Computational Semantics

Ling 571
Deep Processing Techniques for NLP
February 2, 2011

Roadmap

- Motivation:
  - Dialog

- Key problems

- Major tasks

- Computational resources

Dialogue Systems

- User: What do I have on Thursday?

- Parse:
  - (S
  - (Q-WH-Obj
  - (Whwd What)
  - (Aux   do)
  - (NP (Pron I))
  - (VP/NP (V   have)
  - (NP/NP *t*)
  - (PP (Prep   on)
  - (NP (N Thursday))))))

Dialogue Systems

- Parser:
  - Yes, it's grammatical!
  - Here's the structure!

- System: Great, but what am I supposed to DO?!

- Need to associate meaning with structure

Dialogue Systems

- (S
-   (Q-WH-Obj   Action: check cal; USER; Thursday
-     (Whwd What)
-     (Aux   do)
-     (NP (Pron I))   Calowner: USER
-     (VP/NP (V have)   Date: Thursday
-        (NP/NP *t*)
-        (PP (Prep   on)   Date: Thursday
-         (NP (N Thursday)))))) Date: Thursday

Natural Language

- Syntax: Determine the structure of natural language input

- Semantics: Determine the meaning of natural language input

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- Sentences have many entailments, presuppositions

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  - The protests became bloody.
  - The protests had been peaceful.
  - Crowds oppose the government,
  - Some support Mubarak.
  - There was a confrontation between two groups.
  - Anti-government crowds are not Mubarak supporters.
  - Etc..

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- Semantics and models:
  - Meaning maps on states in model theoretic 'worlds', e.g. Montague
    - Focuses on truth conditions of sentences, and their representation

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    - 'rubber duck' vs 'rubber chicken'
    - 'kick the bucket'

More Challenges

- Semantic analysis:
  - How do we derive a representation of the meaning of an utterance?

  - AyCaramba serves meat. ->

    $\exists e\, Isa(e, Serving) \wedge Server(e, AyCaramba) \wedge Served(e, Meat)$

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  - Developing methods for reasoning about these representations and performing inference from them

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- Effectively AI-complete
  - Need representation, reasoning, world model, etc

Major Subtasks

- Hopefully more tractable....

- Computational lexical semantics:
  - Representing word meaning, interword relations, and word-structure relations

- Word sense disambiguation:
  - Selecting the meaning of an ambiguous word in context

- Semantic role labeling:
  - Identifying the thematic roles played by arguments in predicate

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- Decomposition:
  - Swim: GO FROM place1 TO place2 by SWIMMING

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    - Turn

Example: "Plant" Disambiguation

There are more kinds of plants and animals in the rainforests than anywhere else on Earth. Over half of the millions of known species of plants and animals live in the rainforest. Many are found nowhere else. There are even plants and animals in the rainforest that we have not yet discovered.

Biological Example

The Paulus company was founded in 1938. Since those days the product range has been the subject of constant expansions and is brought up continuously to correspond with the state of the art. We're engineering, manufacturing and commissioning world-wide ready-to-run plants packed with our comprehensive know-how. Our Product Range includes pneumatic conveying systems for carbon, carbide, sand, lime and many others. We use reagent injection in molten metal for the…

Industrial Example

Label the First Use of "Plant"

Semantic Role Labeling

- John broke the window.

- John broke the window with a rock.

- The rock broke the window.

- The window was broken by John.

Semantic Role Labeling

- John$_{\text{AGENT}}$ broke the window$_{\text{THEME}}$.

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- The rock$_{INSTRUMENT}$ broke the window$_{THEME}$.

- The window$_{THEME}$ was broken by John$_{AGENT}$.

Semantic Resources

- Growing number of large-scale computational semantic knowledge bases
  - Dictionaries:
    - Longman Dictionary of Contemporary English (LDOCE)
  - WordNet(s)
  - PropBank
  - FrameNet
  - Semantically annotated corpora: SEMCOR, etc

WordNet

- Large-scale, manually constructed sense hierarchy
  - ISA hierarchy, other links

- Pod:
  - **1(n) {pod, cod, seedcase} (the vessel that contains the seeds of a**
  - **plant (not the seeds themselves)**
  - **2 (n) {pod, seedpod} (a several-seeded dehiscent fruit as e.g. of a**
  - **leguminous plant)**
  - **3 (n) {pod} (a group of aquatic mammals)**
  - **4 (n) {pod, fuel pod} (a detachable container of fuel on an airplane)**
  - **5 (v) {pod} (take something out of its shell or pod) pod peas or**
  - **beans**
  - **6 (v) {pod} (produce pods, of plants)**

WordNet Taxonomy View

Sense 3
bass, basso --
(an adult male singer with the lowest voice)
    => singer, vocalist, vocalizer, vocaliser
        => musician, instrumentalist, player
            => performer, performing artist
                => entertainer
                    => person, individual, someone...
                        => organism, being
                            => living thing, animate thing,
                                => whole, unit
                                    => object, physical object
                                      => physical entity
                                        => entity