntactic context of the phrase “inflammation of the”, delimited by a period or comma. The map was ranked according to the number of occurrences. The very first four results were returned as suggestions for a correct decomposition. Furthermore we removed terms from the map which had a morphological identical meaning compared to the “X-itis” terms using the morphosemantically normalized version of the terms which had to be compared. Thus, word fragments like “gastr” and “stomach” are found to be syntactically identical.

We assigned the values 2, 4, and 6 to $treshold_1$, $treshold_2$, and $treshold_3$, respectively. Here is an example output from the Bing Search API, JSON formatted and in human readable form for the term Gastritis:

```json
{
  "SearchResponse": {
    "Version": "2.2",
    "Query": {
      "SearchTerms": "Gastritis is an inflammation of the"
    },
    "Web": {
      "Total": 20800,
      "Offset": 0,
      "Results": [
        {
          "Title": "Gastritis - Wikipedia, the free encyclopedia",
          "Description": "Gastritis is an inflammation of the lining of the stomach, and has many possible causes. The main acute causes are excessive alcohol consumption or prolonged use of ...",
          "Url": "http:\/\/en.wikipedia.org\/wiki\/Gastritis",
          "CacheUrl": "http:\/\/cc.bingj.com\/cache.aspx\?q=%22gastritis+is+an+inflammation+of+the%22&d=4533840991355869&mkt=en-US&w=78a5a766,50575a34",
          "DisplayUrl": "en.wikipedia.org\/wiki\/Gastritis",
          "DateTime": "2012-03-11T06:52:00Z"
        },
        ...
      ]
    }
  }
}
```

As one can see one of the descriptions was fetched from Wikipedia. In this case we extracted lining of the stomach according to our algorithm.

We compared the web mining results with the filler of the Finding site role of each single “X-itis” term. Due to the condition $treshold_1 < treshold_2$, which were set to 2 and 4 respectively, we emphasized that we preferred exact short mining results over fuzzy ones whenever possible. One hundred of Bing results per 14s could be harvested at moderate processing times per “X-itis” term so not violating the constraints from BING for using their API. Also the server which was contacted for getting the morphological normalized word stems at processing time was contacted at a moderate job request time of every 145ms.
Results

For the suffix “-itis” a total of 251 SNOMED CT concepts from the disorder hierarchy were harvested. Expert inspection found evidence for metonymic reading for 30 of them, which corresponds to 11.9%. In 16 of these concepts the reference to anatomy was found to be underspecified. These are real candidates for “hidden” metonymy. As example, Endocervicitis is defined as related to Endocervical Structure, whereas it is denotes, according to textbooks of pathology, only the epithelial layer of the cervix. In 14 concepts the fully specified name was identified as metonymic, the formal definition was correct, i.e. the ontology engineers had enough domain knowledge to avoid metonymy-induced shortcut definitions. As an example the anatomy term assigned to “Coxitis” was, correctly, “Hip joint structure” and not “Thigh structure”, which would correspond to the literal meaning of the term (Latin: “coxa” = “thigh”). Out of the 16 instances for “hidden metonymy”, our Web mining approach retrieved phrases that contained the correct definitions in 11 cases. For instance, for “Endocervicitis” one answer retrieved was “mucous membrane lining of the cervix”. As ten of these eleven concepts are fully defined, the metonymy-induced misinterpretation would have led to false classification results in the case of description logics-based reasoning. An analysis of the cases in which the web mining approach was unsuccessful revealed that here, due to an insufficient number of results using the Criterion 1, the algorithm resorted to more tolerant retrieval patterns, which resulted in irrelevant phrases (such as “posterior outer white layer of the eyeball”, which is an insufficient definition of “Sclerotenonitis”.

For the suffix “-ectomy” a total of 138 SNOMED CT concepts from the procedure hierarchy were harvested. Only two of them could be considered as metonymic, viz. Fenestrectomy and Empyemectomy. The Web mining results were not helpful for these two cases. In seven concepts the name was correct but the formal definition was insufficient.

When analyzing the type of metonymy we found for the inflammation terms 18 references to holonyms (whole for part), one reference to a mereonym (part for whole), and 11 references to hypernyms (general for specific). The two metonymic surgery terms referred to a mereonym.

Our results show that metonymy is a phenomenon that requires some attention in ontology building. Especially in the case of terminology curators that are not familiar with the of medical subspecialty they present, additional tools that use knowledge sources from the Web could speed up the decision making process when it comes to fully define a medical concept. Our question-answering system provided some useful results, but also failed the right answer, especially in the case of rare or even exotic terms, where information on the web was scarce. In these cases, the relaxing of the search criteria increased the noise, but did not yield much more useful information.

In order to avoid this, we would recommend to introduce a threshold of hits for the use of Criterion 1 and 2. If not enough results were yielded, the terminology curator would be asked to search for the required information in previously defined authoritative sources such as medical encyclopedias or specialized textbooks. The web mining approach can nevertheless be recommended as a reminder system, which confronts the terminology specialists with definitional text snippets for each concept they are formally representing.

This method also reveals borderline cases, where different sources yield different information. For instance, we have found competing information on the concept Dermatitis, according to which it is always restricted to the inner layer of the skin or can affect all layers. Another case was the concept Otitis. Here, two snippets found were “(otitis is an inflammation of the) skin lining the ear canal” and “(otitis is an inflammation of the) inner ear and is usually considered synonymous with labyrinthitis”.

Our results were restricted to a special case of SNOMED CT concepts, namely those which had mostly Latin or Greek word stems with classical endings like “-itis” and “-ectomy”. Among other typical suffixes, which were not investigated here, would be “-osis” with the meaning of disease, “-tomy” with the meaning of incision, or “-oma” with the meaning of tumor. Most of these terms already existed, when modern medicine came into being. Some of them survived although the literal meaning is no longer indicative for the medical entities they denote. For instance “neurosis” means literally “disease of the nerves”, which is not tenable in the light of modern psychiatry (and which was not even very discriminative at the time it was coined). We can therefore conclude that – although many terms have survived from past centuries – users (physicians as well as terminology builders) are mostly aware of their change in meaning. SNOMED CT is following this tendency, which is a good message.
Discussion and Conclusion

Metonymic phenomena have only been occasionally been subject to investigation with regard to medical terminology. Gangemi et al. explained the polysemous nature of disease terms (e.g. tumor as a structure vs. tumor as a process) as a metonymic phenomenon. Jon Patrick argued that a special case of metonymy, in which the whole is taken for the part is common in medical discourse and reasoning. For instance, if the shaft of a femur is broken, then it would be acceptable to say “the femur is broken”. The representation of such reasoning patterns such as these, e.g. in SNOMED CT, using approaches as proposed by are discussed as a potential obstacle for an effective use of clinical terminologies at the point of care.

We argue that these cases can be explained by ontological analysis: In the first case, we defend the position that the ambiguity of terms like “tumor” is rather an ontological issue than a linguistic one: there are indeed two entities like the tumor (process) and the tumor (object), which are related to one another just as my life (process) and my body (object). The builders of medical ontologies need to be aware of that and possibly represent those terms deliberately as ambiguous ones, leaving their disambiguation to the context in which they are used.

Regarding Patrick’s argument, we prefer an ontological interpretation. The shaft of the femur is located in the femur. If a fracture is located in the shaft of the femur then it is also located in the femur, according to the transitivity of the location relation. However, as plausible it may be to consider “fracture of the femur” a generalization of what is meant by saying “the shaft of a femur is broken”, it would be incorrect to consider it as equivalent.

Apart from these controversial cases, where linguists and ontologists might or might not agree, we acknowledge that metonymy is an important issue when it comes to correctly label and logically represent medical entities. Our hypothesis is that there are cases in medical terminology in which a metonymic reading is erroneously taken as equivalent to the literal meaning. As a consequence false classifications would result. Further investigation would then be justified not only by a kind of academic interest, but also in the context of the quality assurance of terminological artifacts, since bad quality would result in false encoding, erroneous reasoning, and finally unreliable consequences regarding data analysis and decision support in health care and biomedical science.

References