Natural Language Processing for Knowledge Representation and Reasoning

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Today

Main topic of today:

Recognition of Textual Entailment

Recognizing Textual Entailment

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B Time Warner is the world's largest company.

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The potentially entailing text is either called text or premise. The potentially entailed one hypothesis.

RTE Challenges

From 2005 to 2012: RTE Challenges. Dataset: coming from different applications. Chosen by hand, potentially modified (but marginally – spelling, punctuations...) Controversial pairs have been discarded (typically a third!)

First approach: Lexical Similarity

E.g., Jijkoun, Rijke, Recognizing Textual Entailment: Is Word Similarity Enough?. MLCW 2005: 449-460

Key ideas:

- compute a score for the entailment based on word similarity and weight of individual words
- return true if the score is above a given threshold

Three parameters here:

- weights of individual words
- similarity between words
- value of the threshold

First approach: Lexical Similarity

Weighting words

Key intuition: the less a word appears, the more it is important.

$$ICF(w) = \frac{\#\text{occurences of } w}{\#\text{occurences of all words}}$$

$$\text{weight}(w) = 1 - \frac{ICF(w) - ICF_{\min}}{ICF_{\max} - ICM_{\min}}$$

First approach: Lexical Similarity

Word similarity

Two measures used:

- Lin's dependency-based word similarity
- lexical chains in WordNet

Second "Approach": What to do with syntax

Vanderwende,Coughlin,Dolan, What Syntax can Contribute in Entailment Task.

Human annotators (two) simulate an idealized syntactic parsor.
Look at the proportion of items that could be answered by looking

- at syntax only;
- at syntax and a thesaurus.

Aim at providing a "baseline" for RTE.

Second "Approach": What to do with syntax

Results

On items on which both annotators reached an agreement:

	Without Thesaurus	With Thesaurus
True	78 (10 %)	147 (18%)
False	217 (27%)	244 (31 %)
Not syntax	505 (63 %)	409 (51%)

Second "Approach": What to do with syntax

Appositive construction

$< T >$ The Alameda Central, west of the Zocalo, was created in 1592.

$< H >$ The Alameda Central is west of the Zocalo.

Second "Approach": What to do with syntax

$< T >$ The debacle marked a new low in the erosion of the SPDs popularity, which began shortly after Mr Schroeder's election in 1998.

$< H >$ Schroeder was elected in 1998.

Second "Approach": What to do with syntax

$< T >$ A 30-year-old man has been killed in a shark attack at a surfing beach near Perth in West Australia where he was surfing with four other people.

$< H >$ A 30-year-old man was killed in a shark attack while surfing.

Some surprising items

<T> They are made from the dust of four of Jupiters tiniest moons.

<H> Jupiter has four moons.

<T> William Leonard Jennings sobbed loudly as was charged with killing his 3-year-old son, Stephen, who was last seen alive on Dec. 12, 1962.

<H> William Leonard Jennings killed his 3-year-old son, Stephen.

Third Approach: Using First-Order Prover/Model Builder

E.g., Bos, Markert, When logical inference helps determining textual entailment (and when it doesnt)

Key ideas:

- express both sentences by a first-order formula (topic of a further course)
- possibly use domain knowledge expressed in FOL;
- use first-order prover/model-builder to get semantic feature

Using Natural Logic for RTE

MacCartney, Manning, Natural Logic for Textual Inference

- Every firm polled saw costs grow more than expected, even after adjusting for in inflation.
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Key idea: full semantic interpretation may not be needed for some kind of phenomenas.

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Lexical and syntactic similarity are similar – entailment relation is not.

Semantics Relations by Sets Inclusions

Let U be a set, x and y be two non empty subsets of U. Consider $x \cap y, x \cap \bar{y}, \bar{x} \cap y$ and $\bar{x} \cap \bar{y}$.
What kind of semantic relations can we build from this?

Semantics Relations by Sets Inclusions

name	example	set theoretic definition
equivalence	(couch,sofa)	$x = y$
forward entailment	(crow,bird)	$x \subset y$
reverse entailment	(European, French)	$x \supset y$
negation	(human,nonhuman)	$x \cap y = \emptyset \wedge x \cup y = U$
alternation	(cat,dog)	$x \cap y = \emptyset \wedge x \cup y = U$
cover	(animal, nonhuman)	$x \cap y \neq \emptyset \wedge x \cup y = U$
independence	(hungry,hippo)	everything else

There is also the assumption of x and y being non empty.

Dual under Negation of Semantics Relations

A relation R is dual under negation of a relation S if:

$$(x, y) \in R \Leftrightarrow (\bar{x}, \bar{y}) \in S.$$

Join of semantics relations

Let R and S be two relations. The join of R and S is defined as follows:

$$R \bowtie S = \{(x, z) \in S^2 \mid \exists y (x, y) \in R \wedge (y, z) \in S\}$$

Edit sequences

Three edit operations are allowed on linguistic expressions:

- substitution
- deletion
- insertion

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Thus, starting from x, one gets $e(x)$. Important question: what is the semantic relation between x and $e(x)$, denoted by $\beta(x, e(x))$?

Typing substitutions (1)

$$\beta(\mathrm{SUB}(x, y)) = \beta(x, y)$$

Question: how to type $\beta(x, y)$? This is definitely not trivial.
Lexical resource may be useful:

- synonyms labeled by equivalence (forbid, prohibit)
- hyponyms/hypernyms by forward entailment (crow, bird)
- antonyms usually to alternation
- proper nouns by equivalence or alternation relation
- if not sure enough, independences relation

Typing substitutions (2)

- quantifiers are typed in a more various way.
- coreference resolution for pronouns?
- prepositions: if antonyms, alternation, otherwise equivalence.

Generic deletions and insertions

The default behavior for deletion is to generate the forward entailment relation. Symmetrically for insertions.
This principle has already been seen in practice in the first approach.

Special deletions and insertions

The previous behavior is too rough... For instance when deleting negation.

- (didn't sleep,did sleep)
- (former student,student)
- (alleged spy,spy)

Semantic Composition

Starting from a sentence:

Nobody can enter without pants.

A semantic tree is associated with it:

(nobdy (can ((without pants) enter))).

What is the effect of changing pants by clothes?

Monotonicity

Each node is labeled by UP, DOWN or NON, UP being the default value.

- UP preserves forward and backward entailment
- DOWN reverses forward and backward entailment
- NON project both to independence

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Projectivity

A projectivity signature is a map from semantic relations to semantic relations. A few example:

- negation
- intersective modification ((living human, living non human) or (French wine, Spanish wine)
- quantifiers (some, no, every, not every)

Dealing with manage to, refuse to,...

Nairn, Condoravdi, Karttunen

Nine implication signatures with respect to implications in positive and negative contexts. For instance:

- refused to dance $\rightarrow$ didn't dance
- didn't refuse to dance $\rightarrow$??

The signature of refuse to is thus $-/0$.

Recasting this as natural logic

Provide example of verbs with each of this signature. What semantic type to give to the deletion and the insertions of these verbs?