WordNet
A conceptual-semantic and lexical network

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Lexicon Formalisms - Universität Tübingen

June 7, 2016
Content

1. Wordnets
2. EuroWordNet
3. Word Sense Disambiguation
4. Wordnet-LMF
What is it really?

- a thesaurus?
- a dictionary?
- a semantic map?

⇒ word nets combine parts of all of the above mentions
What is it really?

What ideas does a word net borrow from...

- ...a thesaurus:
  - instead of linking *word forms*, WNs link *concepts*
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  - instead of linking *word forms*, WNs link *concepts*

- ...a dictionary:
  - a dictionary *can* contain multilingual information (translations) - WNs are limited to *one language*
  - WNs have brief *descriptions* for concepts - dictionaries have descriptions for words (*word forms*)
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- ...a thesaurus:
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- ...a dictionary:
  - a dictionary *can* contain multilingual information (translations) - WNs are limited to *one language*
  - WNs have brief *descriptions* for concepts - dictionaries have descriptions for words (word forms)

- ...a semantic map:
  - SMs describe a conceptual space in an unordered way - WNs are *multi-dimensionally* and *hierarchically* structured
**Basic notions**

- **LexUnit (Lexical unit):**
  - word > lexUnit
  - a lexUnit represents one meaning of a word
  - e.g. the word "fish": can be a noun or a verb (at least 2 lexUnits)
  - e.g. the word "glass": can be the material or the container or a measuring unit or...
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- **SynSet**:
  - sets of synonymous lexUnits
  - synSets are not just a collection of lexUnits, they rather represent concepts
  - i.e. a synSet containing more than one lexUnit represents a concept for which there are multiple "words"
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⇒ Let's have a look at the the actual WordNet online http://wordnetweb.princeton.edu/perl/webwn
Basic notions

Concepts:

- A concept can have multiple lexUnits referring to it.
- E.g. the concept of car: car, automobile, auto, automobile, macchina, araba, voiture etc.
- ⇒ A concept is **language-independent** and rather a **cognitive unit**.
### Basic notions

#### Table 3. A part of the aquamotion domain in Swedish, Dutch and Russian (based on Koptjevskaja-Tamm et al. forthcoming)

<table>
<thead>
<tr>
<th>Active motion of an animate Figure</th>
<th>Motion of vessels and people aboard</th>
<th>Passive motion; location on water</th>
<th>Motion of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sw simma</td>
<td>segla</td>
<td>ro</td>
<td>paddla</td>
</tr>
<tr>
<td>Du zwemmen</td>
<td>zeilen</td>
<td>roeien</td>
<td>paddelen</td>
</tr>
<tr>
<td>Ru</td>
<td>plyt'/plavat'</td>
<td>gresti</td>
<td>nestis'</td>
</tr>
</tbody>
</table>

(Koptjevskaja-Tamm, 2008:15)
Conceptual relations: Nouns

- **Hyponymy**
  - synSets are connected by hyponymy-realtions (isA-realtion)
  - i.e. specific concepts are linked to more general ones

  seat
  ⇓ hypernym of
  chair
Conceptual relations: Nouns

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  \[ \downarrow \text{ hypernym of } \]
  - chair
  \[ \downarrow \text{ hypernym of } \]
  - armchair
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<table>
<thead>
<tr>
<th>seat</th>
<th>liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>↓ hypernym of</td>
<td>↑ hyponym of</td>
</tr>
<tr>
<td>chair</td>
<td>water</td>
</tr>
<tr>
<td>↓ hypernym of</td>
<td>↑ hyponym of</td>
</tr>
<tr>
<td>armchair</td>
<td>tab water</td>
</tr>
</tbody>
</table>
Conceptual relations: Nouns

- **Hyponymy**
  - this relation is **transitive**
  - the top node is *entity* - all noun descend from this node
Conceptual relations: Nouns

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  - this relation is **transitive**
  - the top node is entity - all noun descend from this node
  - distinction between **types** and **instances**

seat
\[\uparrow\] is a type of
chair
\[\uparrow\] is a type of
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Conceptual relations: Nouns

- **Hyponymy**
  - this relation is **transitive**
  - the top node is entity - all noun descend from this node
  - distinction between **types** and **instances**

```
<table>
<thead>
<tr>
<th>seat</th>
<th>corporate executive</th>
</tr>
</thead>
<tbody>
<tr>
<td>↑ is a type of</td>
<td>↑ is a type of</td>
</tr>
<tr>
<td>chair</td>
<td>president</td>
</tr>
<tr>
<td>↑ is a type of</td>
<td></td>
</tr>
<tr>
<td>armchair</td>
<td></td>
</tr>
</tbody>
</table>
```
Conceptual relations: Nouns

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  - this relation is **transitive**
  - the top node is **entity** - all noun descend from this node
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- seat
  - ↑ is a type of
  - chair
  - ↑ is a type of
  - armchair
  - ↑ is a type of
  - corporate executive
  - ↑ is a type of
  - president
  - ↑ is an instance of
  - Obama
Meronomy (Part-whole-relation)

1. **Component-meronomy:**
   - leg is a component of table

2. **Substance-meronomy:**
   - oxygen is a part of air

3. **Member-meronomy:**
   - tree is a member of forest

4. **Portion-meronomy** (in GermaNet):
   - 1g is a portion of 1kg
Lexical relations: Adjectives

- descriptive adjectives
  - organized into **direct antonym** pairs
    e.g.: wet - dry
  - each member of a pair is connected to **semantically similar** adjectives
    e.g.: wet - damp, drenched
    dry - arid
Lexical relations: Adjectives

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  - each member of a pair is connected to **semantically similar** adjectives
    - e.g.: wet - damp, drenched
dry - arid

- **relational adjectives**
  - relational adjectives are linked to their corresponding nouns (cross-POS relation)
    - atomic - atom
Conceptual relations: Verbs

- **Troponymy**
  - similar to the hyponymy relation
  - relates synSets of verbs such that one expresses a **manner** of the other
    - speed: walk - sneak
    - volume: talk - whisper
    - etc.
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    - etc.

- **Entailment**
  - buy - pay
  - divorce - marry
Lexical and conceptual relations: Verbs

(Henrich, slides on GermaNet)
http://globalwordnet.org/wordnets-in-the-world/
What is EuroWordNet?

- a database of wordnets from different languages
- wordnets are interconnected via an Inter-Lingual-Index (ILI)
- ILI is an unstructured set of concepts, called ILI-records (based in those of the English WordNet)
- wordnets are connected to the ILI - thus the wordnets are not directly linked

⇒ Obviously this can be of great help in automated translation tasks
What is EuroWordNet?

What about different lexicalisations of concepts?

- some languages may lexicalise concepts differently than others
- thus: a specific wordnet may not cover a particular concepts whereas another wordnet covers that concept
- e.g. Dutch does not lexicalise the concept of 'container', so there is no such synset in the Dutch WordNet
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⇒ EuroWordNet provides some useful relations between ILI-records and the synsets of wordnets to overcome conceptual gaps or not perfectly fitting meanings
Relations between ILI-records and synsets

- **EQ_SYNONYM:**
  - holds if exactly one synset is connected to exactly one ILI-record (1-to-1)
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or
  - if many synsets are connected to one ILI-record (many-to-1) or
  - or when there is doubt about precise mapping
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- **EQ_HAS_HYPERNYM**: holds if a synset is more specific than any available ILI-record

- **EQ_HAS_HYPONYM**: holds if a synset can only be connected to a more specific ILI-record
Relations between ILI-records and synsets: Examples

- **EQ_NEAR_SYNONYM**: The sense for the Dutch 'schoonmaken' (to clean) matches 4 different ILI-records
Relations between ILI-records and synsets: Examples

- **EQ_NEAR_SYNONYM:** The sense for the Dutch 'schoonmaken' (to clean) matches 4 different ILI-records

- **EQ_HAS_HYPERNYM:** The Spanish sense of 'alevín' (young fish) would be linked to the ILI-record 'fish'
Two approaches

1. including every concept from all languages (ILI would be a superset of all wordnets)
2. Reduce the number of ILI-records to a set of essential concepts
Two approaches: maximize number of ILI-records

1. including every concept from all languages (ILI would be a superset of all wordnets)
   - lot of manual work
   - a lot of very specific concepts
   - many meanings that are predictable due to lexical productivity (trockenmachen, trockenreiben, etc)
Two approaches: minimize number of ILI-records

1. Reduce the number of ILI-records to a set of essential concepts
   - extension of ILI only if **specific** but **unpredictable** concept is met (Arbeitzeitverkürzung)
   - equivalence relation can still be found if there are **similar mapping** from different languages to the ILI-records
   - deleting **arbitrary** distinctions (linke those for clean)
   - combining similar ILI-records to **composite ILI-records**
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⇒ Currently EuroWordNet uses this approach
Conclusion

- With EWN wordnets can be used for translation tasks
- Using an ILI the wordnets can have different structures
- Language specific differences are taken care of using different equivalence relations
From a rap song:

'Du siehst mich [...] stehen wie der Mazda RX7, am Porsche angelehnt.'
Little fun with ambiguity

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Which reading of angelehnt best fits the example?

1. leaning or
2. inspired
Little fun with ambiguity

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'Du siehst mich [...] stehen wie der Mazda RX7, am Porsche angelehnt.'

Which reading of angelehnt best fits the example?

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⇒ The whole point of this sentence is, to make angelehnt have two readings at the same time.
What is Word Sense Disambiguation?

- many words are ambiguous
- the process of finding the most appropriate reading/meaning/sense of a word form is an easy task for humans
- doing that computationally is a hard task
- this task is called word sense disambiguation
What is Word Sense Disambiguation?

What do we need to be able to disambiguate words senses computationally?

- a word form
- a context in which it occurs
- senses linked to the word form (e.g. a dictionary or a word net)
- an algorithm
What is ambiguity?

A word form is ambiguous if it is

- polysemous (wood: tree or forest?)
- a homograph (homonym) (bark: sound of a dog or skin of a tree?)
- vague (child: male child or female child?)
What is a context?

The context of a word form are the surrounding words and their meanings.

- 'Since the customers were happy, they gave a large tip to the waitress'
- 'tip' is the target word we want to disambiguate
- 'Since the...gave a large' and 'to the waitress' is the context
Word senses

Which senses does the word form 'bank' have?

WordNet gave me these:

<table>
<thead>
<tr>
<th></th>
<th>bank</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>sloping land (especially the slope beside a body of water)</td>
</tr>
<tr>
<td>2</td>
<td>a financial institution that accepts deposits and channels the money into lending activities</td>
</tr>
<tr>
<td>3</td>
<td>a long ridge or pile</td>
</tr>
<tr>
<td>4</td>
<td>an arrangement of similar objects in a row or in tiers</td>
</tr>
<tr>
<td>5</td>
<td>a supply or stock held in reserve for future use (especially in emergencies)</td>
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</tbody>
</table>

This information can be used for disambiguation of 'river bank' for example.
The procedure of WSD

Compare clues from the context to the different senses of the target

Figure 2.1: The general idea of word sense disambiguation.

(Henrich, 2015:20)
Lesk algorithm

'Since the customers were happy, they gave a large tip to the waitress'

- get all the senses for all the word forms (context and target)
- compare all senses with all the other senses
- find overlaps in the sense descriptions
Lesk algorithm

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- get all the senses for all the word forms (context and target)
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Problem: too many combinations

- customer: 1 reading
- happy: 4 readings
- give: 56 readings
- large: 11 readings
- waitress: 2 readings

all according to WordNet
Let’s take an easier to process example: ’river bank’

<table>
<thead>
<tr>
<th>bank</th>
<th>river</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 sloping land (especially the slope beside a body of water)</td>
<td>1 a large natural stream of water (larger than a creek)</td>
</tr>
<tr>
<td>2 a financial institution that accepts deposits and channels the money into lending activities</td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
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overlap(r1, b1) = 1
overlap(r1, b2) = 0
overlap(r1, b3) = 0
...
⇒ r1 and b1 are the intended senses
other Lesk Algorithms

1. **augmented** Lesk algorithm:
   not only the target’s senses are used but also those of related words (hyponyms, meronyms etc.)

2. **simplified** Lesk algorithm:
   find overlap in target’s readings and the words of the context
Conclusion

- Word nets provide everything we need for WSD
- WNs are one of the main sources when dealing with WSD
- WordNet or GermaNet unfortunately do not provide sense descriptions for every synSet
XML format is pretty close to the internal structure of GermaNet (SynSets and relations)

- the Network is currently described in two DTDs
  - one containing all the synsets
  - another one containing all relations (lexical and conceptual)
  - ⇒ everything is covered by the two DTDs
Current GermaNet XML format

Figure 1. Structure of the XML synset files.

(Henrich et.al, 2010:458)
Current GermaNet XML format

Figure 3. Structure of the XML relation file.

(Henrich et.al, 2010:459)
<synset id="s58377" category="verben">
   <lexUnit id="182207">
      sense="1"
      namedEntity="no"
      artificial="no"
      styleMarking="no">
         <orthForm>leuchten</orthForm>
         <frame>NN</frame>
         <example>
            <text>
               Der Mond leuchtete in der Nacht.
            </text>
            <exframe>NN</exframe>
         </example>
   </lexUnit>
   <lexUnit id="182208">
      sense="2"
      namedEntity="no"
      artificial="no"
      styleMarking="no">
         <orthForm>strahlen</orthForm>
   </lexUnit>
   <paraphrase>
      Lichtstrahlen aussenden, große Helligkeit verbreiten
   </paraphrase>
</synset>
Current GermaNet XML format

<con_rel name="hyperonymy"
  from="s58377" to="s58376"
  dir="revert" inv="hyponymy" />

<lex_rel name="antonymy"
  from="12471" to="12470"
  dir="both" />

BUT: Other wordnets may have a different structure
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- `s58377` and `s58376` being synSets
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- `lex_rel` is a lexical relation from `12471` to `12470`
- `12471` and `12470` being lexUnits
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BUT: Other wordnets may have a different structure
Why not introduce a meta-model?
Why not introduce a **meta-model**?

**LMF** (lexical mark-up framework) is such a model
- provides a common framework for lexicons
- make exchanging data between lexicons easy
- easier merging of lexicons
LMF for GermaNet

(Henrich et al., 2010:460)
LMF for GermaNet

(Henrich et. al, 2010:460)

- rather word-based (current GermaNet DTD is synSet-based)
- lexUnit is not a child of synSet
LMF for GermaNet

(Henrich et. al, 2010:460)

- rather word-based (current GermaNet DTD is synSet-based)
- lexUnit is not a child of synSet
- the Sense-type has an attribute synset which connects lexUnits to synsets
- if two different lexUnits have the same synsetID in Sense, then they are members of the same synset, thus synonymous
Apply WN-LMF to GermaNet: 'Step by step'

Figure 1. Structure of the XML synset files.

Figure 5. The Wordnet-LMF structure.
Apply WN-LMF to GermaNet: ’Step by step’

current GermaNet: red; wordnet-LMF: blue

1 synsets ⊂ Lexicon
2 synset → Synset

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Figure 5. The Wordnet-LMF structure.
Apply WN-LMF to GermaNet: 'Step by step'

1. synsets $\subseteq$ Lexicon
2. synset $\rightarrow$ Synset
3. paraphrase $\rightarrow$ Definition

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Apply WN-LMF to GermaNet: 'Step by step'

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Apply WN-LMF to GermaNet: 'Step by step'

1. \( \text{synsets} \subset \text{Lexicon} \)
2. \( \text{synset} \rightarrow \text{Synset} \)
3. \( \text{paraphrase} \rightarrow \text{Definition} \)
4. \( \text{lexUnit} \rightarrow \text{Sense} \)
5. \( \text{orthForm} \rightarrow \text{Lemma} \)
6. \( \text{frame} \rightarrow \emptyset \)
7. \( \text{example} \rightarrow \text{Statement} \)
Apply WN-LMF to GermaNet: ’Step by step’

1. synsets \( \subseteq \) Lexicon
2. synset \( \rightarrow \) Synset
3. paraphrase \( \rightarrow \) Definition
4. lexUnit \( \rightarrow \) Sense
5. orthForm \( \rightarrow \) Lemma
6. frame \( \rightarrow \) \( \emptyset \)
7. example \( \rightarrow \) Statement

From relation DTD:
8. con_rel \( \rightarrow \) Synset Relation
9. lex_rel \( \rightarrow \) \( \emptyset \)
Almost everything from the current synSet DTD is covered in the wordnet-LMF except for:

- some relations
  - all lexical relations (antonymy, semantic similarity, cross-POS relations, etc.)
  - entailment realtion for verby (divorce - marry)
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- frames (e.g. valency for verbs)

⇒ There is revised wordnet-LMF structure which covers what the former version didn’t
Apply WN-LMF to GermaNet: Challenges

(Henrich et. al, 2010:463)
Apply *revised* WN-LMF to GermaNet

**Figure 1.** Structure of the XML synset files.

- synsets \(\subset\) Lexicon
- synset \(\rightarrow\) Synset
- paraphrase \(\rightarrow\) Definition
- lexUnit \(\rightarrow\) Sense
- orthForm \(\rightarrow\) Lemma
- frame \(\rightarrow\) Subcat. Frame
- example \(\rightarrow\) Statement

from relation DTD:

- con_rel \(\rightarrow\) Synset Relation
- lex_rel \(\rightarrow\) Sense Relation
GermaNet has its own DTD

it pretty much fits into the wordnet-LMF structure

for it to fit completely, the wordnet-LMF has to be extended

the extension exists in LMF proper. Wordnet-LMF is a subset of LMF proper
Summary

What we’ve seen today:

- **Structure of wordnets**
  - network of synSets (concepts)
  - a synSet contains lexUnits
  - synSets and lexUnits are linked via conceptual and lexical relations, resp.

- **EuroWordNet**
  - consists of an ILI, which contains ILI-records
  - ILI-records represent concepts
  - EWN is language and wordnet-structure independent
  - synSets are linked to ILI-records via different equivalence relations
Summary

What we’ve seen today:

- **Word sense disambiguation**
  - wordnets can be used to disambiguate word senses
  - different Lesk algorithms (finding highest overlap between sense descriptions)

- **GermaNet DTDs and wordnet-LMF**
  - GermaNet is structured into two DTDs (synSets and relations)
  - GermaNet almost perfectly fits the current wordnet-LMF
  - missing data can be included using the revised wordnet-LMF (in proper LMF)
Let’s discuss

- What advantages come along with the wordnet-LMF?
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- What other purposes can wordnets be good for?
- Could we use wordnet to distinguish polysemy and homonymy?

Francopoulo G., George M., Calzolari N., Monachini M., Bel N., Pet M., Soria C. 2006. Lexical Markup Framework (LMF)


http://www.sfs.uni-tuebingen.de/~vhenrich/ss15/java/

https://wordnet.princeton.edu