A Framenet and Frame Annotator for German Social Media

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Lexical semantic resource types

- **WordNet (Fellbaum 1998)**
  - extensive ontology, but no inherent method for disambiguation or annotation, better for nouns than verbs

- **FrameNet (Baker et al. 1998, Johnson & Fillmore 2000, Ruppenhofer et al. 2010)**
  - systematic classification of abstracted verb senses with semantically restricted "slot-filler" arguments: potential for disambiguation, but coverage problem at the token level

- **PropBank (Palmer et al. 2005)**
  - consecutive argument structure annotation of corpus verbs (propositions): better coverage and statistical balance, but less generalization than FrameNet

- **VerbNet (Kipper et al. 2006)**
  - less granularity, more limited set of roles and predicate classes
Frames: From resource to annotation

- **corpus-driven:** German SALSA framenet (Burchardt et al. 2006) and SHALMANESER parser (Burchardt et al. 2009)
  - 600 different frames, half specific to German, but coverage limited to the hand-annotated corpus
  - heuristic frame assignment for lexicon gaps, based on Word Net synsets
  - ML-based corpus annotation

- **parser-driven:** PFN-DE ("parser framenet", this paper)
  - unabridged lexicon, simple parsing-oriented framenet scheme
  - matches the valency lexicon and noun ontology of an existing morphosyntactic parser (GerGram)
  - supports a rule-based frame annotator that directly exploits GerGram's tags and dependency links
  - matches a similar system for Danish (Bick 2011), allowing comparable corpus annotation for our bilingual Social Media Corpus (XPEROHS, Baumgarten et al. 2019)
Cross-lingual framenet bootstrapping

1. step: Danish-German verb sense matches based on an MT dictionary (GramTrans, Bick 2007)
   - MT: verb polysemy resolution by listing arguments with semantic slot filler information
   - valency patterns as an anchor for frame transfer: harvest a Danish frame (including its selection restrictions) by matching the MT dictionary's argument list, choosing - for each translation - the frame with the same valency pattern

2. step: manual checking of the harvested frames
   - german valency patterns used to identify gaps in existing entries and as skeletons for verbs without an MT entry

3. step: identifying frame lexicon gaps in a preliminary annotation of the XPEROHS corpus
   - frequency-based manual frame additions
   - systematic check of construction verbs for idiomatic senses/constructions
PFN-DE: Lexicon size and granularity

✦ Frame lexicon size:
  • 11,333 verb lemmas
  • 14,695 different lemma+frame combinations
  • 1.297 frames / lemma (1.237 semantic types / lemma), Zipfian distribution
  • coverage: all entries in the parser lexicon have at least 1 frame), corpus: 1-2% lexical frame failure rate

✦ Frame types
  • 483 types (almost all Danish frames also used for German)
  • 1,700 different combinations of "atomic" frames, to capture additional lexical information (aspect, directionality, urgency), often triggered by prefixes:
    - *weiterlaufen (run on)* - fn:run&continue
    - *loslaufen (start running)* - fn:run&start
    - *verglimmen (stop burning)* - fn:burn&stop
  • 7,316 distinct role/complement-specified "syntactic" frames

✦ Non-verbal predicates
  • 1,400 nouns, 400 adjectives
  • systematic frame transfer from verbs to deverbal nouns and participle adjectives
    - *erkranken* --> *Erkrankung (falling ill)*: inherits 'sick' frame, preposition trigger (*Erkrankung an*) and §CAU argument role
Lexical support for the frame annotator: syntactic and semantic slot restrictions

- e.g. *bestehen*: 5 meanings
  - 'pass' [an exam] (accusative-monotransitive): `<FN:succeed/S§AG'H/O§TH'occ>`
  - 'consist of' (PP-monotransitive: *b. aus*): `<FN:consist/S§HOL'cc/P-aus§PART'cc|H>`
  - 'insist on' (PP-monotransitive *b. auf*): `<FN:demand/S§SP'H/P-auf§TH'cc|act>`
  - 'be' (PP-monotransitive: *b. in*): `<FN:be_copula/S§TH'ac|act/P-in§ATR'ac|act>`
  - 'persist' (intransitive): `<FN:persist/S§PAT'conv|build|inst>`

- for complements other than np's and pp's, syntactic form or POS can be specified instead of semantic type:
  - 'fcl' – finite clause, 'icl' – non-finite clause, 'num' – numeral

- only 834 valency patterns were sense-ambiguous
  - --> 92-93% of verbs could in theory be sense-disambiguated using syntactic clues alone
### Semantic roles

- **44 atomic semantic roles**
- **88 combinations, e.g. §AG-EXP subj. of zuhören (listen)**

<table>
<thead>
<tr>
<th>Semantic role</th>
<th>surface verb args %</th>
<th>secondary v- args %</th>
<th>all surface args %</th>
</tr>
</thead>
<tbody>
<tr>
<td>§TH Theme</td>
<td>18.88</td>
<td>20.67</td>
<td>36.17</td>
</tr>
<tr>
<td>§ATR Attribute</td>
<td>8.13</td>
<td>1.32</td>
<td>8.91</td>
</tr>
<tr>
<td>§LOC-TMP Point in time</td>
<td>8.64</td>
<td>0</td>
<td>6.33</td>
</tr>
<tr>
<td>§MNR Manner</td>
<td>8.13</td>
<td>0</td>
<td>5.49</td>
</tr>
<tr>
<td>§LOC Location</td>
<td>6.24</td>
<td>2.90</td>
<td>5.30</td>
</tr>
<tr>
<td>§AG Agent</td>
<td><strong>9.29</strong></td>
<td><strong>38.63</strong></td>
<td>5.72</td>
</tr>
<tr>
<td>§EXT Extension</td>
<td>1.89</td>
<td>0.05</td>
<td>3.04</td>
</tr>
<tr>
<td>§META Meta adverbial</td>
<td>3.95</td>
<td>0</td>
<td>2.59</td>
</tr>
<tr>
<td>§COG Cognizer</td>
<td>4.01</td>
<td><strong>8.21</strong></td>
<td>2.27</td>
</tr>
<tr>
<td>§DES Destination</td>
<td>2.13</td>
<td>0.76</td>
<td>1.82</td>
</tr>
<tr>
<td>§BEN Beneficiary</td>
<td>2.56</td>
<td>1.32</td>
<td>1.81</td>
</tr>
<tr>
<td>§PAT Patient</td>
<td>2.44</td>
<td><strong>4.33</strong></td>
<td>1.61</td>
</tr>
<tr>
<td>§REFL Reflexive</td>
<td>2.48</td>
<td>0</td>
<td>1.44</td>
</tr>
<tr>
<td>§ID Identity</td>
<td>0.01</td>
<td>0</td>
<td>1.21</td>
</tr>
<tr>
<td>§SP Speaker</td>
<td>1.95</td>
<td><strong>6.57</strong></td>
<td>1.17</td>
</tr>
<tr>
<td>§CAU Cause</td>
<td>1.49</td>
<td>1.24</td>
<td>1.02</td>
</tr>
<tr>
<td>§ACT Action</td>
<td>1.34</td>
<td>1.40</td>
<td>2.19</td>
</tr>
<tr>
<td>§REC Recipient</td>
<td>0.94</td>
<td>0.94</td>
<td>1.75</td>
</tr>
<tr>
<td>§EV Event</td>
<td>1.18</td>
<td>1.61</td>
<td>1.56</td>
</tr>
<tr>
<td>§EXP Experiencer</td>
<td>1.32</td>
<td>2.63</td>
<td>1.31</td>
</tr>
<tr>
<td>§DON Donor</td>
<td>0.12</td>
<td>0.31</td>
<td>0.07</td>
</tr>
</tbody>
</table>
Light / non-role complements

- **verb particles** -- syntactic dummy tag (MV<), no role
  - *sie machte das Licht aus* (she turned off the light)
    - lemma: "*ausmachen*" (turn off), fn:*deactivate*

- **support verbs**: complement-based semantics and dependents -- full syntactic tag, dummy role (§INC)

- **PP incorporates** (§INC on the noun, blocks other roles)
  - *auf der Strecke bleiben* (be lost, 'stay on the road'), fn:*disappear*
  - *in Kraft treten* (come into effect, 'step into power'), fn:*activate*
The frame annotator

- run as an additional module after GerGram morphosyntactic annotation
- uses the same formalism as GerGram and DanGram (Constraint Grammar), with full structural and tag compatibility with both parsers
- frame choice triggered by syntactic and semantic clues (GerGram tags) in iterative disambiguation and mapping steps
  - e.g. `<FN: tell/S§SP'H/D§REC'H/O§MES'fact|sem-s|fcl> (e.g. melden, zutragen)`
  - presence of a finite clause object (O:fcl) triggers this frame, if there is no other frame with O:fcl for the same lemma
- field-based assignment of roles:
  - subject (S) --> §SP (speaker)
  - fcl object (O) --> §MES (message)
  - dative object (D) --> §REC (receiver)
Frame mapping and disambiguation

1. Frame template mapping (disambiguation through lemmatization)
   - *er nahm den Bus* (he took the bus), lemma: nehmen <FN:take/>
   - *er nahm 5 kg zu* (he put on 5 kg), lemma: zu|nehmen <FN:increase/>
   - *er nahm ihr die Aufgabe ab* (he relieved her of the task), lemma: ab|nehmen <FN:rid/>

2. Frame template selection

3. Frame template removal

4. Role instantiation

5. Mapping of free roles
Selection and removal rules

- removal is simpler, safer and more robust than selection, because a single mismatch can trigger the former
- lexical matches are safest, e.g. *Wert* (worth) in:
  - `legen <FN:mind/S§COG’H/O-Wert§INC/P-auf§TH’all>`
- syntactic functions are relatively safe, but not always expressed (check for competing lower-valency frames)
- most important are semantic slot fillers, to disambiguate frames with identical valency skeletons
  - shallow noun ontology with 200 categories, e.g. `<Hprof>` (profession), `<Hfam>` (family member), `<Hideo>` (ideological), `<sem-r>` (readable), `<sem-c>` (concept), `<sem-s>` (sayable)
  - to allow for fuzzy matches, the grammar lumps tags into umbrella categories, e.g. 'HUMAN', 'THING', 'PLACE'
  - progressive relaxation of the matching algorithm:
    - precise match --> umbrella match
    - all slots match --> some matches --> one or no slot matches
    - highest number of syntactic matches
Exploiting (secondary) dependencies

- in order to constitute semantic rather than syntactic links, dependencies need to be raised for prepositions and transparent nouns

- dependency trees can only be used directly if roles manifest as surface constituents, and these need to be nouns to allow semantic matches
  - in 45% of cases, there is no, or only pronominal, surface representation

- improvement: assign secondary/additional dependency links for relatives, infinitive subjects, coordination etc.

<table>
<thead>
<tr>
<th></th>
<th>filled slots (incl. secondary dep.)</th>
<th>filled slots (primary dep. only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUBJ</td>
<td>74.5 %</td>
<td>72.7 %</td>
</tr>
<tr>
<td>ACC</td>
<td>73.1 %</td>
<td>72.9 %</td>
</tr>
<tr>
<td>DAT</td>
<td>60.3 %</td>
<td>60.3 %</td>
</tr>
<tr>
<td>SC</td>
<td>97.7 %</td>
<td>97.7 %</td>
</tr>
</tbody>
</table>
## Annotation example

<table>
<thead>
<tr>
<th>Word</th>
<th>Lemma</th>
<th>Secondary tag, Frame</th>
<th>POS, morphology</th>
<th>Syntactic function</th>
<th>Semantic role</th>
<th>Dep. link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ich (I)</td>
<td>ich</td>
<td></td>
<td>PERS</td>
<td>@SUBJ&gt;</td>
<td>§COG</td>
<td>#1-&gt;2</td>
</tr>
<tr>
<td>verstehe (understand)</td>
<td>verstehen</td>
<td>&lt;mv&gt;<a href="">FN:comprehend</a></td>
<td>V PR 1S FIN</td>
<td>@FS-STA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nicht (not)</td>
<td>nicht</td>
<td></td>
<td>ADV</td>
<td>@ADVL&gt;</td>
<td>§CAU</td>
<td>#3-&gt;2</td>
</tr>
<tr>
<td>warum (why)</td>
<td>warum</td>
<td>&lt;clb&gt;&lt;interr&gt;</td>
<td>ADV</td>
<td>@ADVL&gt;</td>
<td>§CAU</td>
<td>#4-&gt;7</td>
</tr>
<tr>
<td>es (there)</td>
<td>es</td>
<td></td>
<td>PERS</td>
<td>@S-SUBJ&gt;</td>
<td>§TH-NIL</td>
<td>#5-&gt;7</td>
</tr>
<tr>
<td>Eltern (parents)</td>
<td>Eltern</td>
<td>&lt;HH&gt;</td>
<td>N nG P ACC</td>
<td>@ACC&gt;</td>
<td>§TH</td>
<td>#6-&gt;7</td>
</tr>
<tr>
<td>gibt (are)</td>
<td>geben</td>
<td>&lt;mv&gt;<a href="">FN:exist</a></td>
<td>V PR 3S FIN</td>
<td>@FS-&lt;ACC&gt;</td>
<td>§TH</td>
<td>#7-&gt;2</td>
</tr>
<tr>
<td>,</td>
<td>,</td>
<td></td>
<td>PU</td>
<td>@PU</td>
<td></td>
<td>#8-&gt;0</td>
</tr>
<tr>
<td>die (that)</td>
<td>die</td>
<td>&lt;clb&gt;&lt;rel&gt;</td>
<td>INDP nG P NOM</td>
<td>@SUBJ&gt;</td>
<td></td>
<td>#9-&gt;17</td>
</tr>
<tr>
<td>die (the)</td>
<td>die</td>
<td>&lt;def&gt;</td>
<td>ART F S ACC</td>
<td>@&gt;N</td>
<td></td>
<td>#10-&gt;11</td>
</tr>
<tr>
<td>Erziehung (education)</td>
<td>Erziehung</td>
<td><a href="">FN:teach</a></td>
<td>N F S ACC</td>
<td>@ACC&gt;</td>
<td>§ACT</td>
<td>#11-&gt;17</td>
</tr>
<tr>
<td>ihrer (their)</td>
<td>sie</td>
<td>&lt;poss&gt;</td>
<td>DET nG P GEN</td>
<td>@&gt;N</td>
<td></td>
<td>#12-&gt;13</td>
</tr>
<tr>
<td>Kinder (children)</td>
<td>Kind</td>
<td>&lt;H&gt;</td>
<td>N NEU P GEN</td>
<td>@N&lt;</td>
<td>§BEN</td>
<td>#13-&gt;11</td>
</tr>
<tr>
<td>möglichst (as possible)</td>
<td>möglich</td>
<td>&lt;jcan&gt;</td>
<td>ADV SUP</td>
<td>@&gt;A</td>
<td></td>
<td>#14-&gt;15</td>
</tr>
<tr>
<td>früh (early)</td>
<td>früh</td>
<td>&lt;atemp&gt;</td>
<td>ADV</td>
<td>@ADVL&gt;</td>
<td>§LOC-TMP</td>
<td>#15-&gt;17</td>
</tr>
<tr>
<td>Fremden (strangers)</td>
<td>Fremder</td>
<td><a href="">ADJ:jsoc</a>&lt;Q-&gt;&lt;nadj&gt;</td>
<td>N nG P ACC</td>
<td>@DAT&gt;</td>
<td>§REC</td>
<td>#16-&gt;17</td>
</tr>
<tr>
<td>überlassen (leave)</td>
<td>überlassen</td>
<td>&lt;mv&gt;<a href="">FN:allow</a> ▲</td>
<td>V INF</td>
<td>@FS-N&lt;</td>
<td>§ATR</td>
<td>#17-&gt;6</td>
</tr>
<tr>
<td>wollen (want)</td>
<td>wollen</td>
<td>&lt;aux&gt;<a href="">FN:wish</a></td>
<td>V PR 3P FIN</td>
<td>@AUX</td>
<td></td>
<td>#18-&gt;17</td>
</tr>
</tbody>
</table>
Evaluation: Data

- Corpus: 2 years of Twitter (~ 2 billion words)
  - extraction of all main verb-lemmas and their semantic class frame (f >= 1000 for noise reduction)
  - 8894 lemma-frame combinations (= 202.4 million tokens)
  - Manual check for non-German words and POS errors: 7,726 real German verb frames, representing 6,127 lemmas and 193.4 million tokens
    = half the German verb lexicon (= 99.9% token coverage according to Zipf’s law)
  - 1.245 frame classes / verb lemma, ca. = lexicon distribution and therefore likely to be representative in spite of the frequency cut-off
  - ambiguity higher at the token-level: 3.126 frame senses / verb
Evaluation: Ambiguity and coverage

- coverage failures
  - token level: 1.11% no frame + 0.25% no surviving frame
  - type level: 5.88% (impact of very rare verbs)

- frame ambiguity
  - higher at the token-level: 3.126 frame senses / verb
  - unevenly distributed: 78.6% monosemous verbs, 10 most frequent verbs (10.36% of all verb tokens) are very ambiguous:

<table>
<thead>
<tr>
<th>verb lemma</th>
<th>token count</th>
<th>frame senses</th>
</tr>
</thead>
<tbody>
<tr>
<td>lassen</td>
<td>2824239</td>
<td>11</td>
</tr>
<tr>
<td>geben</td>
<td>2455458</td>
<td>10</td>
</tr>
<tr>
<td>machen</td>
<td>2124256</td>
<td>34</td>
</tr>
<tr>
<td>spielen</td>
<td>1457122</td>
<td>4</td>
</tr>
<tr>
<td>nehmen</td>
<td>1416502</td>
<td>24</td>
</tr>
<tr>
<td>sehen</td>
<td>1414451</td>
<td>5</td>
</tr>
<tr>
<td>kommen</td>
<td>1251055</td>
<td>13</td>
</tr>
<tr>
<td>bleiben</td>
<td>1250034</td>
<td>3</td>
</tr>
<tr>
<td>haben</td>
<td>1237781</td>
<td>8</td>
</tr>
<tr>
<td>halten</td>
<td>1226771</td>
<td>17</td>
</tr>
</tbody>
</table>
Evaluation: Performance

- random sample of tweets (9,054 parser tokens) annotated and manually evaluated
  - 884 main verb tags
  - 20 wrong POS, 1 wrong lemma, 1 aux/mv error), often due to spelling errors in the word or its context
  - 8 verbs not recognized as such

- frame tagger performance
  - coverage: 99% (1 verb OOV, 8 cases where the correct frame was not among the ones listed in the lexicon)
  - recall / precision:

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>P</th>
<th>F-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>total incl. POS errors</td>
<td>90.7%</td>
<td>96.5%</td>
<td>93.6</td>
</tr>
<tr>
<td>ignoring POS errors</td>
<td>93.0%</td>
<td>97.4%</td>
<td>95.2</td>
</tr>
</tbody>
</table>

- comparison
  - English Twitter out-of-domain (Hartmann et al. 2017): 62.17% full frame identification
  - German SHALMANESER (Burchardt et al. 2009): 79% correct WSD
  - in-domain German SRL test data (CoNLL 2009):
    - without linguistic features (Do et al. 2018): F=73.5
    - with syntax-aware neural networks (Cai & Lapata 2019): F=82.7%
Conclusions and outlook

- New resource: a German framenet intended for direct integration into a parser pipeline
  - valency-based, "framenet light" approach
  - bilingual compatibility Danish-German
  - coverage on par with morphosyntactic parsing
  - robust frame sense annotation (F=93.6 for social media data)

- Future work
  - add missing senses to existing verb entries (now: precision better than recall)
  - reduce underlying tagging errors for POS and dependency in the face of non-standard orthography
  - test the assumption that other domains without orthographical problems should work as well, given the general nature of the underlying morphosyntactic parser

- Cross-lingual aspects
  - It might be possible to generalize the Danish-German parser interoperability and dictionary-based bootstrapping to further (related?) languages. Thus, work is ongoing for a compatible Portuguese framenet and annotator.
Info: framenet.dk
Demo: visl.sdu.dk/de
contact: eckhard.bick@mail.dk