SEMANTICS

- Introduction
- Meaning Representation
- Meaning Interpretation
Introduction

Semantics is about the meaning of the sentences. Semantic Interpretation is the process of obtaining the sentence meaning.

Sentence in NL → Logic Form

Contextual Information

Meaning Representation

Determining the correct meaning for each word

Combination of the meaning of the words to build a logical form
Introduction

• The semantic representation of an object is obtained from the semantic interpretation of its components.
• The semantic interpretation process must be based in a theory, not in an "ad-hoc" process. This theory must support:
  • - lexical and syntactic ambiguity
  • - complex phenomena: negation, quantification, inferences, etc.
• An interface mechanism between syntax and semantic must be defined.
Composition of meaning from the meaning of parts

• Incorporating the feature **sem** to each CFG rule
  • \( S \rightarrow NP \text{ loves } NP \)
  • \( S[\text{sem}=\text{loves}(x,y)] \rightarrow NP[\text{sem}=x] \text{ loves } NP[\text{sem}=y] \)
  • The meaning of \( S \) is obtained from the meaning of the NPs

![Diagram](image-url)
Adding **sem** feature

Example Rule 1
- S • NP loves NP
  - \(S[\text{sem}=\text{loves}(x,y)]\) • NP[sem=x] loves NP[sem=y]

Example Rules 2
- V[sem=loves] • loves
- VP[sem=v(obj)] • V[sem=v] NP[sem=obj]
- S[sem=vp(subj)] • NP[sem=subj] VP[sem=vp]

Example of resulting analysis
- George loves Laura
- \(\text{sem}=\text{loves(Laura)(George)}\)
Composition of meaning from the meaning of parts

- Simple semantic interpretation
  - IS bottom-up
  - Grammar is in CNF
  - Each node two sons: 1 function & 1 argument

- To obtain semantic interpretation: application of the function to argument
input: ¿Who organizes the party?

logical form:
(question
  (referent (X))
  (X instance (X, persona)
   (el1 (Y instance(Y, party))
    (· · · Z instance(Z, organizes)
     present(Z)
     value_prop(Z, agent, X)
     value_prop(Z, patient,Y)))))))
• This form includes four different types of knowledge:
  • Logical
  • Conceptual
  • Speech act
  • Pragmatics
• The semantic formalism must support these different types of knowledge.
Representations Based on Logic

- A finite set of **functions** with arguments.

- A finite set of **predicates** (functions that return a boolean value) with arguments.

- **A finite set of constants** and **variables**.

- A finite set of logical **connectors**.
- A finite set of **quantifiers**, that will be applied over the predicates.
Objects

• Three types:
  • Boolean
    • True or false
  • Entities
    • Classes and their elements. For example, NPs
    • Especifications of space and time
  • Functions
Functions

- Use of $\lambda$ expressions in functions
  - names
    - the cat
    \[ \forall \lambda g \text{ cat}(g) \]
  - adjectives
    - The cat black and fat
    \[ \forall \lambda g \text{ cat}(g) \land \text{black}(g) \land \text{fat}(g) \]
  - Other modifiers
    - Peter's cat
    \[ \forall \lambda g \text{ cat}(g) \land \text{belongs_to}(g, \text{peter}) \]
Functions

- Arity of predicates
  
  **Unary predicate: over entities**
  \[ \forall \lambda g \text{ cat}(g) \]

  **Binary predicate over 2 entities**
  \[ \forall \lambda g \text{ belong}_\text{to}(g,\text{pepe}) \]

  **Binary predicate over 2 unary predicates over entities**
  
  • Almost all cats see.
  
  • almost(\[ \lambda g \text{ cat}(g), \lambda g \text{ see}(g) \])
Basic problems of Representation

- Quantification
- Intrasentencial reference
- Subordination
- Negation
- Conjuntion
- Ambiguity

A cat eats a fish

\((\exists \, X:\text{cat} \ (\exists \, Y:\text{fish} \ \text{eats} \ (X, Y)))\)
Which information has to be represented?
All information that can be obtained from the sentenced and it could be useful.

For example, Allen states that to represent a nominal phrase four different types of information is necessary:

1. Operator
2. Variable
3. Type
4. Modifiers
The boy     (DEF/SING N1 BOY)

The big boy   (DEF/SING N1 BOY (BIG N1))

Each boy eat a big cake
(PAST C1 EAT
   (AGENT C1 (EACH N1 BOY))
   (THEME C1 (INDEF/SING P1 CAKE (BIG P1))))

JOHN ARRIVED AT THE STATION
(PAST L1 ARRIVE
   (AGENT L1 (NAME J1 PERSONA "JOHN")))
   (TO-LOC L1 (DEF/SING E1 STATION)))
The logical forms are associated with the verb, the central part of the sentence. They included the modifiers representing the different cases: *agentive, instrument, thema, patient, locative, temporal, etc...*
The Semantic Networks

• Labeled directed graphs
  • nodes ==> concepts (classes or types) / objects (instancias)
  • edges ==> binary relations (binary predicates) between concepts.
• Quillian (1968), Simmons (1973)
• Knowledge Representation Systems based on semantic networks
  • NePS (Shapiro), Partitioned network (Hendrix)
  • KL-ONE (Brachman)
• Global organization of the Knowledge Base.
• Inference rules (basically, inheritance)
The Semantic Networks

• Advantages
  • Visibility.
  • Associative representation. Efficient access.
  • Appropriate for knowledge searching and inference.
  • Representation of both general and specific knowledge.
  • Supporting complex matching processes.
The Semantic Networks

• Disadvantages

• Representation of relations of arity higher than two is difficult (unary and binary relations are easily represented).

• Representation of logic operations such as negation, implication and disjunction is difficult.

• Representation of quantification is difficult.
Frames

- Representation of stereotypes
- Descriptors
- Classes and instances
- Descriptors (attributes) and relationships.
- Facetts
- trawberrys
- Semantic objects and relations predefined
- Not standard objects.
Frames

- Inheritance of properties
- Other forms of inferences
  - “The red car”: The car is not completely red but only the external part.
  - “one coffee spoon of sugar = the quantity of sugar that corresponds to that in a coffee spoon”
- Procedimental information
- Different levels of granularity and abstraction
  - 350 gr. of beans, two pieces of fruit, plenty of
Frames

- Sets of simple objects:
  - Enumeration:
    - three potatoes, salt and pepper
  - Global reference:
    - Fresh fruit, garlic
  - Quantification:
    - A tee spoon of sugar
  - Disjunction:
    - "one big potato or two small ones"
- Not exhaustive lists:
  - Apples, bananas, oranges, etc...
Frames

Objects not quantified.

- Mass:
  - 3 Kg de rice
- Not formal metrics:
  - A cup of rice
- Not specific quantities:
  - A little bit of salt, some sugar
• Properties
  • Describing the content:
    • Mature fruit
  • Describing the de form:
    • A big apple
  • Describing what it is not:
    • Olives without bones
• States, process, actions, success
  • Fry the sliced onion until golden brown
Graphs of conceptual dependency

- Semantic graphs where nodes and edges belong to the set of predefined semantic objects and relationships (Schanck).
- Understanding a text $\Rightarrow$ following (logical) causal chain
- The elements in the chain are *conceptualizations* and are linked by (logic) *causal relationships*.
- Schanck’s formalism is a *dependency grammar*.
- Representation based on actions and associated with *deep structure* based on:
  - PP Names, ACT Actions
  - PA Adjetives, AA Adverbs
Conceptualizations

**Actor**: An actor acts (agentivo act)

\[
\text{PP} \leftrightarrow \text{ACT}
\]

**Goal**: An action achieves a goal (objective)

\[
\text{O} \\
\text{ACT} \leftarrow \text{PP}
\]

**Place**: Change in the owner of an object:

\[
\text{ACT} \leftarrow \text{R} \quad \text{PP} \\
\text{PP} \\
\text{PP}
\]
**Directive:** Initial and final points of an action:

**Instrument:**
Predefined Semantic Actions

**Physical actions**: MOVE, PROPEL, EXPEL, GRASP, INGEST

*Ingest*: An actor X moves an object Y from an external position W to an internal position (in a physical body) Z.

![Diagram](image)

**Changes in the state:**
- **PTRANS**: Physical movement
- **ATRANS**: Change in the abstract relationship

**Instruments:**
- **SPEAK**: Making a sound
- **ATTEND**: Direct a sense towards an stimulus

**Mental actions:**
- **MTRANS**: Transferring information
- **MBUILD**: Combination
"Juan is running"