Detecting Relational Constructions in German Texts Automatically

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concept types

person, pope, house, verb, sun, Mary, wood, brother, mother, meaning, distance, spouse, argument, entrance
## Concept Types: Relationality ($\pm R$)

<table>
<thead>
<tr>
<th>Type</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-relational</td>
<td>person, pope, house, verb, sun, Mary, wood</td>
</tr>
<tr>
<td>Relational</td>
<td>brother, mother, meaning, distance, spouse, argument, entrance</td>
</tr>
</tbody>
</table>

Löbner (2011)
### Concept Types: Uniqueness of Reference ($\pm U$)

<table>
<thead>
<tr>
<th></th>
<th>Non-Unique Reference ($-U$)</th>
<th>Unique Reference ($+U$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Relational ($-R$)</td>
<td>Person, house, verb, wood</td>
<td>Mary, pope, sun</td>
</tr>
<tr>
<td>Relational ($+R$)</td>
<td>Brother, argument, entrance</td>
<td>Mother, meaning, distance, spouse</td>
</tr>
</tbody>
</table>

Löbner (2011)
### Concept types

<table>
<thead>
<tr>
<th>Concept Type</th>
<th>Non-Unique Reference</th>
<th>Unique Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-relational</strong> ($-R$)</td>
<td>Sortal concept</td>
<td>Individual concept</td>
</tr>
<tr>
<td></td>
<td>person, house, verb, wood</td>
<td>Mary, pope, sun</td>
</tr>
<tr>
<td></td>
<td>$\lambda x. \ P(x)$</td>
<td>$\iota u. \ P(u)$</td>
</tr>
<tr>
<td><strong>Relational</strong> ($+R$)</td>
<td>Proper relational concept</td>
<td>Functional concept</td>
</tr>
<tr>
<td></td>
<td>brother, argument, entrance</td>
<td>mother, meaning, distance, spouse entrance</td>
</tr>
<tr>
<td></td>
<td>$\lambda y \lambda x. \ R(x, y)$</td>
<td>$\lambda y. \ f(y)$</td>
</tr>
</tbody>
</table>

Löbner (2011)
Theory of concept types and determination (CTD)

Every concept type comes with a ‘natural mode’ of determination: congruent determination.

<table>
<thead>
<tr>
<th>DET⁺:</th>
<th>indefinite</th>
<th>a book, (\tilde{\gamma}) a pope</th>
</tr>
</thead>
<tbody>
<tr>
<td>DET−:</td>
<td>plural</td>
<td>books, (\tilde{\gamma}) popes</td>
</tr>
<tr>
<td></td>
<td>quantifiers</td>
<td>any book, (\tilde{\gamma}) any pope</td>
</tr>
<tr>
<td></td>
<td>demonstratives</td>
<td>this book, (\tilde{\gamma}) this pope</td>
</tr>
<tr>
<td>DET⁺:</td>
<td>singular definite</td>
<td>the pope, (\tilde{\gamma}) the stone</td>
</tr>
<tr>
<td>DET−:</td>
<td>absolute</td>
<td>the pope, (\tilde{\gamma}) the head</td>
</tr>
<tr>
<td>DET−:</td>
<td>possessive pronoun</td>
<td>my head, (\tilde{\gamma}) my stone</td>
</tr>
</tbody>
</table>
Incongruent determination: shifts

- The teacher has recommended a book. Mary buys the book. (anaphoric use)
- Mothers act like popes. (generic uses)
- Mary bought a Picasso. (metaphorical shift)
Incongruent determination: shifts

- The teacher has recommended a book. Mary buys the book. (anaphoric use)
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- Mary bought a Picasso. (metaphorical shift)

Incongruent determination is made explicit in languages with:

- weak/strong definite article split
  e.g. Rhineland dialects, ‘Dr Zoch kütt’ vs. ‘Dä Zoch kütt’
- (in)alienability split
  e.g. Lakhota, 2SG-spirit DEF ‘your spirit’ vs. 2SG-REL-book DEF ‘your book’
Research hypothesis

C02: Conceptual shifts – statistical evidence

- Congruent determination is more frequent than incongruent determination.
- The frequency pattern of determination modes in which a noun occurs (its determination fingerprint) depends on its concept type.
Research hypothesis

C02: Conceptual shifts – statistical evidence

- Congruent determination is more frequent than incongruent determination.
- The frequency pattern of determination modes in which a noun occurs (its determination fingerprint) depends on its concept type.

Question

Is it possible to determine the concept type of a noun automatically?
Research hypothesis

C02: Conceptual shifts – statistical evidence

- Congruent determination is more frequent than incongruent determination.
- The frequency pattern of determination modes in which a noun occurs (its determination fingerprint) depends on its concept type.

Question

Is it possible to determine the concept type of a noun automatically?

Necessary prerequisite

Determine the determination mode automatically:
- relatively easy for $Det_{\pm U}$ (closed class of determiners)
- more complex for $Det_{\pm R}$ (topic of today’s talk)
Aim: automatic detection of relational constructions in German

4 basic constructions:

- [Der Hut]_{P^{um}} [des Mannes]_{P^{or}} ist grün. (right genitive, \textit{rgen})
- [Maries]_{P^{or}} [Hut]_{P^{um}} ist grün. (left genitive, \textit{lgen})
- [Mein]_{P^{or}} [Hut]_{P^{um}} ist grün. (possessive pronoun, \textit{lpron})
- [Der Hut]_{P^{um}} [von Marie]_{P^{or}} ist grün. (right ‘von’, \textit{rvon})

non-trivial task:

- Er soll den Knochen vom Hund aufheben. (noun attached PP)
- Er soll den Knochen vom Boden aufheben. (verb attached PP)
- Peter bekommt ein Buch von Marie. (ambigue)
**Aim: automatic detection of relational constructions in German**

4 basic constructions:

- \ [[Der Hut]_{P^\text{um}} [des Mannes]_{P^\text{or}} \text{ ist grün.} (right genitive, \textit{rgen})
- \ [[Maries]_{P^\text{or}} [Hut]_{P^\text{um}} \text{ ist grün.} (left genitive, \textit{lgen})
- \ [[Mein]_{P^\text{or}} [Hut]_{P^\text{um}} \text{ ist grün.} (possessive pronoun, \textit{lpron})
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non-trivial task:

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Seed corpus containing 300 sentences (Horn & Kimm 2014)

main data: 800 sentences (randomly drawn from Leipzig Corpora) annotated by 2 annotators with ‘PUM’, ‘POR’ and no-poss

example: (Der, PUM.rvon) (Bürgermeister, PUM.rvon) (von, POR.rvon) (Berlin, POR.rvon) (spricht, no-poss) (schnell, no-poss)

annotator agreement: 81.9% (\(\kappa = 0.767\), max \(\kappa = 0.936\))
## Data

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>no relation (no-poss)</td>
<td>4915</td>
</tr>
<tr>
<td>Right genitive (rgen)</td>
<td>180</td>
</tr>
<tr>
<td>Possessive pronoun (lpron)</td>
<td>120</td>
</tr>
<tr>
<td>Right ‘von’ (rvon)</td>
<td>13</td>
</tr>
<tr>
<td>Left genitive (lgen)</td>
<td>12</td>
</tr>
</tbody>
</table>

frequencies of possessive classes in seed corpus; word-based count
Features: extracted from MATE trees

Marie wischte über das Ceranfeld des Herdes.

wischen (V)

marie (NE)   ueber (PREP)   ceranfeld (N)

der (ART)   herd (N)

der (ART)
Features: extracted from MATE trees

Marie wischte über das Ceranfeld des Herdes.

For each word take 5-tuple:
- surface form
- lemma
- POS tag
- case marker
- s-ending

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceranfeld</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>Ceranfeld</td>
<td></td>
<td>acc</td>
</tr>
<tr>
<td>Ceranfeld</td>
<td></td>
<td>false</td>
</tr>
</tbody>
</table>
Features: multidimensional feature vector

syntactic parent + context window: ±2

\[
\begin{pmatrix}
  x_{i-2} \\
  über \\
  über \\
  PREP \\
  - \\
  false
\end{pmatrix},
\begin{pmatrix}
  x_{i-1} \\
  das \\
  der \\
  ART \\
  acc \\
  true
\end{pmatrix},
\begin{pmatrix}
  x_i \\
  Ceranfeld \\
  ceranfeld \\
  N \\
  acc \\
  false
\end{pmatrix},
\begin{pmatrix}
  x_{i+1} \\
  des \\
  der \\
  ART \\
  gen \\
  true
\end{pmatrix},
\begin{pmatrix}
  x_{i+2} \\
  Herdes \\
  herd \\
  N \\
  gen \\
  true
\end{pmatrix},
\begin{pmatrix}
  x_p^? \\
  wischte \\
  zwischen \\
  V \\
  - \\
  false
\end{pmatrix}
\]

wischen (V)

marie (NE)  ueber (PREP)  ceranfeld (N)

Marie wischte über das Ceranfeld des Herdes.
Rule base

- \( rvon \equiv N \leftarrow von \leftarrow (N \lor NE) \)
- \( lpron \equiv N \leftarrow \text{PRPOSS} \)
- \( rgen \equiv N \leftarrow N \leftarrow \text{ART}^1 \)
- \( lgen \equiv N \leftarrow \text{NE}_{\text{gen}} \)
  - \( lgen \equiv N \leftarrow \text{N}_{\text{gen}} \) very rarely
  - \( \Rightarrow \text{N}_{\text{gen}} \) many misclassifications.

\[^1\text{Original rule: } rgen \equiv N \leftarrow \text{N}_{\text{gen}} \leftarrow \text{ART}\]
Statistical ML algorithms

Statistical Algorithms

- **Non-sequential**: Maximum Entropy\(^2\)
- **Sequential**: Conditional Random Fields\(^3\), SVM\(^{HMM}\)\(^4\)

\(^2\)Ratnaparkhi (1998); implementation: OpenNLP
\(^3\)Lafferty (2001); implementation:
http://www.chokkan.org/software/crfsuite/
\(^4\)Altun (2003); implementation:
http://www.cs.cornell.edu/people/tj/svm_light/svm_hmm.html
## Word-based evaluation by classifier

<table>
<thead>
<tr>
<th></th>
<th>SVM$^\text{HMM}$</th>
<th>CRF</th>
<th>ME</th>
<th>Tree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P</td>
<td>R</td>
<td>P</td>
<td>R</td>
</tr>
<tr>
<td>no-poss</td>
<td>97.8</td>
<td>99.3</td>
<td>97.3</td>
<td>99.2</td>
</tr>
<tr>
<td>POSS</td>
<td>90.8</td>
<td>79.6</td>
<td>88.5</td>
<td>75.3</td>
</tr>
<tr>
<td>PUM</td>
<td>91.4</td>
<td>75.5</td>
<td>91.9</td>
<td>70.5</td>
</tr>
</tbody>
</table>

30-fold cross-validation, green: Highest F-value in a row

Problems with the tree classifier: “... sei seine Partei$^\text{PUM}$ der Auffassung$^\text{POSS}$, ...”
Word-based evaluation by classifier and relational type

<table>
<thead>
<tr>
<th></th>
<th>SVM</th>
<th>HMM</th>
<th>CRF</th>
<th>ME</th>
<th>Tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>lgen POSS</td>
<td>93.15</td>
<td>71.58</td>
<td>94.83</td>
<td>57.89</td>
<td>93.48</td>
</tr>
<tr>
<td>lgen PUM</td>
<td>97.5</td>
<td>53.42</td>
<td>97.22</td>
<td>47.95</td>
<td>100</td>
</tr>
<tr>
<td>lpron POSS</td>
<td>96.51</td>
<td>92.74</td>
<td>96.93</td>
<td>88.27</td>
<td>99.3</td>
</tr>
<tr>
<td>lpron PUM</td>
<td>99.49</td>
<td>81.07</td>
<td>99.47</td>
<td>77.37</td>
<td>98.18</td>
</tr>
<tr>
<td>rgen POSS</td>
<td>99.25</td>
<td>83.17</td>
<td>99.37</td>
<td>78.64</td>
<td>99.12</td>
</tr>
<tr>
<td>rgen PUM</td>
<td>96.75</td>
<td>78.63</td>
<td>96.54</td>
<td>73.61</td>
<td>97.66</td>
</tr>
<tr>
<td>rvon POSS</td>
<td>98.4</td>
<td>58.57</td>
<td>96.9</td>
<td>59.52</td>
<td>94.74</td>
</tr>
<tr>
<td>rvon PUM</td>
<td>94.23</td>
<td>63.64</td>
<td>95.45</td>
<td>54.55</td>
<td>91.67</td>
</tr>
</tbody>
</table>

Problematic cases:

- **lgen**: “Peters Haus” (NE)
- **rvon**: “das Haus von Peter” vs. “Maria hat das Buch von Peter bekommen”
- **rgen**: “die Wut der Arbeiter” (nom.? gen.?)
Results of merging decisions: majority vote

<table>
<thead>
<tr>
<th>Type</th>
<th>P</th>
<th>R</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSS</td>
<td>91.6</td>
<td>80.3</td>
<td>85.6</td>
</tr>
<tr>
<td>PUM</td>
<td>93.2</td>
<td>74.4</td>
<td>82.7</td>
</tr>
</tbody>
</table>
Structure-based evaluation

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>R</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full matches</td>
<td>93.58</td>
<td>87.14</td>
<td>90.24</td>
</tr>
<tr>
<td>Partial matches</td>
<td>94.38</td>
<td>88.64</td>
<td>91.42</td>
</tr>
</tbody>
</table>

Examples:

- **Gold**: das Haus$_{PUM}$ von Peter und Maria$_{POSS}$
- **Silver**: das Haus$_{PUM}$ von Peter$_{POSS}$ und Maria
The influence of chunk lengths

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>R</th>
<th>F</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>long chunks ((LR &gt; 4))</td>
<td>97.7%</td>
<td>71.7%</td>
<td>82.7%</td>
<td>61</td>
</tr>
<tr>
<td>short chunks ((LR \leq 4))</td>
<td>94.1%</td>
<td>90.4%</td>
<td>92.2%</td>
<td>597</td>
</tr>
</tbody>
</table>
Summary

Next steps:
- Merging parse trees
- Meta-learning
- Large-scale evaluation of Löbner’s theory