Topics for Today

Semantic Interpretation

1. Logical form
2. Representing words
3. Functional form / semantic roles

Semantic Interpretation

The process of mapping a sentence into its **logical form**. **logical form**: the representation of context-independent, literal meaning

1. Do you know what time it is?
2. Tax returns are due on April 15th.
3. I walked to the bank.
5. I’m getting cold.

Advantages of Computing Logical Form

Modularity

“...can study sentence meaning in detail without all the complications of sentence usage. In particular, if sentences have no context-independent meaning, then we may not be able to separate the study of language from the study of general human reasoning and context.” - *James Allen, his NLP textbook*

I walked to the bank.
I swam to the river bank.

Components of a Meaning Representation

Compositional semantics: we can derive the meaning of the whole sentence from the meanings of the parts. Need to specify the following:

1. the meaning of individual words
2. how the meanings of individual words combine to form the meaning of groups of words
3. how it all fits in with syntactic analysis
Meaning of Individual Words

**word sense**: basic semantic unit

Organize the word senses into a set of broad classes of objects by which we classify the world: physical objects, quantity, quality, relation, place, time, position, *states*, *events*, ideas, concepts, plans, *actions*.

Represent senses of a word by providing a pointer to places in the taxonomy. **check** →

- check1 : hockey sense
- check2 : check mark sense

Semantic Ambiguity

**lexical ambiguity**  
Dexter *ran* last year.

**structural ambiguity tied to syntactic ambiguity**  
WalMart’s plans to open a new store in Ithaca were initially thwarted by *fiesty* Yankees and lawyers.

**structural ambiguity tied to semantic scoping ambiguity**  
Every boy loves a dog.

Noun Phrases

...in first-order logic

- **Marsha is a child.** : (child1 Marsha1)
- **Marsha is a child.** : (child1 (name m1 Marsha1))
- **She is a child.** : (child1 (pro s1 she1))
- **the dog** : (the x: (dog1 x)), (the dog1)
- **the mangy dog** : (the x: (& (dog1 x) (mangy1 x))), (mangy1 (dog1 def)), (the mangy dog1)

Verbs

**Romeo loves Juliet.**  
(loves1 (name r1 Romeo1) (name j1 Juliet1))

**Max broke the window with the hammer.**  
(<past break1> (name m1 Max1) (the window1) (the hammer1))

**The hammer broke the window.**  
(<past break1> (the hammer1) (the window1))

**The window broke.**  
(<past break1> (the window1))

Not quite right...
Features of the Semantic Representation

- **words**: word senses
- **noun phrases**:
  - structure representing meaning of whole phrase
  - note the difference between class of objects and particular object (e.g., definite vs. indefinite reference)
- **clauses and sentences**: denote functional structure — who did what to whom.

Uncovering the Functional Structure

Small set of abstract semantic relationships/roles that hold between a verb and its arguments: thematic roles, predicate-argument structure

Max broke the window with the hammer. \(<\text{past} \ break_1> \ (\text{agent } \text{Max}_1) \ (\text{theme } (\text{the window}_1)) \ (\text{instr } (\text{the hammer}_1))\)

The hammer broke the window. \(<\text{past} \ break_1> \ (\text{instr } (\text{the hammer}_1)) \ (\text{theme } (\text{the window}_1))\)

The window broke. \(<\text{past} \ break_1> \ (\text{theme } (\text{the window}_1))\)

The window was broken by Max. \(<\text{past} \ break_1> \ (\text{agent } \text{Max}_1) \ (\text{theme } (\text{the window}_1)))\)

<table>
<thead>
<tr>
<th>Role</th>
<th>Definition</th>
<th>Example</th>
<th>Realization</th>
</tr>
</thead>
<tbody>
<tr>
<td>agent</td>
<td>instigator of the action</td>
<td><em>John broke the window.</em></td>
<td>S, by-pp</td>
</tr>
<tr>
<td>instr</td>
<td>force/tool causing event</td>
<td><em>The hammer broke the window.</em></td>
<td>with-pp, S</td>
</tr>
<tr>
<td>patient/them</td>
<td>thing affected</td>
<td><em>John broke the window.</em></td>
<td>DO, S</td>
</tr>
<tr>
<td>experiencer</td>
<td>person involved in perception/state</td>
<td><em>John saw the clouds.</em></td>
<td>S</td>
</tr>
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</table>
### Role Definition Example Realization

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<tr>
<td>destination</td>
<td>final location</td>
<td>I walked <em>to Upson.</em></td>
<td><em>to-pp, into-pp</em></td>
</tr>
<tr>
<td>from-loc</td>
<td>original location</td>
<td>I walked <em>from Bard to Upson.</em></td>
<td><em>from-pp, out of</em></td>
</tr>
<tr>
<td>path</td>
<td>path over which something travels</td>
<td>I walked <em>along the ridge.</em></td>
<td><em>along-pp, across-pp</em></td>
</tr>
<tr>
<td>recipient</td>
<td>final possessor</td>
<td>I gave John <em>the book.</em></td>
<td><em>IO, to-pp</em></td>
</tr>
</tbody>
</table>

### Difficulties in Determining Functional Form

I paid Mildred $20 for the sweater.  
I bought the sweater from Mildred for $20.

Lynn became sick.

I ate the spaghetti with a fork.
I ate the spaghetti with John.
I ate the spaghetti with sauce.
I ate the spaghetti with glee.

The man killed the cat.  
The man killed in the car accident was drunk.

### Putting It All Together

**weak interaction** from time to time the syntactic processor may allow the semantic component to decide whether to abandon or continue with a given analysis.

**strong interaction** semantics and context actually influence which syntactic entities get proposed in the first place

Psycholinguistic evidence: both directions
- The teachers taught by the Berlitz method passed the test.
- The children taught by the Berlitz method passed the test.

### Semantic Interpretation

Most methods make the assumption that semantic interpretation is a **compositional** process.

- Syntax-driven rule-by-rule approach.

Other options:
- **Throw out syntax altogether.** Produce semantic representation directly from sentence. Pretty extreme...
- **Somewhere in between.** Partial syntactic analysis; use as input for subsequent semantic interpretation.