Ontology and Taxonomy

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Ontology

Nature of being, becoming, existence, or reality, as well as the basic categories of being and their relations.

Types, properties, and interrelationships of the entities that fundamentally exist for a particular domain of discourse.
Taxonomy

The science of classification according to a pre-determined system, with the resulting catalog used to provide a conceptual framework for discussion, analysis, or information retrieval.

Bloom’s Taxonomy

- **Remember**
  - Recall facts and basic concepts
    - define, duplicate, list, memorize, repeat, state

- **Understand**
  - Explain ideas or concepts
    - classify, describe, discuss, explain, identify, locate, recognize, report, select, translate

- **Apply**
  - Use information in new situations
    - execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch

- **Analyze**
  - Draw connections among ideas
    - differentiate, organize, relate, compare, contrast, distinguish, examine, experiment, question, test

- **Evaluate**
  - Justify a stand or decision
    - appraise, argue, defend, judge, select, support, value, critique, weigh

- **Create**
  - Produce new or original work
    - design, assemble, construct, conjecture, develop, formulate, author, investigate
WordNet

A lexical database that groups nouns, verbs, adjectives and adverbs into sets of cognitive synonyms (synsets) interlinked by conceptual-semantic and lexical relations.

Synonymy, Antonymy, Hyponymy, Meronymy

<table>
<thead>
<tr>
<th>POS</th>
<th>Words</th>
<th>Synsets</th>
<th>Senses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noun</td>
<td>117,798</td>
<td>82,115</td>
<td>146,312</td>
</tr>
<tr>
<td>Verb</td>
<td>11,529</td>
<td>13,767</td>
<td>25,047</td>
</tr>
<tr>
<td>Adjective</td>
<td>21,479</td>
<td>18,156</td>
<td>30,002</td>
</tr>
<tr>
<td>Adverb</td>
<td>4,481</td>
<td>3,621</td>
<td>5,580</td>
</tr>
<tr>
<td>Total</td>
<td>155,287</td>
<td>117,659</td>
<td>206,941</td>
</tr>
</tbody>
</table>

http://wordnet.princeton.edu
Word Sense

A word can have multiple meanings (senses).

Chair

Noun
Seat
Professorship
President
Death chair

Verb
Act or preside as chair
Lead or preside over

How fine-grained do word senses need to be?  

 Automatically distinguish word senses?
Lexical Relation

- Sense
- Synonym
- Hyponym
- Hypernym
- Antonym
- Meronym

Diagram:

- body
  - arm
  - leg
  - neck
  - cavity

- person
  - peer

- relative
  - relative

- peer
  - associate

- member
  - sister
  - frat. brother
  - fellow

- friend
  - buddy

- brother
  - blood brother
  - male sibling

- relative
  - blood brother
  - male sibling

- syn
  - brother

- associ
  - associate

- mem
  - member

- friend
  - buddy

- pal
  - chum

- buddy
  - best friend

- pal
  - chum
Entailment

If (V₁ is true), then (V₂ must be true).

If (A is snoring), then (A must be sleeping).

Unless V₁ and V₂ are synonyms, the converse is not true.

If (A is sleeping), then (A must be snoring).

The contradiction is true.

If (A is not sleeping), then (A must not be snoring).

Temporal inclusion

\[ T(V₁) \subseteq T(V₂) : \text{If (A is snoring), then (A must be sleeping).} \]

\[ T(V₁) \supseteq T(V₂) : \text{If (A bought B), then (A must have paid for B).} \]

\[ T(V₁) = T(V₂) : \text{If (A is marching), then (A must be walking).} \]
Hyponym

(To $E_1$) is a kind of (to $E_2$).

Noun

A horse is a kind of an animal.

Verb

Ambling is a kind of walking.

Multiple hyponyms

A mule is a kind of a donkey and a horse.

Ambling is a kind of walking and being slow.
Troponym

(To \(V_1\)) is (to \(V_2\)) in some particular manner.

(To shout) is (to talk) loud.

(To amble) is (to walk) in slow, relaxed manner.

Troponyms \(\rightarrow\) “entailments with temporal inclusions”.

(To amble) \(\rightarrow\) (To walk)

(To amble) \(\subseteq\) (To walk)

Co-Troponym

siblings differentiated by their manner.

To walk/run is to move at a pace/fast.
Backward Presupposition

Backward Presupposition

If A **failed/succeeded** in B, then A must have **done** B.

If A **forgot** B, A must have **known** B.

If A is **rejected** for B, A must have **applied** for B.

Causative Relations

(V1 causes V2) → (V1 entails V2).

(Give A to B) entails (B have A).
Entailment

With Temporal Inclusion

Hyponym
"snore" vs. "sleep"

Troponym
"march" vs. "walk"

Without Temporal Inclusion

Backward Presupposition
"forget" vs. "know"

Causal Relation
"give" vs. "have"
WordNet Similarity

Path Lengths
Wu and Palmer, 1994
Leacock and Chodorow, 1998

Resnik, 1995
Jiang and Conrath, 1997
Lin, 1998

http://ws4jdemo.appspot.com
Path Length

Path = 5

Similarity

\[ \frac{1}{\text{path}} = 0.2 \]

Lowest Common Subsumer

Path = 5

(ROOT)

entity\#n.1

physical_entity\#n.1

object\#n.1

whole\#n.2

living_thing\#n.1

organism\#n.1

person\#n.1

male\#n.2

Lowest Common Subsumer

boy\#n.1

enrollee\#n.1

student\#n.1

boy

student

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Path Length

\[
\text{Path} = 5
\]

Similarity

\[
\frac{1}{\text{path}} = 0.2
\]
Leacock and Chodorow, 1998

Path = 5

Similarity

\[- \log \left( \frac{\text{path}(w_i, w_j)}{2 \cdot \text{max_depth}} \right)\]

pre-determined

440x255

person

causal_agent

physical_entity

object

whole

living_thing

organism

enrollee

student
Path = 5

Similarity

\[- \log \left( \frac{\text{path}(w_i, w_j)}{2 \cdot \text{max_depth}} \right)\]

Leacock and Chodorow, 1998
Wu & Palmer, 1994

\[
\text{Similarity} = \frac{2 \times \text{depth}(\text{lcs}(w_i, w_j))}{\text{depth}(w_i) + \text{depth}(w_j)} = 0.8
\]

\[
\text{depth}(w_i) + \text{depth}(w_j)
\]
Wu & Palmer, 1994

\[
\text{Similarity} = \frac{2 \times \text{depth}(\text{lcs}(w_i, w_j))}{\text{depth}(w_i) + \text{depth}(w_j)} = 0.85
\]
Resnik, 1995

\[ P(c) = \frac{\sum_{w \in \text{words}(c)} \#(w)}{N} \]

\[ IC(c) = -\log P(c) \]

**Similarity**

\[ IC(LCS(w_i, w_j)) \]

- **ROOT**
  - entity
    - physical_entity
      - object
        - whole
          - living_thing
            - organism
              - person
                - male
                  - boy
                    - boy
                - enrollee
                  - student
                    - student
Resnik, 1995

\[ IC(\text{LCS}(w_i, w_j)) \]

- **Similarity**
- **ROOT**
  - entity\#n.1
  - physical_entity\#n.1
    - object\#n.1
      - whole\#n.2
      - living_thing\#n.1
        - organism\#n.1
  - person\#n.1
    - relative\#n.1
    - female\#n.2
      - female_offspring\#n.1
        - girl\#n.3
      - male\#n.2
        - male_offspring\#n.1
          - boy\#n.3
        - child\#n.2
          - boy
      - offspring\#n.1
        - relative
          - female
            - female_offspring
              - girl
            - boy
              - male_offspring
                - boy

\[ IC(\text{LCS}(w_i, w_j)) \]
Jiang & Conrath, 1997

\[(IC(c_i) + IC(c_j)) - 2 \cdot IC(LCS(c_i, c_j))\]

Lin, 1998

\[\frac{IC(LCS(w_i, w_j))}{IC(c_i) + IC(c_j)}\]
Jiang & Conrath, 1997

\[
(\text{IC}(c_i) + \text{IC}(c_j)) - 2 \cdot \text{IC}(\text{LCS}(c_i, c_j))
\]

Lin, 1998

\[
\frac{\text{IC}(\text{LCS}(w_i, w_j))}{\text{IC}(c_i) + \text{IC}(c_j)}
\]
FrameNet

Frame Semantics

The meaning of a word cannot be understood without a frame of semantic knowledge relating to the specific concept it refers to.

Semantic Frame vs. PA structures?

A description of event, relation, or entity and the participants in it.

apply_heat, cooking_creation, revenge

Lexical Units vs. verb classes?

Words that belong to the same semantic frame.

revenge → avenge.v, avenger.n, get_even.v, payback.n, retaliate.v, ...

https://framenet.icsi.berkeley.edu
FrameNet Elements

**Core Frame Element**

Instantiates a *conceptually necessary* component of a frame.

*revenge* → *avenger, injured party, injury, offender, punishment*

**Non-core Frame Element**

Can be instantiated in *any* semantically *appropriate* frame.

*revenge* → *degree, depictive, duration, instrument, manner, …*

**Semantic Type**

The type of a frame element to be *broadly constant* across uses.

e.g., sentient, physical entity, state of affairs, temperature, etc.
FrameNet Relations

Coreness Set

A set of frame elements in that the presence of a member of the set is sufficient to satisfy a semantic valence of its predicate.

Revenge $\rightarrow \{injured \ party, \ injury\}, \{avenger, \ punishment\}$

Requires

The occurrence of a core FE requires another core FE to occur.

The robber tied \textcolor{red}{Harry} to the chair.

\begin{tabular}{ccc}
item & goal \\
\textcolor{red}{Harry} & \textcolor{red}{to \ the \ chair} & \\
\end{tabular}

Excludes

The occurrence of a core FE excludes other core FEs to occur.

The robber tied \textcolor{red}{Harry’s ankles} together.

\begin{tabular}{ccc}
items \\
\textcolor{red}{Harry’s ankles} & \textcolor{red}{together} & \\
\end{tabular}
Semantic Frames

Lexical Unit
bake.v, barbecue.v, blanch.v, boil.v, braise.v, broil.v, etc.

Semantic Frame
Apply Heat

Core FE
cook
food
sentient

beneficiary
degree
manner
medium
coparticipant
duration
means
place
purpose

Core Set
container
heating
instrument
physical entity
temporal setting
temperature
time

Non-core FE

Semantic Type

bake.v, barbecue.v, blanch.v, boil.v, braise.v, broil.v, etc.
Frame Inheritance and Relations

- Process
  - Activity
    - Internally affect
      - Event
        - Internally act
          - Transitive action
            - Objective influence
              - Apply Heat
                - is used by
                  - Cooking creation
                - is causative of
                  - Absorb heat

Frame Inheritance
Frame Relations
Sub-Frames and Precedence

- Crime scenario
  - Committing crime
  - Criminal investigation
  - Criminal process
    - Arrest
    - Arraignment
    - Trial
    - Sentencing
      - Court examination
      - Jury deliberation
      - Verdict

- Notification of charges
- Entering of plea
- Bail decision
- Bail decision
- Notification of charges
Paraphrase

John e-mailed Mary his info.

John communicated his info to Mary by e-mail.
Frame Elements

Frame Semantics

The meaning of a word cannot be understood without a frame of semantic knowledge relating to the specific concept it refers to.

Semantic Frame

A description of event, relation, or entity and the participants in it.

apply_heat, cooking_creation, revenge

Semantic Frame vs. Predicate Argument Structures?