Word Senses, WordNet and the Ontologies Groupings

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Annotation procedure, WSJ

PropBank

- PTB II - Extraction of all sentences with given verb
- Create Frame File for that verb  *Paul Kingsbury*
  - (3100+ lemmas, 4400 framesets, 118K predicates)
  - Over 300 created automatically via VerbNet
- First pass: Automatic tagging  *Joseph Rosenzweig*
  - http://www.cis.upenn.edu/~josephr/TIDES/index.html#lexicon
- Second pass: Double blind hand correction
- Tagging tool highlights discrepancies  *Scott Cotton*
- Third pass: *Solomonization* (adjudication)
  - *Betsy Klipple, Olga Babko-Malaya, Claire Bonial, Katie Conger, Julia Bonn, ...*
Annotator accuracy – ITA 84%

Annotator Accuracy - primary labels only

<table>
<thead>
<tr>
<th># of annotations (log scale)</th>
<th>hertlerb</th>
<th>forbesk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10000000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

accuracy

0.96
0.95
0.94
0.93
0.92
0.91
0.9
0.89
0.88
0.87
0.86

warmstr
ksledge
jnyant
jaywang
malayao
ptepper
delikan

CLEAR
Current PropBank Status

Pradhan, et.al., IJSC 2007, Albright, et. al., JAMIA, 2013, Palmer, et. al., ICON-09

- DARPA-GALE, OntoNotes 5.0
  - BBN, Brandeis, Colorado, Penn
  - Multilayer structure: NE, TB, PB, WS, Coref
  - Three languages: English, Arabic, Chinese
  - Several Genres (@ ≥ 200K): NW, BN, BC, WT
    - Close to 2M words @ language (less PB for Arabic)
  - Parallel data, E/C, E/A
  - PropBank frame coverage for rare verbs
  - Recent PropBank extensions

- Clinical Notes – 400K available, goal is 700K
- Hindi/Urdu PropBank, 400K Hindi, 200K Urdu
- BOLT – discussion forums, SMS, email, Egyptian
The set of verbs is open. But the distribution is highly skewed. For English, the 1000 most frequent lemmas cover 95% of the verbs in running text.

- Graphs show counts over English Web data containing 150 M verbs.
Verb Frames Coverage By Language –
Current Count of Senses (lexical units)

<table>
<thead>
<tr>
<th>Language</th>
<th>Final Count</th>
<th>Estimated Coverage in Running Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>10,615*</td>
<td>99%</td>
</tr>
<tr>
<td>Chinese</td>
<td>24,642</td>
<td>98%</td>
</tr>
<tr>
<td>Arabic</td>
<td>7,015</td>
<td>99%</td>
</tr>
</tbody>
</table>

- Only 111 English adjectives
Word Senses in PropBank

- Orders to ignore word sense not feasible for 700+ verbs
  - *Mary left the room*
  - *Mary left her daughter-in-law her pearls in her will*

Frameset `leave.01"move away from":`
Arg0: entity leaving
Arg1: place left

Frameset `leave.02"give":`
Arg0: giver
Arg1: thing given
Arg2: beneficiary

*How do these relate to word senses in other resources?*
WordNet – Princeton
(Miller 1985, Fellbaum 1998)

On-line lexical reference (dictionary)

- Nouns, verbs, adjectives, and adverbs grouped into synonym sets
- Other relations include hypernyms (ISA), antonyms, meronyms
- Typical top nodes - 5 out of 25
  - (act, action, activity)
  - (animal, fauna)
  - (artifact)
  - (attribute, property)
  - (body, corpus)
WordNet – Princeton – *leave*, *n.4, v.14*

(Miller 1985, Fellbaum 1998)

- Limitations as a computational lexicon
  - Contains little syntactic information
  - No explicit lists of participants
  - Sense distinctions very fine-grained,
  - Definitions often vague

- Causes problems with creating training data for supervised Machine Learning – SENSEVAL2
  - Verbs > 16 senses (including *call*)
  - Inter-annotator Agreement ITA 71%,
  - Automatic Word Sense Disambiguation, WSD 64%

*Dang & Palmer, SIGLEX02*
Creation of coarse-grained resources

- Unsupervised clustering using rules (Mihalcea & Moldovan, 2001)
- Clustering by mapping WN senses to ODE (Navigli, 2006).
- OntoNotes - Manually grouping WN senses and annotating a corpus (Weischedel et al., 2011)
- Supervised clustering WN senses using OntoNotes and another set of manually tagged data (Snow et al., 2007).
OntoNotes Goal: Modeling Shallow Semantics DARPA-GALE

- AGILE Team: BBN, Colorado, ISI, Penn
- Skeletal representation of literal meaning
- Synergistic combination of:
  - Syntactic structure
  - Propositional structure
  - Word sense
  - Coreference
Empirical Validation – Human Judges

Group Verbs in VerbNet Classes -> Regroup

Sample Annotation -> 90% (85%) ITA Score

Actual Annotation -> Adjudication

Leave 49% -> 86%
Groupings Methodology – Human Judges (w/ Dang and Fellbaum)

- Double blind groupings, adjudication

- Syntactic Criteria (VerbNet was useful)
  - Distinct subcategorization frames
    - *call him an idiot*
    - *call him a taxi*
  - Recognizable alternations – regular sense extensions:
    - *play an instrument*
    - *play a song*
    - *play a melody on an instrument*

*SIGLEX01, SIGLEX02, JNLE07, Duffield, et. al., CogSci 2007*
Groupings Methodology (cont.)

- Semantic Criteria
  - Differences in semantic classes of arguments
    - Abstract/concrete, human/animal, animate/inanimate, different instrument types,…
  - Differences in the number and type of arguments
    - Often reflected in subcategorization frames
    - *John left the room.*
    - *I left my pearls to my daughter-in-law in my will.*
  - Differences in entailments
    - Change of prior entity or creation of a new entity?
  - Differences in types of events
    - Abstract/concrete/mental/emotional/….
  - Specialized subject domains
WordNet: - call, 28 senses, 9 groups

Loud cry

WN5, WN16, WN12

Label

WN3, WN19

Challenge

WN18, WN27

Phone/radio

WN1, WN22

WN2, WN13

WN28

WN17, WN11

WN24,

Bird or animal cry

WN15, WN26

Request

WN4, WN7, WN8, WN9

Call a loan/bond

WN20, WN25

Visit

WN6, WN23

Bid

WN10, WN14, WN21,
OntoNotes Status

- More than 2,500 verbs grouped
- Average ITA per verbs = 89%
- [http://verbs.colorado.edu/html_groupings/](http://verbs.colorado.edu/html_groupings/)
- More than 150,000 instances annotated
- WSJ, Brown, ECTB, EBN, EBC, WebText
- Training and Testing

*How do the groupings connect to PropBank?*
Sense Hierarchy

(Palmer, et al, SNLU04 - NAACL04, NLE07, Chen, et. al, NAACL06)

- PropBank Framesets – ITA >90%
  coarse grained distinctions
  20 Senseval2 verbs w/ > 1 Frameset
  Maxent WSD system, 73.5% baseline, 90%

  Sense Groups (Senseval-2) - ITA 82%
  Intermediate level
  (includes Levin classes) – 71.7%

- WordNet – ITA 73%
  fine grained distinctions, 64%

  Tagging w/groups, ITA 90%, 200@hr;
  Taggers - 86.9%
  Semeval07

  Chen, Dligach & Palmer, ICSC 2007
  Dligach & Palmer, ACL-11, - 88%

CLEAR – Colorado
SEMLINK-PropBank, VerbNet, FrameNet, WordNet, OntoNotes

PropBank Groupings
Frameset1

carry

WN1 WN2
WN3 WN8
WN9 WN16 WN17 WN19
WN28 WN32 WN35 WN36

WN5 WN20 WN22 WN24
WN24 WN31 WN33 WN34
WN11 WN23
WN27 WN37 WN38

cost-54.2, ON2
fit-54.3, ON3

ON4 – win election

*ON5-ON11 carry oneself, carried away/out/off, carry to term

Palmer; Dang & Fellbaum, NLE 2007
VerbNet – based on Levin, B., 93

Class entries:
- Capture generalizations about verb behavior
- Organized hierarchically
- Members have common semantic elements, semantic roles, syntactic frames, predicates

Verb entries:
- Refer to a set of classes (different senses)
- each class member linked to WN synset(s), ON groupings, PB frame files, FrameNet frames,
Mapping from PB to VerbNet

http://verbs.colorado.edu/semlink
FrameNet: Telling. *inform*

<table>
<thead>
<tr>
<th>Time</th>
<th>In 2002,</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speaker</td>
<td>the U.S. State Department</td>
</tr>
<tr>
<td>Target</td>
<td>INFORMED</td>
</tr>
<tr>
<td>Addressee</td>
<td>North Korea</td>
</tr>
<tr>
<td>Message</td>
<td>that the U.S. was aware of this program, and regards it as a violation of Pyongyang's nonproliferation commitments</td>
</tr>
</tbody>
</table>
### Mapping from PropBank to VerbNet
(similar mapping for PB-FrameNet)

<table>
<thead>
<tr>
<th>Frameset id = leave.02</th>
<th>Sense = give</th>
<th>VerbNet class = future-having 13.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arg0</td>
<td>Giver</td>
<td>Agent/Donor*</td>
</tr>
<tr>
<td>Arg1</td>
<td>Thing given</td>
<td>Theme</td>
</tr>
<tr>
<td>Arg2</td>
<td>Benefactive</td>
<td>Recipient</td>
</tr>
</tbody>
</table>

*FrameNet Label

---

Baker, Fillmore, & Lowe, COLING/ACL-98
Fillmore & Baker, WordNetWKSHP, 2001
PropBank/VerbNet/FrameNet

- Complementary
- Redundancy is harmless, may even be useful
- PropBank provides the best training data
- VerbNet provides the clearest links between syntax and semantics
- FrameNet provides the richest semantics
- Together they give us the most comprehensive coverage
- So…. We’re also mapping VerbNet to FrameNet
Mapping Issues (2)
VerbNet verbs mapped to FrameNet

- **VerbNet clear-10.3**
  - clear
  - clean
  - drain
  - empty

- **FrameNet Classes**
  - Removing
  - Emptying
Mapping Issues (3)

VerbNet verbs mapped to FrameNet

<table>
<thead>
<tr>
<th>VN Class: <em>put 9.1</em></th>
<th>FrameNet frame: <em>place</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Members: <em>arrange</em>, <em>immerse</em>, <em>lodge</em>, <em>mount</em>, <em>sling</em>**</td>
<td>Frame Elements:</td>
</tr>
<tr>
<td>Thematic roles:</td>
<td>• Agent</td>
</tr>
<tr>
<td>• agent (+animate)</td>
<td>• Cause</td>
</tr>
<tr>
<td>• theme (+concrete)</td>
<td>• Theme</td>
</tr>
<tr>
<td>• destination (+loc, -region)</td>
<td>• Goal</td>
</tr>
<tr>
<td>Frames:</td>
<td>Examples:</td>
</tr>
<tr>
<td>• …</td>
<td>• …</td>
</tr>
</tbody>
</table>

*different sense
** not in FrameNet
Class formation Issues: *create*

Susan Brown

FrameNet

VerbNet

Create

verb

engender

1, 2

5, 6

Grp 1

Grp 2

Grp 3
Class formation Issues: produce
Susan Brown

VerbNet

FrameNet

1, 2
3, 6
4, 5
7

grp 1
grp 2
grp 3

1
2
6
7

intentionally create
behind the scenes
cause to start
Class formation Issues: *break*/Verbnet

Susan Brown

WN44 – the skin broke
WN49 – the simple vowels broke in many Germanic languages
Class Formation Issues: break/FrameNet
Susan Brown

grp 1
1 10
31 51

grp 2
2, 20
38, 40
43, 58
3, 32
41, 45
61
cause_to_fragment

grp 3
4 5 29
35, 17, 44, 53, 63

grp 4
6, 3
compliance

render_nonfunctional
experience_bodily_harm
WordNet: - leave, 14 senses, groups,

Depart, a job, a room, a dock, a country (for X)

Leave behind, leave alone

Create a State /cause an effect:
Left us speechless, leave a stain

exclude

stop, terminate:
the road leaves off, not leave off your jacket, the results exclude
Leave behind, leave alone…

- John left his keys at the restaurant.
  We left behind all our cares during our vacation.
  They were told to leave off their coats.
  Leave the young fawn alone.
  Leave the nature park just as you found it.
- I left my shoes on when I entered their house.
  When she put away the food she left out the pie.
  Let's leave enough time to visit the museum.
  He'll leave the decision to his wife.
- When he died he left the farm to his wife.
  I'm leaving our telephone and address with you.
Overlap between Groups and PropBank Framesets – 95%
Broader coverage still needed

- Only 78% 82%? of PropBank verbs included in VN (but many senses of those types are missing)
- Most classes focused on verbs with NP and PP complements
- Neglected verbs that take adverbial, adjectival, and sentential complements
SEMLINK

- Extended VerbNet: 5,391 senses (91% PB)
- Type-type mapping PB/VN, VN/FN
  - (100+ new classes from (Korhonen and Briscoe, 2004; Korhonen and Ryant, 2005))
- Semi-automatic mapping of WSJ PropBank instances to VerbNet classes and thematic roles, hand-corrected. (now FrameNet also)
- VerbNet class tagging as automatic WSD

*Brown, Dligach, Palmer, IWCS 2011*

- Run SRL, map Arg2 to VerbNet roles, Brown performance improves

*Yi, Loper, Palmer, NAACL07*
Summary

- Reviewed available lexical resources
  - WordNet, Groupings, PropBank, VerbNet, FrameNet

- We need a whole that is greater than the sum of the parts – Semlink

- Greater coverage, greater richness, increased training data over more genres, opportunities for generalizations
Lexical resources can provide

- Generalizations about subcat frames & roles
- Backoff classes for OOV items for portability
- Semantic similarities/”types” for verbs
- Event type hierarchies for inferencing

Need to be unified and empirically validated and extended: Semlink+

- VN & FN need PB like coverage, and techniques for automatic domain adaptation - Lexlink

Hybrid lexicons – symbolic and statistical lexical entries?