CPE 372/641 Natural Language Processing

Semantics: Representing Meaning

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NLP Credits and Acknowledgment

These slides were adapted from presentations of the Authors of the book

SPEECH and LANGUAGE PROCESSING:

An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition

and some modifications from presentations found in the WEB

Transition

- First we worked with words (morphology)
- Then we looked at syntax and grammar
- Now we're moving on to meaning

Meaning

- So far, we have focused on the structure of language – not on what things ***mean***
- We have seen that words have different meaning, depending on the context in which they are used
- Everyday language tasks that require some semantic processing
  - Answering an essay question on an exam
  - Deciding what to order at a restaurant by reading a menu
  - Realizing that you've been misled
  - …

Meaning

- Now, look at meaning representations, representations that link linguistic forms to knowledge of the world
- We are going to cover:
  - What is the meaning of a word
  - How can we represent the meaning
  - What formalisms can be used

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

Meaning Representations

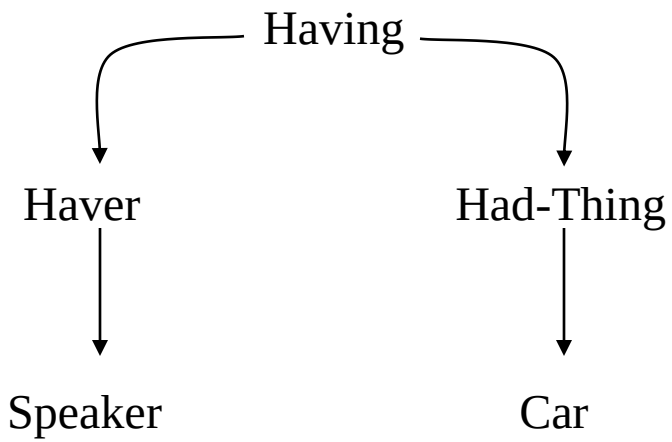
- What could this mean…
  - representations of linguistic inputs that capture the meanings of those inputs
- For us it means
  - Representations that permit or facilitate semantic processing
    - Permit us to reason about their truth (relationship to some world)
    - Permit us to answer questions based on their content
    - Permit us to perform inference (answer questions and determine the truth of things we don't actually know)

Common Meaning Representations

- First Order Predicate Calculus (FOPC):

$$\exists\, x,y Having(x) \wedge Haver(S,x) \wedge HadThing(y,x) \wedge Car(y)$$

- Semantic Net: I have a car



Common Meaning Representations

- Conceptual Dependency Diagram:

  Car

  ⇑ Poss-By

  Speaker

- Frame-based Representations

  Having

  Haver: Speaker

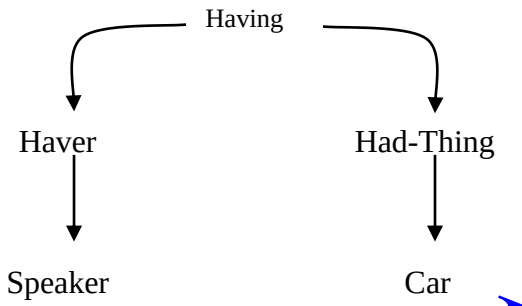
  HadThing: Car

Common Meaning Representations (4 Examples)

- First Order Predicate Calculus (FOPC):

  $\exists\, x,y Having(x) \wedge Haver(S,x) \wedge HadThing(y,x) \wedge Car(y)$

- Semantic Net:



- Conceptual Dependency Diagram:

  Car
  ⇑ Poss-By
  Speaker

- Frame-based Representations

Having Haver: Speaker HadThing: Car

I have a car

Correspondence Between Representations

- They all share a common foundation:

  => meaning representation consists of structures composed of sets of symbols

Symbol Structures:

- Objects
- properties of objects
- relations among objects

Two Distinct Perspectives

- All represent the meaning of a particular linguistic input
  - *I have a car*
- All represent the state of affair in some world
  - Literal meaning vs. figurative meaning
    - *I like quizzes*

What Can Serve as a Meaning Representation?

- Anything that serves the core practical purposes of a program that is doing semantic processing ...
  - Answer questions
    - *What is the tallest building in the world?*
  - Determining truth
    - *Is the blue block on the red block?*
  - Drawing inferences
    - *If the blue block is on the red block and the red block is on the tallest building in the world, then*
      - *the blue block is on the tallest building in the world*
- What are basic requirements of meaning representation?

Requirements meaning representations must fulfill?

- Verifiability
- Ambiguity
- Canonical Form
- Inference
- Expressiveness

Verifiability

- The system's ability to compare the state of affairs described by a representation to the state of affairs in some world as modeled in the knowledge base

Does Herfi serve vegetarian food?

Serves (Herfi, vegetarian food)

Ambiguity

- The system should allow us to represent meanings unambiguously
  - *Arabic teachers* has 2 representations
  - **Vagueness:** The system should allow us to represent vagueness
    - *I want to eat Italian food.*
      - *(pasta? spaghetti? lasagna?)*

Canonical Form

- Distinct inputs could have the same meaning
  - *Does Herfi serve vegetarian dishes?*
  - *Do they have vegetarian food at Herfi?*
  - *Are vegetarian dishes served at Herfi?*
  - *Does Herfi serve vegetarian fare?*
- Alternative (if not the same):
  - Four different semantic representations
  - Store all possible meaning representations in KB

Canonical Form

- Solution: inputs that mean the same thing should have the same meaning representation
  - Vegetarian dishes, vegetarian food, vegetarian fare
  - Have, serve
- Relations among objects to be identical, how?
  - syntactic role analysis (e.g., subjects and objects)
    - Herfi serves vegetarian dishes
    - Vegetarian dishes are served by Herfi

Inference

- Consider a more complex request

  Can vegetarians eat at Herfi?

  It would be a mistake to invoke the canonical form to force the system to assign the same representation to this request as those of:

  Does Herfi serve vegetarian food?

- Why are they result is the same answer?

Inference

- Inference: system's ability to draw valid conclusions based on the meaning representation of inputs and its store of background knowledge
- The system must draw conclusions about the truth of propositions that are not explicitly represented in the knowledge base, but that are logically derivable from the propositions that are present

Variables for inference

I'd like to find a restaurant where I can get vegetarian food

- First observation:
  - The request does not make reference to any particular restaurant
  - Use of variables since we do not know the name of restaurant
  - A representation can be:
    - *Serves(X, vegetarianFood)*

Expressiveness

- Must accommodate wide variety of meanings
- First Order Predicate Calculus (FOPC) is expressive enough to handle many of the NLP needs

Summary: Meaning representations must fulfill the following requirements

- Verifiability
- Ambiguity
- Canonical Form
- Inference
- Expressiveness