Polarity Information for RTE

based on Nairn et al. (2006)

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Hauptseminar „Linguistic Inference and Textual Entailment“
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Overview

- Logical Textual Inference
- Polarity
- Verbal constructions
  - Factive constructions
  - Implicative constructions
- Implication signatures
- Textual Inference Approach
  - Polarity propagation algorithm
- Examples in RTE-2 data
Logical textual inference

- recognize whether given text can be strictly or plausibly inferred from, or is contradicted by, another piece of text

- based on
  - linguistic knowledge
  - assumptions about language use
  - knowledge about the world
  - any combination thereof
Polarity

A grammatical category that distinguishes affirmative and negative.

Examples

<table>
<thead>
<tr>
<th>positive</th>
<th>negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ed opened the door.</td>
<td>Ed didn’t open the door.</td>
</tr>
<tr>
<td>Ed managed to open the door.</td>
<td>Ed forgot to open the door.</td>
</tr>
</tbody>
</table>
Different semantic behaviours

- Verbal constructions of the same verb may have different semantic behaviours

- Factive constructions
  - forget/remember/know/...that...
  - presuppose rather than entail that complement sentence is true
Different semantic behaviours

- implicative constructions
  - forget/remember/know/...to...
  - have entailments
  - some carry presuppositions
    - difficult to pin down

<table>
<thead>
<tr>
<th>Ed didn’t manage/dare/bother/happen to open the door.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entailment:</strong></td>
</tr>
<tr>
<td><strong>Presuppositions:</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Purpose of paper

- build partial computational semantics for implicative constructions
  - ignoring presupposition
- handling of simple factive constructions
- interaction between implicative and factive verbs
- in context of AQUAINT project
AQUAINT

- PASCAL-like experiment on local textual inference
- more nuanced task
  - Entailment
    - true
    - false
    - unknown
      - neither Hypothesis nor negated Hypothesis can be inferred
Types of implicative verbs

Entailment either positive or negative depending on polarity of environment.

- **two-way implicatives**
  - yield entailment in both affirmative and negative environments
  - forget to
    - negative entailment in affirmative environment
    - positive entailment in negative environment

- **one-way implicatives**
  - yield entailment only in one of the environments
  - force to, attempt to
Challenges

- no database for this type of semantic information
  - compilation of table of „implication signatures“
- embedded structures of factives and implicatives
  - polarity of environment of embedding predicates determined relatively to the chain of predicates
  - recursive computation of relative polarity

Ed didn’t manage to remember to open the door.
Implication Signatures

- **identification of natural implications of verbs**
  - decreasing frequency verbs in BNC
- **by hand**
- **classification of 400 complement-taking verbs**
  - infinitival complements
  - that-complements
  - 1/3 of them carried implication
Types of implication

- entailment
  - positive
  - negative

- presupposition
  - factive
  - counterfactive
## Implication Signature Table

<table>
<thead>
<tr>
<th>Category</th>
<th>Word in subcat frame</th>
<th>Relative Polarity</th>
<th>Entailment</th>
<th>Presupposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two-way implicatives</td>
<td>manage to</td>
<td>(+) positive</td>
<td>(-) negative</td>
<td>(+) positive</td>
</tr>
<tr>
<td></td>
<td>forget to</td>
<td>(-) negative</td>
<td>(+) positive</td>
<td>(-) negative</td>
</tr>
<tr>
<td>One-way implicatives</td>
<td>force to</td>
<td>(+) positive</td>
<td>none</td>
<td>(-) negative</td>
</tr>
<tr>
<td></td>
<td>refuse to</td>
<td>(-) negative</td>
<td>none</td>
<td>(+) positive</td>
</tr>
<tr>
<td>One-way -implicatives</td>
<td>attempt to</td>
<td>none</td>
<td>(-) negative</td>
<td>none</td>
</tr>
<tr>
<td></td>
<td>hesitate to</td>
<td>none</td>
<td>(+) positive</td>
<td>none</td>
</tr>
<tr>
<td>Factuals</td>
<td>forget that</td>
<td>(+) positive</td>
<td>(+) positive</td>
<td>(+) positive</td>
</tr>
<tr>
<td>Counterfactuals</td>
<td>pretend that</td>
<td>(-) negative</td>
<td>(-) negative</td>
<td>(-) negative</td>
</tr>
<tr>
<td>Neutral</td>
<td>want to</td>
<td>none</td>
<td>Presupposition</td>
<td>Entailment/Presupposition</td>
</tr>
</tbody>
</table>

**Entailment**

<table>
<thead>
<tr>
<th>Relative Polarity</th>
<th>(-) negative</th>
<th>(+) positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-)</td>
<td>(-) negative</td>
<td>(+) positive</td>
</tr>
</tbody>
</table>

**Presupposition**

<table>
<thead>
<tr>
<th>Relative Polarity</th>
<th>(-) negative</th>
<th>(+) positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-)</td>
<td>(-) negative</td>
<td>(+) positive</td>
</tr>
</tbody>
</table>
Textual inference approach

- Parsing of text
- Transformation into normalized representation (skolemization & canonicalization)
- Representation: verbal predication corresponds to constructed concept
  - Mapping of verbal predicate to concept in background ontology
  - Role restrictions: based on arguments and modifiers
  - Concept named according to the normalized verbal predicate
- \( \Rightarrow \) Input to entailment and contradiction detection
Textual Inference Approach

entailment and contradiction detection (ECD)

- structural matching
- inference-based techniques
- operation on packed representations
  - ambiguities encoded
  - no need for disambiguation
Implication Projection

- Solution to interaction of multiple embedded clauses
- Entailment of complement-taking construction
  - Dependent on the polarity of its context
  - Context polarity is not determined locally
    - B dependent on embedding structure of contexts
  - Neutralization possible
    - Ed refused not to attempt to leave.
      - B negative entailment of not attempt is neutralized by the negative polarity of refuse
- Polarity of context depends on the sequence of potential polarity switches stretching back to the top context
Implication Projection

- each complement-taking verb
  - performs operations on its parent context’s polarity
    - polarity switching
    - polarity perserving
    - polarity setting according to signature table entry of the verb

- polarity = relative
  - if the polarity switching sequence starts below top level context, final polarity may be different
  - polarity of a context = polarity relative to ancestor context

- polarity = recursive
  - top level polarity of most interest
  - polarities of lower levels needed to compute top level polarity
Implication Projection Algorithm

- every context $C$
  - relative polarity towards set of ancestor contexts $p(C)$
    - positive $(+)_C$
    - negative $(-)_C$
  - positive towards itself

- computation of polarity sets $(+)_C$ and $(-)_C$
  - parent’s sets $(+)_p(C)$ and $(-)_p(C)$
  - with reference to the verb $V_{p(C),C}$
  - the verb’s signature $\text{sig}_e(V_{p(C),C})$
Relative polarity computation

\[ \ominus C = \{C\} \cup \begin{cases} 
\oplus_p(C) & \text{if } \text{sig}^+(V_p(C),C) = + \\
\ominus_p(C) & \text{if } \text{sig}^-(V_p(C),C) = + \\
\emptyset & \text{otherwise}
\end{cases} \]

\[ \Theta C = \begin{cases} 
\oplus_p(C) & \text{if } \text{sig}^+(V_p(C),C) = - \\
\ominus_p(C) & \text{if } \text{sig}^-(V_p(C),C) = - \\
\emptyset & \text{otherwise}
\end{cases} \]
Ed did not forget to force Dave to leave.

\[ n \text{ Dave leave } \begin{cases} \dagger & + \\ - \text{ force Dave to leave } \dagger & + \\ \beta \text{ forget to force Dave to leave } \dagger & - \\ - \text{ not forget to force Dave to leave } \dagger & + \end{cases} \]
Propagation of Polarities
Instantiation of contexts

relative context polarities serve for
  - extraction of information about instantiability and uninstantiability of contexts

instantiables
  - head event skolem of a context + role fillers should be made instantiable
    ∃ in the context it arises
    ∀ in all contexts relative to which its originating context has positive polarity

uninstantiables
  - in all contexts relative to which its originating context has negative polarity

\[
\text{instantiables}(C) =_{def} \{ \text{head}(C') \mid C' \in \bigoplus C' \} \\
\text{uninstantiables}(C) =_{def} \{ \text{head}(C') \mid C' \in \bigotimes C' \}
\]
Author commitment

truth/falsity in top level context
- reveals author commitment towards utterance
- composition of
  - truth of complement clause
    - instantiability of head predicate skolem + head predicate skolem denotes event description
    † instantiation of event description
  - falsity of complement clause
    - uninstantiability ‡ non-instantiation

Author commitment ~ truth of utterance
## Polarity in RTE-2 data

<table>
<thead>
<tr>
<th></th>
<th>Neutral</th>
<th>Factive</th>
<th>Counterfactive</th>
<th>Implicative</th>
<th>Negation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>IR</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>QA</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>SUM</td>
<td>14</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>7</td>
<td>0</td>
<td>14</td>
<td>2</td>
<td>51</td>
</tr>
</tbody>
</table>

- 400 positive entailment pairs
  - only expressions that are important for entailment value
Polarity in RTE-2 data

--518-YES-SUM--

[U.S. planned job cuts] [dropped] by 15 percent [in January] and below the 100,000 level for the first time since August 2004, a report said on Tuesday. #

[U.S. planned job cuts] [fell] [in January]. ##

- said - neutral
- typical text-hypothesis combination in RTE
  - T - report/claim
  - H - content of report/claim presented as fact
Polarity in RTE-2 data

Mr. Fitzgerald *revealed* he was one of several top officials who *told* Mr. Libby in June 2003 that [Valerie Plame], wife of the former ambassador Joseph Wilson, *worked* [for the CIA]. #

[Valerie Plame] [worked] [for the CIA]. ##

- 2 predicates
  - revealed - factive
  - told - neutral

 use of propagation algorithm to compute polarity
Polarity in RTE-2 data

- has been able - implicative
- entailment based on
  - conversational implicatures
  - common-sense interpretation of to be able to
Polarity in RTE-2 data

For sailors, [the lighthouse of Alexandria] ensured a safe return to the Great Harbor; for architects, it was the tallest building on Earth; and for scientists, it was the mysterious mirror that fascinated them most: its reflection could be seen more than 50 km (35 miles) off-shore. For all these reasons, [[the lighthouse] [was considered] [one of the Seven Wonders of the world]]. #

[The lighthouse of Alexandria] [was] [one of the seven wonders of the world]. ##

n was considered - neutral
Polarity in RTE-2 data

For example, Nelson Mandela [was considered] a "terrorist" by the US government during "apartheid" South Africa. Did the US "corporament" support "apartheid" South Africa? #

Nelson Mandela is a terrorist. ###

- same context: positive polarity
  - but: entailment does not hold
- questions:
  - differences?
  - other factors involved?
  - error?
Conclusions

- polarity actually occurs
  - in natural texts
  - in RTE data (yet infrequently)

- method to compute polarity values for
  - simple structures
    - factive
    - implicational
  - embedded structures

- first systematic implementation of textual inferences based on
  - polarity
  - interaction of implicative verbs and factive verbs
  - author commitment to truth or falsity of complement clause
References


K. Garoufi (to be published): Towards a better understanding of Textual Entailment.