Semantic Clarification of the Representation of Procedures and Diseases in SNOMED CT

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Context: SNOMED CT (Clinical Terms)

- Comprehensive clinical terminology system
- Constructed by merging, expanding, and restructuring SNOMED RT and Clinical Terms Version 3 (former Read Codes).
- 364,000 concepts, 984,000 terms, 1.45 million defined relationships between concepts
- Government agreements in U.S. & U.K.
- Increasing interest into SNOMED CT in other countries
SNOMED CT
OAV and DL notation

- Object – Attribute – Value (OAV) Triplets
- Objects and Values are SNOMED “concepts”
- Attributes are SNOMED “relations”

<table>
<thead>
<tr>
<th>SNOMED Concept 1</th>
<th>SNOMED Relationship</th>
<th>SNOMED Concept 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renal glomerular disease</td>
<td>is_a</td>
<td>Renal disease</td>
</tr>
<tr>
<td>Renal glomerular disease</td>
<td>has_finding_site</td>
<td>Kidney</td>
</tr>
<tr>
<td>Glomerulum</td>
<td>part_of</td>
<td>Kidney</td>
</tr>
</tbody>
</table>

Description Logics (DL) representation:

cf. Kent Spackman, AMIA 2002
Renal glomerular disease $\sqsubseteq$ Renal disease
Renal glomerular disease $\sqsubseteq \exists$ has_finding_site.Kidney
Glomerulum $\sqsubseteq \exists$ part-of.Kidney

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Semantics</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C$</td>
<td>${d \in \Delta^I \mid I(C) = d}$</td>
</tr>
<tr>
<td>$R$</td>
<td>${(d, e) \in \Delta^I \times \Delta^I \mid I(R) = (d, e)}$</td>
</tr>
<tr>
<td>$\exists R.C$</td>
<td>${d \in \Delta^I \mid R^I(d) \cap C^I \neq \emptyset}$</td>
</tr>
<tr>
<td>$C \sqsubseteq D$</td>
<td>$C^I \subseteq D^I$</td>
</tr>
</tbody>
</table>

Objective of this talk

- Ontological Inquiry of the representation of Processes in SNOMED CT
- Clarification of the meaning of the “relationship group” attribute in SNOMED CT
- „Process“ in the sense of Diagnostic or Therapeutic Procedures
- Pathological and Physiological Processes

Removal of foreign body from stomach by incision
Hierarchical Arrangement of Processes

Medical Procedure

Surgical Procedure

Removal of foreign body from stomach by endoscopy

Removal of foreign body from stomach by incision

Endoscopic Exploration

Removal of foreign body

Incision of Stomach

Removal of foreign body
Parent and Child Processes

Taxonomy of Processes: 
is-a relation between parent and child processes

Removal of foreign body from stomach by endoscopy
Removal of foreign body from stomach by incision

Medical Procedure
Surgical Procedure
Processes and Subprocesses

Medical Procedure

Surgical Procedure

Removal of foreign body from stomach by endoscopy

Removal of foreign body from stomach by incision

Processes/Subprocesses

Endoscopic Exploration

Removal of foreign body

Incision of Stomach

Removal of foreign body
How to semantically relate processes with their subprocesses

1. A (complex) process is subsumed by its subprocesses:
   - Subprocesses do not exist simultaneously. An instance of *Removal of foreign body from stomach by incision* is first an instance of *Incision of stomach* and then becomes an instance of *Removal of foreign body*.

2. Subprocesses are temporal parts of a (complex) process:
   - A complex process can be aborted before completion. The complex process *Removal of foreign body from stomach by incision* can only be instantiated if the subprocesses have been completed.
Theory 1: A (complex) process is subsumed by its subprocesses

- Surgical Procedure
  - Endoscopic Exploration
  - Removal of foreign body from stomach by endoscopy
  - Removal of foreign body from stomach by incision
  - Incision of Stomach

Theory: A (complex) process is subsumed by its subprocesses.
Theory 2: Subprocesses are temporal parts of a (complex) process

- **Surgical Procedure**
  - **is-a** **Removal of foreign body from stomach by endoscopy**
  - **is-a** **Removal of foreign body from stomach by incision**
  - **has-part** **Endoscopic Exploration**
  - **has-part** **Removal of foreign body from Stomach**
  - **has-part** **Incision of Stomach**
## Representation in SNOMED CT

<table>
<thead>
<tr>
<th>SNOMED® Concept 1</th>
<th>SNOMED® Relationship</th>
<th>SNOMED® Concept 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Removal of Foreign Body from the Stomach by Incision</strong></td>
<td><strong>Is A</strong></td>
<td><strong>Removal of foreign body from digestive system</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Is A</strong></td>
<td><strong>Removal of foreign body from stomach</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Is A</strong></td>
<td><strong>Incision of stomach</strong></td>
</tr>
<tr>
<td><strong>Method</strong></td>
<td><strong>Removal - action</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Direct Morphology</strong></td>
<td><strong>Foreign body</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Method</strong></td>
<td><strong>Incision - action</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Procedure site</strong></td>
<td><strong>Stomach Structure</strong></td>
<td></td>
</tr>
</tbody>
</table>

...compatible with Theory 1
Theory 1: A (complex) process is subsumed by its subprocesses
\textit{RemovalOfForeignBodyFromStomachByIncision} \equiv \\
RemovalOfForeignBodyFromDigestiveSystem \text{ AND} \\
RemovalOfForeignBodyFromStomach \text{ AND} \\
IncisionOfStomach \text{ AND} \\
\exists \text{ Method.RemovalAction \text{ AND}} \\
\exists \text{ DirectMorphology.ForeignBody \text{ AND}} \\
\exists \text{ Method.IncisionAction \text{ AND}} \\
\exists \text{ ProcedureSite.stomachStructure}

...indistinguishable from “incision of foreign body and removal of stomach” ???
### Relationship Groups in SNOMED CT

<table>
<thead>
<tr>
<th>SNOMED® Concept 1</th>
<th>SNOMED® Relationship</th>
<th>SNOMED® Concept 2</th>
<th>RG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Removal of Foreign Body from the Stomach by Incision</strong></td>
<td><strong>Is A</strong></td>
<td><strong>Removal of foreign body from digestive system</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Is A</strong></td>
<td><strong>Removal of foreign body from stomach</strong></td>
<td><strong>0</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Is A</strong></td>
<td><strong>Incision of stomach</strong></td>
<td><strong>0</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Method</strong></td>
<td><strong>Removal - action</strong></td>
<td><strong>1</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Direct Morphology</strong></td>
<td><strong>Foreign body</strong></td>
<td><strong>1</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Method</strong></td>
<td><strong>Incision - action</strong></td>
<td><strong>2</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Procedure site</strong></td>
<td><strong>Stomach Structure</strong></td>
<td><strong>2</strong></td>
<td></td>
</tr>
</tbody>
</table>
Nesting with relationship groups (RGs) in DL formalism

\[ RemovalOfForeignBodyFromStomachByIncision \equiv \]
\[ RemovalOfForeignBodyFromDigestiveSystem \ \text{AND} \]
\[ RemovalOfForeignBodyFromStomach \ \text{AND} \]
\[ IncisionOfStomach \ \text{AND} \]
\[ \exists RG. (\exists Method.RemovalAction \ \text{AND} \]
\[ \exists DirectMorphology.ForeignBody) \ \text{AND} \]
\[ \exists RG. (\exists Method.IncisionAction \ \text{AND} \]
\[ \exists ProcedureSite.stomachStructure) \]

Mix-up prevented. Compatible with which theory?
Theory 2: Subprocesses are temporal parts of a (complex) process

- Removal of foreign body from stomach by endoscopy
- Removal of foreign body from stomach by incision

Subprocesses:
- Endoscopic Exploration
- Incision of Stomach
Theory 2: Subprocesses are temporal parts of a (complex) process

Removal of foreign body from stomach by incision

- Removal of foreign body
  - Removal
    - Foreign Body
      - Direct morphology
    - Method
  - Method
  - Direct morphology
- Incision of Stomach
  - Incision
    - Stomach Structure
      - Procedure site
    - Method
  - Method
  - Procedure site

∃ has-part (∃ Method.Removal AND ∃ DirectMorphology.ForeignBody)

∃ has-part (∃ Method.Incision AND ∃ ProcedureSite.stomachStructure)
Nesting with relationship groups (RGs) in DL formalism

RemovalOfForeignBodyFromStomachByIncision ≡
RemovalOfForeignBodyFromDigestiveSystem AND
RemovalOfForeignBodyFromStomach AND
IncisionOfStomach AND

∃ RG1. (∃ Method.RemovalAction AND
∃ DirectMorphology.ForeignBody) AND

∃ RG2. (∃ Method.IncisionAction AND
∃ ProcedureSite.stomachStructure)
SNOMED relation groups can be re-interpreted as has-part

\[ \text{RemovalOfForeignBodyFromStomachByIncision} \equiv \]
\[ \text{RemovalOfForeignBodyFromDigestiveSystem AND} \]
\[ \text{RemovalOfForeignBodyFromStomach AND} \]
\[ \text{IncisionOfStomach AND} \]

\[ \exists \text{has-part.}(\exists \text{Method.RemovalAction AND} \]
\[ \exists \text{DirectMorphology.ForeignBody}) \]
\[ \text{AND} \]

\[ \exists \text{has-part.}(\exists \text{Method.IncisionAction AND} \]
\[ \exists \text{ProcedureSite.stomachStructure}) \]
Difference between “X” and “X-Action” in SNOMED CT

\[ RemovalOfForeignBodyFromStomachByIncision \equiv \]

\[ RemovalOfForeignBodyFromDigestiveSystem \land \]

\[ RemovalOfForeignBodyFromStomach \land \]

\[ IncisionOfStomach \land \]

\[ \exists \text{ has-part.} (\exists \text{ Method.RemovalAction } \land \]

\[ \exists \text{ DirectMorphology.ForeignBody}) \land \]

\[ \exists \text{ has-part.} (\exists \text{ Method.IncisionAction } \land \]

\[ \exists \text{ ProcedureSite.stomachStructure}) \]
RemoveForeignBodyFromStomachByIncision \equiv
\text{RemovalOfForeignBodyFromDigestiveSystem AND}
\text{RemovalOfForeignBodyFromStomach AND}
\text{IncisionOfStomach AND}
\exists \text{ has-part.}(\exists \text{ Method.RemovalAction AND}
\exists \text{ DirectMorphology.ForeignBody}) \text{ AND}
\exists \text{ has-part.}(\exists \text{ Method.IncisionAction AND}
\exists \text{ ProcedureSite.stomachStructure})
Conclusions

- Relationship groups in SNOMED CT may represent the mereological relation between procedures / actions / processes and their parts.
- Suggest: Rename the relationship group attribute RG by *has-part* or *has-subprocess* in these cases.
- Make a clearer distinction between atomic classes (such as *IncisionAction*) and those classes which have atomic classes as parts (such as *IncisionProcess*). The present names are misleading.
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(UK)
Theory 1: Process is instantiated by its subprocesses

Acknowledgements: Boris Hennig, unpublished
Difference between “X” and “X-Action” in SNOMED CT

\[
\text{RemovalOfForeignBodyFromStomachByIncision} \equiv \\
\text{RemovalOfForeignBodyFromDigestiveSystem AND} \\
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\text{IncisionOfStomach AND} \\
\exists \text{ has-part.}(\exists \text{ Method.RemovalAction AND} \\
\exists \text{ DirectMorphology.FOREignBody}) \land \\
\exists \text{ has-part.}(\exists \text{ Method.IncisionAction AND} \\
\exists \text{ ProcedureSite.stomachStructure})
\]
Theory 2: Subprocesses are parts of their parent processes
Parent and Child Processes

**Taxonomy of Processes:**
*is-a* relation between parent and child processes

**Surgical Procedure**
- Removal of foreign body from stomach

1. **Removal of foreign body from stomach by endoscopy**
   - Preparation for Endoscopy
   - Introduction of Endoscope
   - Exploration
   - Extraction of Endoscope
   - Removal of foreign body

2. **Removal of foreign body from stomach by incision**
   - Preparation for Surgery
   - Incision
   - Exploration
   - Removal of foreign body
   - Closure
Processes and Subprocesses

Surgical Procedure

Removal of foreign body from stomach

Removal of foreign body from stomach by endoscopy

Preparation for Endoscopy
Introduction of Endoscope
Exploration

Removal of foreign body

Extraction of Endoscope

Removal of foreign body by incision

Preparation for Surgery
Incision
Exploration

Removal of foreign body

Partonomy of Processes

Closure