

**CSCI 5832**  
**Natural Language Processing**

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Jim Martin  
Lecture 18

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**Today 3/20**

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- Semantics

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**Transition**

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- First we did words (morphology)
- Then simple sequences of words
- Then we looked at true syntax
- Now we're moving on to meaning. Where some would say we should have started to begin with.

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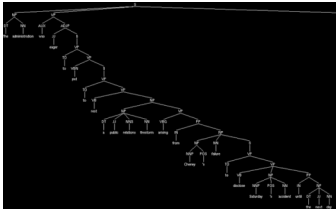
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## Example

Even if this is the right tree,  
what does that tell us about the  
meaning?



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## Meaning

- Language is useful and amazing because it allows us to encode/decode...
  - ♦ Descriptions of the world
  - ♦ What we're thinking
  - ♦ What we think about what other people think
- Don't be fooled by how natural and easy it is...  
In particular, you never really...
  - ♦ Utter word strings that match the world
  - ♦ Say what you're thinking
  - ♦ Say what you think about what other people think

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## Meaning

- You're simply uttering linear sequences of words such that when other people read/hear and understand them they come to know what you think of the world.

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**Meaning Representations**

- We're going to take the same basic approach to meaning that we took to syntax and morphology
- We're going to create representations of linguistic inputs that capture the meanings of those inputs.
- But unlike parse trees and the like these representations aren't primarily descriptions of the structure of the inputs...

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**Meaning Representations**

- In most cases, they're simultaneously descriptions of the meanings of utterances and of some potential state of affairs in some world.

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**Meaning Representations**

- What could this mean...
  - ♦ representations of linguistic inputs that capture the meanings of those inputs
- For us it means
  - ♦ Representations that permit or facilitate semantic processing

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## Semantic Processing

- Ok, so what does that mean?
- Representations that
  - ♦ Permit us to reason about their truth (relationship to some world)
  - ♦ Permit us to answer questions based on their content
  - ♦ Permit us to perform inference (answer questions and determine the truth of things we don't actually know)

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## Semantic Processing

- Touchstone application is often question answering
  - ♦ Can a machine answer questions involving the meaning of some text or discourse?
  - ♦ What kind of representations do we need to mechanize that process?

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## Semantic Processing

- We're going to discuss 2 ways to attack this problem (just as we did with parsing)
  - ♦ There's the principled, theoretically motivated approach...
    - Computational/Compositional Semantics
      - Chapters 17 and 18
  - ♦ And there are limited, practical approaches that have some hope of being useful
    - Information extraction
      - Chapter 22

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## Semantic Analysis

- Compositional Analysis
  - ♦ Create a FOL representation that accounts for all the entities, roles and relations present in a sentence.
    - Similar to our approach to full parsing
- Information Extraction
  - ♦ Do a superficial analysis that pulls out only the entities, relations and roles that are of interest to the consuming application.
    - Similar to chunking

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## Information Extraction (preview)

Investigators worked leads Monday in Riverside County where the car was reported stolen and reviewed security tape from Highway 241 where it was abandoned, said city of Anaheim spokesman John Nicoletti.

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## Information Extraction Named Entities

- Investigators worked leads Monday in Riverside County where the car was reported stolen and reviewed security tape from Highway 241 where it was abandoned, said city of Anaheim spokesman John Nicoletti.

Investigators worked leads [Monday] in [Riverside County] where the car was reported stolen and reviewed security tape from [Highway 241] where it was abandoned, said city of [Anaheim] spokesman [John Nicoletti].

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## Information Extraction Events

- Investigators worked leads Monday in Riverside County where the car was reported stolen and reviewed security tape from Highway 241 where it was abandoned, said city of Anaheim spokesman John Nicoletti.

Investigators worked leads Monday in Riverside County where the car was reported stolen and reviewed security tape from Highway 241 where it was abandoned, said city of Anaheim spokesman John Nicoletti.

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## Information Extraction Events

- Investigators worked leads Monday in Riverside County where the car was reported stolen and reviewed security tape from Highway 241 where it was abandoned, said city of Anaheim spokesman John Nicoletti.

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## Break

- Today's material is a mixture of Chapters 17 and 18.
- The next quiz will be pushed back to 4/15 and will cover
  - ♦ 17,18,19,20

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## Break

- I'm not normally this scatterbrained.
- We're going to finish delivery of the book by next week (assuming we can make acrobat do the right things).
- I'll be less disorganized when you get back from break...

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## Representational Schemes

- We're going to make use of First Order Logic (FOL) as our representational framework
  - ♦ Not because we think it's perfect
  - ♦ Many of the alternatives turn out to be either too limiting or
  - ♦ They turn out to be notational variants

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## FOL

- Allows for...
  - ♦ The analysis of truth conditions
    - Allows us to answer yes/no questions
  - ♦ Supports the use of variables
    - Allows us to answer questions through the use of variable binding
  - ♦ Supports inference
    - Allows us to answer questions that go beyond what we know explicitly

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## FOL

- This choice isn't completely arbitrary or driven by the needs of practical applications
- FOL reflects the semantics of natural languages because it was designed that way by human beings
- In particular...

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## Meaning Structure of Language

- The semantics of human languages...
  - ♦ Display a basic predicate-argument structure
  - ♦ Make use of variables
  - ♦ Make use of quantifiers
  - ♦ Use a partially compositional semantics

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## Predicate-Argument Structure

- Events, actions and relationships can be captured with representations that consist of predicates and arguments to those predicates.
- Languages display a division of labor where some words and constituents function as predicates and some as arguments.

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## Predicate-Argument Structure

- Predicates
  - ♦ Primarily Verbs, VPs, PPs, Sentences
  - ♦ Sometimes Nouns and NPs
- Arguments
  - ♦ Primarily Nouns, Nominals, NPs, PPs
  - ♦ But also everything else; as we'll see it depends on the context

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## Example

- *Mary gave a list to John.*
- Giving(Mary, John, List)
- More precisely
  - ♦ Gave conveys a three-argument predicate
  - ♦ The first arg is the subject
  - ♦ The second is the recipient, which is conveyed by the NP in the PP
  - ♦ The third argument is the thing given, conveyed by the direct object

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## Not exactly

- The statement
  - ♦ The first arg is the subject can't be right.
- Subjects can't be givers.
- We mean that the meaning underlying the subject phrase plays the role of the giver.

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## Better

- Turns out this representation isn't quite as useful as it could be.
  - Giving(Mary, John, List)
- Better would be



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## Predicates

- The notion of a predicate just got more complicated...
- In this example, think of the verb/VP providing a template like the following



- The semantics of the NPs and the PPs in the sentence plug into the slots provided in the template

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## Semantic Analysis

- Semantic analysis is the process of taking in some linguistic input and assigning a meaning representation to it.
  - There a lot of different ways to do this that make more or less (or no) use of syntax
  - We're going to start with the idea that syntax does matter
    - The compositional rule-to-rule approach

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## Compositional Analysis

- Principle of Compositionality
  - ♦ The meaning of a whole is derived from the meanings of the parts
- What parts?
  - ♦ The constituents of the syntactic parse of the input
- What could it mean for a part to have a meaning?

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## Example

- AyCaramba serves meat



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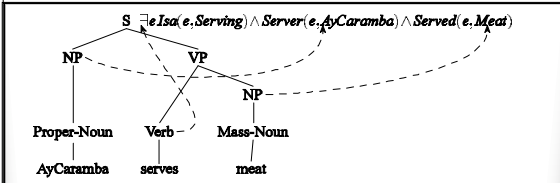
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## Compositional Analysis



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## Augmented Rules

- We'll accomplish this by attaching semantic formation rules to our syntactic CFG rules
- Abstractly



- This should be read as the semantics we attach to A can be computed from some function applied to the semantics of A's parts.

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## Example

- |                         |                |
|-------------------------|----------------|
| • Easy parts...         | • Attachments  |
| • NP -> PropNoun        | {PropNoun.sem} |
| • NP -> MassNoun        | {MassNoun.sem} |
| • PropNoun -> AyCaramba | {AyCaramba}    |
| • MassNoun -> meat      | {MEAT}         |

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## Example

- |                  |                      |
|------------------|----------------------|
| • S -> NP VP     | • {VP.sem(NP.sem)}   |
| • VP -> Verb NP  | • {Verb.sem(NP.sem)} |
| • Verb -> serves | • ???                |



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## Lambda Forms

- A simple addition to FOL
  - Take a FOPC sentence with variables in it that are to be bound.
  - Allow those variables to be bound by treating the lambda form as a function with formal arguments



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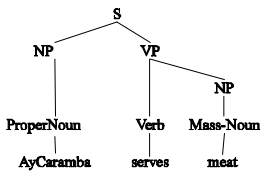
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## Example



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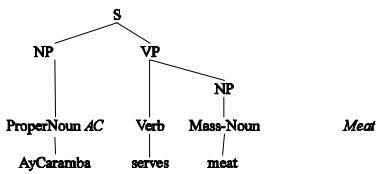
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## Example



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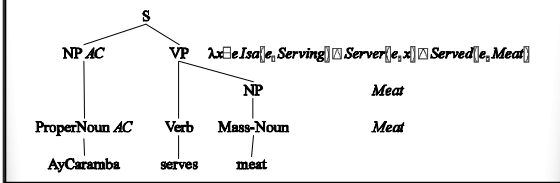
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## Example



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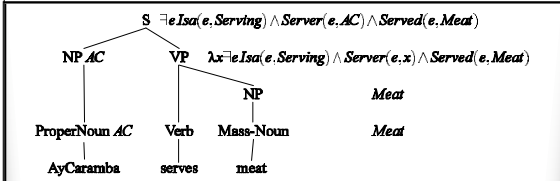
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## Example



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## Next Time

Finish reading 17 and 18 for next time.  
Have a good break.

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