Natural Language Processing

Lecture 18b: Semantic Roles
Semantics Roadmap

• You should already have been convinced that grammatical structure is an important aspect of language
• Now we are discussing semantics or meaning
• Up until today, we have talked about meaning as something that individual words have (whether in isolation or in context)
• So far today, we have talked about representing the meanings of propositions/sentences in meaning representation languages
• Now, we are going to discuss an enhancement to this view, the notion that individual noun phrases can be characterized as having roles relative to a predicate or frame
• Noah built an ark out of gopher wood.
• He loaded two of every animal onto the ark.
• Noah piloted the ark into stormy weather.
• When the skies cleared, all rejoiced.
• Noah\textsubscript{1} built an ark\textsubscript{2} out of gopher wood.
• He\textsubscript{1} loaded two of every animal onto the ark\textsubscript{2}.
• Noah\textsubscript{1} piloted the ark\textsubscript{2} into stormy weather.
• When the skies\textsubscript{3} cleared, all\textsubscript{4} rejoiced.
Paraphrase

• Noah built an ark out of gopher wood.
• An ark was built by Noah. It was made from gopher wood.
• Noah constructed an ark with wood from a gopher tree.
• Using gopher wood, Noah managed to put together an ark.
• Noah built an ark.
• ...
Traditional Semantic Roles

- In the linguistics literature, one sees a number of common terms for semantic roles:
  - Agent
  - Patient
  - Theme
  - Force
  - Experiencer
  - Stimulus
  - Recipient
  - Source
  - Goal
  - etc.

- These have their place, and are useful to know if you want to understand what a semantic role is, but are not widely used in NLP.

- In NLP, we tend to use finer-grained (and sometimes cryptically named) semantic role labels.
Traditional Semantic Roles

• **David** *threw* **the midterms** from **Pausch Bridge** to **the hillside below**.
  – **David**—agent
  – **the midterms**—theme
  – **Pausch Bridge**—source
  – **the hillside below**—goal
Neo-Davidsonian Representation

• David *threw* the midterms from Pausch Bridge to the hillside below
  – \( \text{THROW}(\text{David, midterms, PauschBridge, hillside}) \)
  – \( \exists e \ \text{THROW}(e) \land \text{AGENT}(e, \text{David}) \land \text{THEME}(e, \text{midterms}) \land \text{SOURCE}(e, \text{PauschBridge}) \land \text{GOAL}(e, \text{hillside}) \)

• The midterms were *thrown* from Pausch Bridge
  – \( \text{THROW}(\text{midterms, PauschBridge}) \)
  – \( \exists e \ \text{THROW}(e) \land \text{THEME}(e, \text{midterms}) \land \text{SOURCE}(e, \text{PauschBridge}) \)
Semantic Role Labeling

**Input:** a sentence, paragraph, or document

**Output:** for each predicate*, labeled spans identifying each of its arguments.

*Predicates are sometimes identified in the input, sometimes not.
Predicates

- Noah **built** an ark out of gopher wood.
- An ark was **built** by Noah. It was **made** from gopher wood.
- Noah **constructed** an ark with wood from a gopher tree.
- Using gopher wood, Noah managed **to put together** an ark.
Predicates and Arguments

• Noah built an ark out of gopher wood.
• An ark was built by Noah. It was made from gopher wood.
• Noah constructed an ark with wood from a gopher tree.
• Using gopher wood, Noah managed to put together an ark.
Breaking, Eating, Opening

- John broke the window.
- The window broke.
- John is always breaking things.
- The broken window testified to John’s malfeasance.

- Eat!
- We ate dinner.
- We already ate.
- The pies were eaten up quickly.
- Our gluttony was complete.

- Open up!
- Someone left the door open.
- John opens the window at night.
Introducing PropBank

• Corpus (PTB) with propositions annotated
  – Predicates (verbs)
  – Arguments (semantic roles)

• Semantic roles are Arg0, Arg1, etc., each with a description
  – Arg0 is typically the most agent-like argument
  – Labels for other arguments are somewhat arbitrary
“Agree” in PropBank

- arg0: agreeer
- arg1: proposition
- arg2: other entity agreeing
- The group agreed it wouldn’t make an offer.
- Usually John agrees with Mary on everything
“Fall (move downward)” in PropBank

- **arg1**: logical subject, patient, thing falling
- **arg2**: extent, amount fallen
- **arg3**: starting point
- **arg4**: ending point
- **argM-loc**: medium
- **Sales** fell to $251.2 million from $278.8 million.
- **The average junk bond** fell by 4.2%.
- **The meteor** fell through the atmosphere, crashing into Cambridge.
**Figure 20.16** Parse tree for a PropBank sentence, showing the PropBank argument labels. The dotted line shows the path feature NP↑S↓VP↓VBD for ARG0, the NP-SBJ constituent *the San Francisco Examiner*. 
FrameNet

• A frame is a schematic representation of a situation involving various participants, and other conceptual roles

• In FrameNet, frames—not verbs—are first-class citizens
  – To a first approximation, verbs that relate to the same situation belong to the same frame
  – Roles are given fine-grained labels that are specific to the frame, but not the verb
  – Frames can center around words other than verbs
# change_position_on_a_scale

## Core roles

<table>
<thead>
<tr>
<th>Role</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ATTRIBUTE</strong></td>
<td>scalar property that the ITEM possesses</td>
</tr>
<tr>
<td><strong>DIFFERENCE</strong></td>
<td>distance by which an ITEM changes its position</td>
</tr>
<tr>
<td><strong>FINAL_STATE</strong></td>
<td>ITEM’s state after the change</td>
</tr>
<tr>
<td><strong>FINAL_VALUE</strong></td>
<td>position on the scale where ITEM ends up</td>
</tr>
<tr>
<td><strong>INITIAL_STATE</strong></td>
<td>ITEM’s state before the change</td>
</tr>
<tr>
<td><strong>INITIAL_VALUE</strong></td>
<td>position on the scale from which the ITEM moves</td>
</tr>
<tr>
<td><strong>ITEM</strong></td>
<td>entity that has a position on the scale</td>
</tr>
<tr>
<td><strong>VALUE_RANGE</strong></td>
<td>portion of the scale along which values of ATTRIBUTE fluctuate</td>
</tr>
</tbody>
</table>

## Some non-core roles ...

<table>
<thead>
<tr>
<th>Role</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DURATION</strong></td>
<td>length of time over which the change occurs</td>
</tr>
<tr>
<td><strong>SPEED</strong></td>
<td>rate of change of the value</td>
</tr>
<tr>
<td><strong>GROUP</strong></td>
<td>the group in which an ITEM changes the value of an ATTRIBUTE</td>
</tr>
</tbody>
</table>
• **Verbs**: advance, climb, decline, decrease, diminish, dip, double, drop, dwindle, edge, explode, fall, fluctuate, gain, grow, increase, jump, move, mushroom, plummet, reach, rise, rocket, shift, skyrocket, slide, soar, swell, swing, triple, tumble

• **Nouns**: decline, decrease, escalation, explosion, fall, fluctuation, gain, growth, hike, increase, rise, shift, tumble

• **Adverb**: increasingly
Demo

https://framenet.icsi.berkeley.edu/fndrupal/
How Can We Build an SRL System?

1. Parse
2. For each predicate word in the parse:
   For each node in the parse:
   Classify the node with respect to the predicate