SemLink: Overview

- WordNet, OntoNotes Groupings, PropBank
- VerbNet
  - Verbs grouped in hierarchical classes
  - Explicitly described class properties
- FrameNet
  - Links among lexical resources
  - PropBank, FrameNet, WordNet, OntoNotes groupings
- Automatic Semantic Role Labeling with PropBank/VerbNet

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)


(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 (Hovy et al., 2006)
- 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

the 90% solution (1700 verbs)

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, JNLX07, 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

- WN5, WN16, WN12
  - Loud cry
- WN3, WN19
  - Label
- WN1, WN22
  - Challenge
- WN18, WN27
  - Phone/radio
- WN2, WN13
  - WN28
- WN17, WN11
  - WN24
- WN15, WN26
  - Bird or animal cry
- WN4, WN7, WN8, WN9
  - Request
- WN20, WN25
  - Call a loan/bond
- WN6, WN23
  - Visit
- WN10, WN14, WN21, WN24
  - Bid

OntoNotes Status

- More than 2,500 verbs grouped
- Average ITA per verbs = 89%
- 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?

Frames File Example: expect

Roles:
- Agent\textsubscript{ARG0}: expecter
- Theme\textsubscript{ARG1}: thing expected

Example: Transitive, active:

Portfolio managers expect further declines in interest rates.

Agent: 

REL: expect

Theme: further declines in interest rates
Where we are now - DETAILS

- 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

Included in OntoNotes 5.1: Extensions to PropBank

- Original annotation coverage:
  - PropBank: verbs; past participle adjectival modifiers
  - NomBank: relational and eventive nouns.
- Substantial gap – trying to bridge
  - light verbs, other predicative adjectives, eventive nouns

English Noun and LVC annotation

- Example Noun: Decision
  - Roleset: Arg0: decider, Arg1: decision...
  - “…[your\textsubscript{ARG0}] [decision\textsubscript{REL}]
    [to say look I don’t want to go through this anymore\textsubscript{ARG1}]”

- Example within an LVC: Make a decision
  - “…[the President\textsubscript{ARG0}] [made\textsubscript{REL-LVB}]
    the [fundamentally correct\textsubscript{ARGM-ADJ}]
    [decision\textsubscript{REL}] [to get on offense\textsubscript{ARG1}]”

PropBank Verb Frames Coverage

- 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

<table>
<thead>
<tr>
<th>Language</th>
<th>Projected Count</th>
<th>Final Count</th>
<th>Estimated Coverage in Running Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>5,100</td>
<td></td>
<td>99%</td>
</tr>
<tr>
<td>Chinese</td>
<td>18,200*</td>
<td></td>
<td>96%</td>
</tr>
<tr>
<td>Arabic</td>
<td>5,250*</td>
<td></td>
<td>99%</td>
</tr>
</tbody>
</table>

* This covers all the verbs and most of the predicative adjectives/nouns in ATB, and CTB

How do the PropBank verb frames relate to Word Senses?
Answer requires more explanation about OntoNotes senses

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?

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% Senseval07

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

SEMLINK-PropBank, VerbNet, FrameNet, WordNet, OntoNotes Groupings
(Palmer, Dang & Fellbaum, NLE07, Chen, Dligach & Palmer, ICSC 2007)

PropBank Framesets

carry

WN1 WN2
WN5 WN20 WN22 WN24
WN24 WN31 WN33 WN24
WN28 WN32 WN35 WN36

WN1 WN3 WN8
WN9 WN16 WN17 WN19
WN11 WN23
WN27 WN37 WN38

WN2 WN31 WN24

cost-54.2, ON2

fit-54.3, ON3

ON4 – win election

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

- WSJ too domain specific,
  - Additional Brown corpus annotation & GALE data
  - FrameNet has selected instances from BNC
- Args2-4 seriously overloaded, poor performance
  - VerbNet and FrameNet both provide more fine-grained role labels

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/AACL-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
- FrameNet Classes

- Clear
- clean
- drain
- empty

- Removing
- Emptying

Mapping Issues (3)
VerbNet verbs mapped to FrameNet

<table>
<thead>
<tr>
<th>VN Class: put 9.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Members: arrange*, immerse, lodge, mount, sling**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FrameNet frame: place</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame Elements:</td>
</tr>
<tr>
<td>• Agent</td>
</tr>
<tr>
<td>• Cause</td>
</tr>
<tr>
<td>• Theme</td>
</tr>
<tr>
<td>• Goal</td>
</tr>
</tbody>
</table>

| Examples: |
| • … |

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

Class formation Issues: *produce*
Susan Brown

Class formation Issues: *break* / VerbNet
Susan Brown

Class Formation Issues: *break* / FrameNet
Susan Brown
WordNet: - leave, 14 senses, grouped

WN1, WN5, WN8

WN6, WN10, WN2, WN4, WN9, WN11, WN12

WN14, WNleave_off1, WNleave_off2, WNleave_behind1, WNleave_behind2, WNleave_alone1, WNleave_alone2

WN3, WN7

WNleave_out1, WNleave_out2

“leave off” stop, terminate

exclude

Depart, a job, a room, a dock, a country

Leave behind, leave alone

Create a State

WNleave_off1

CLEAR – Colorado

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WordNet: - leave, 14 senses, groups, PB

WN1, WN5, WN8

WN6, WN10, WN2, WN4, WN9, WN11, WN12

WN14, WNleave_off1, WNleave_behind1, WNleave_behind2, WNleave_alone1, WNleave_alone2

WN3, WN7

WNleave_out1, WNleave_out2

“leave off” stop, terminate

exclude

Depart, a job, a room, a dock, a country

Leave behind, leave alone

Create a State

WNleave_off1

stop, terminate: the road leaves off, not leave off your jacket, the result

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Overlap between Groups and PropBank Framesets – 95%

Frameset1

Frameset2

WN1, WN2, WN3, WN4

WN5, WN6, WN7, WN8

WN9, WN10, WN11, WN12, WN13, WN14, WN19

WN20

develop

Palmer, Dang & Fellbaum, NLE 2007

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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.

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Broader coverage still needed

- Only 78% of PropBank verbs included in VN
- 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

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?
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