Natural Language Processing

Info 159/259
Lecture 22: Discourse (Nov. 7, 2017)

David Bamman, UC Berkeley
discourse

semantics

syntax

POS

words
Four score and seven years ago our fathers brought forth on this continent, a new nation, conceived in Liberty, and dedicated to the proposition that all men are created equal. Now we are engaged in a great civil war, testing whether that nation, or any nation so conceived and so dedicated, can long endure. We are met on a great battle-field of that war. We have come to dedicate a portion of that field, as a final resting place for those who here gave their lives that that nation might live. It is altogether fitting and proper that we should do this.

But, in a larger sense, we can not dedicate -- we can not consecrate -- we can not hallow -- this ground. The brave men, living and dead, who struggled here, have consecrated it, far above our poor power to add or detract. The world will little note, nor long remember what we say here, but it can never forget what they did here. It is for us the living, rather, to be dedicated here to the unfinished work which they who fought here have thus far so nobly advanced. It is rather for us to be here dedicated to the great task remaining before us -- that from these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion -- that we here highly resolve that these dead shall not have died in vain -- that this nation, under God, shall have a new birth of freedom -- and that government of the people, by the people, for the people, shall not perish from the earth.
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Discourse

- Discourse covers linguistic expression beyond the boundary of the sentence.
  - Dialogues: the structure of turns in conversation
  - Monologues: the structure of entire passages, documents
LUKE
I'll never join you!

VADER
If you only knew the power of the dark side. Obi-Wan never told you what happened to your father.

LUKE
He told me enough! It was you who killed him.

VADER
No. I am your father.

LUKE
No. No. That's not true! That's impossible!

VADER
Search your feelings. You know it to be true.

LUKE
No! No! No!
LUKE
I'll never join you!

VADER
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No. **I am your father.**

LUKE
No. No. **That's not true!**
**That's impossible!**

VADER
Search your feelings. You know it to be true.

LUKE
No! No! No!
General Secretary Gorbachev, if you seek peace, if you seek prosperity for the Soviet Union and eastern Europe, if you seek liberalization, come here to this gate.

Mr. Gorbachev, open this gate.

Mr. Gorbachev, tear down this wall!
General Secretary Gorbachev, if you seek peace, if you seek prosperity for the Soviet Union and eastern Europe, if you seek liberalization, come here to this gate.

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Mr. Gorbachev, tear down this wall!
• General Secretary Gorbachev,
• if you seek peace,
• if you seek prosperity for the Soviet Union and eastern Europe,
• if you seek liberalization,
• come here to this gate.
• Mr. Gorbachev, open this gate.
• Mr. Gorbachev, tear down this wall!
What is the **structure** of discourse?
Discourse structure

• John hid Bill’s car keys. He was drunk

• John hid Bills car keys. He likes spinach.
Discourse structure

• Useful for:
  • Text summarization (Louis et al. 2010)
  • Evaluating writing (Burnstein et al. 2013)
Discourse structure

- Two representations of structure in discourse:
  - deep structure (RST)
  - shallow structure (PDTB)
RST

- Rhetorical structure theory (Mann and Thompson 1987)

- RST Corpus: 385 WSJ articles (from Penn Treebank) = 176K words.
Elementary discourse units

- Elementary discourse units: the “minimal building blocks of a discourse tree” (Carlson 2002)
Elementary discourse units

- Clauses
- Prosodic units
- Turns of talk
- Sentences
<table>
<thead>
<tr>
<th>Xerox Corp’s third-quarter net income grew 6.2% on 7.3% higher revenue.</th>
<th>This earned mixed reviews from Wall Street analysts.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xerox Corp’s third-quarter net income grew 6.2% on 7.3% higher revenue, which earned mixed reviews from Wall Street analysts.</td>
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<td></td>
</tr>
</tbody>
</table>

Carlson et al. 2002
Elementary discourse units

- Clauses
- Prosodic units
- Turns of talk
- Sentences

RST Discourse treebank
Clauses in RST

• Subject/object clauses (gerunds, infinitives) are not EDUs:

• Making computer smaller often means sacrificing memory.

• Insurers could see claims totaling nearly $1 billion from the San Francisco earthquake

Carlson et al. 2002
Clauses in RST

• Some phrasal EDUs that begin with a strong discourse marker

  • because
  • in spite of
  • as a result of
  • according to

Carlson et al. 2002
With its distant orbit, Mars experiences frigid weather. Surface temperatures average -60 C and can dip to -123 C. Only the midday sun at tropical latitudes is warm enough to thaw the ice.

- With its distant orbit,
- Mars experiences frigid weather.
- Surface temperatures average -60 C
- and can dip to -123 C.
- Only the midday sun at tropical latitudes is warm enough
- to thaw the ice
Relations

- Adjacent EDUs are linked with discourse relations.
Relations

- Relations hold between a **nucleus** and **satellite**.
  - Nucleus: more salient to discourse
  - Satellite: supporting information
- Analogous to head/dependent in dependency parsing but scoped over constituents.

Mars experiences frigid weather.

Surface temperatures average -60 C
<table>
<thead>
<tr>
<th>Attribution</th>
<th>Reported speech (direct and indirect)</th>
<th>[The legendary GM chairman declared] [that his company would make “a car for every purse and purpose.”]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>The context or the grounds with respect to which the nucleus is to be interpreted</td>
<td>[Banco Exterior was created in 1929 to provide subsidized credits for Spanish exports.] [The market for export financing was liberalized in the mid-1980s, however, forcing the bank to face competition.]</td>
</tr>
<tr>
<td>Cause</td>
<td>Nuclear causes the satellite</td>
<td>[This year, a commission appointed by the mayor to revise New York's system of government completed a new charter,] [expanding the City Council to 51 from 35 members.]</td>
</tr>
<tr>
<td>Comparison</td>
<td>Two spans are compared along some dimension</td>
<td>[It was as easy] [as collecting sea shells at Malibu.]</td>
</tr>
<tr>
<td>Condition</td>
<td>Truth of nucleus associated with fulfillment of condition expressed in satellite</td>
<td>[S.A. brewing would make a takeover offer for all of Bell Resources] [if it exercises the option,] according to the commission</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Contrast</td>
<td>Two nuclei contrast each other</td>
<td>[But from early on, Tiger’s workers unionized,] [while Federal’s never have.]</td>
</tr>
<tr>
<td>Elaboration</td>
<td>Further information about content of nucleus</td>
<td>[The projects are big.] [They can be C$1 billion plus.]</td>
</tr>
<tr>
<td>Enablement</td>
<td>Satellite increases chance of nucleus being realized</td>
<td>[“I’d like to see (Kidder) succeed.] [But they have to attract good senior bankers who can bring in the business from day one.”]</td>
</tr>
<tr>
<td>Evaluation</td>
<td>An appraisal, estimation, rating, interpretation, or assessment of a situation.</td>
<td>[Employers must deposit withholding taxes exceeding $3,000 within three days after payroll -- or pay stiff penalties --] [and that’s a big problem for small businesses.]</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Explanation</td>
<td>Satellite present factual explanations for nucleus</td>
<td>[But their 1987 performance indicates that they won't abandon stocks unless conditions get far worse.] [“Last time, we got rewarded for buying stocks when the panic was the worst,” said John]</td>
</tr>
<tr>
<td>Joint</td>
<td>Elements are listed [List]</td>
<td>[A union, sooner or later, has to have an adversary,] [and it has to have a victory.]</td>
</tr>
<tr>
<td>Manner-Means</td>
<td>Satellite explains the way in which something is done.</td>
<td>[Magazine editors did not take the criticisms] [lying down.]</td>
</tr>
<tr>
<td>Topic-Comment</td>
<td>Topic is introduced and then commented upon</td>
<td>[As far as the pound goes,] [some traders say a slide toward support at $1.5500 may be a favorable development for the dollar this week.]</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Summary</td>
<td>Satellite summarizes the information presented in the nucleus.</td>
<td>[Stocks are bracing for a turbulent separation, following DZ’s announcement that the exchanges will sever ties.] [On Friday, DZ ordered the Kuala Lumpur Stock Exchange to take appropriate action immediately to cut its links with the Stock Exchange of Singapore.]</td>
</tr>
<tr>
<td>Temporal</td>
<td>Nuclear occurs before satellite [Temporal-before]</td>
<td>[We want to make sure they know what they want] [before they come back.]</td>
</tr>
<tr>
<td>Topic-Change</td>
<td>sharp change in focus going from one segment to the other.</td>
<td>[South Africa freed the ANC’s Sisulu and seven other political prisoners.... Mandela, considered the most prominent leader of the ANC, remains in prison. But his release within the next few months is widely expected.] [The Soviet Union reported that thousands of goods needed to ease widespread shortages across the nation were piled up at ports and rail depots, and food shipments were rotting because of a lack of people and equipment to move the cargo.]</td>
</tr>
</tbody>
</table>
## Relations

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<th>List</th>
<th>Billy was the mate and Long John was the quartermaster</th>
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<td>Elaboration</td>
<td>The company wouldn’t say, citing competitive reasons</td>
</tr>
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<td>Attribution</td>
<td>Analysts estimated that sales at US stores declined</td>
</tr>
<tr>
<td>Same-Unit</td>
<td>[two EDUS interrupted by another EDU]</td>
</tr>
<tr>
<td>Contrast</td>
<td>The priest was in a bad mood but the lama was happy</td>
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<tr>
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<td>T is the pointer to the root of a binary tree. Initialize T</td>
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Most common relations in RST treebank
## Relations

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<th>Relation</th>
<th>Example</th>
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Most common relations in RST treebank
With its distant orbit, Mars experiences frigid weather. Surface temperatures average -60°C and can dip to -123°C. Only the midday sun at tropical latitudes is warm enough to thaw the ice.

Arrows are directed from nucleus to satellite (undirected edges are nuclei).
With its distant orbit, Mars experiences frigid weather. Surface temperatures average -60 C and can dip to -123 C. Only the midday sun at tropical latitudes is warm enough to thaw the ice.

- A given span of text will hold several (nested) relations
RST parsing

- Shift-reduce (Marcu 1999, Sagae 2009)
- Neural-network shift reduce (Ji and Eisenstein 2014)
- Recursive neural network (Li et al. 2014)
Shift: Remove EDU from front of input buffer and push it onto stack

Reduce(label): assert relation between subtree at stack₁ and subtree at stack₂: remove stack₁ and stack₂ from stack; create a new subtree from stack₁ and stack₂ and place it onto the stack
Each relation generates three possible transition labels (for the position or the nucleus and satellite in the subtree)

- Attribution-NS
- Attribution-SN
- Attribution-NN

With its distant orbit, Mars experiences frigid weather.
Mars experiences frigid weather.

With its distant orbit,
Surface temperatures average -60 C and can dip to -123 C.

**Stack**

**Action**

Shift: Remove EDU from front of input buffer and push it onto stack.

Reduce(label): assert relation between subtree at stack\(_1\) and subtree at stack\(_2\):
remove stack\(_1\) and stack\(_2\) from stack; create a new subtree from stack\(_1\) and stack\(_2\) and place it onto the stack.
Surface temperatures average -60 C and can dip to -123 C

Shift: Remove EDU from front of input buffer and push it onto stack

Reduce(label): assert relation between subtree at stack\textsubscript{1} and subtree at stack\textsubscript{2}: remove stack\textsubscript{1} and stack\textsubscript{2} from stack; create a new subtree from stack\textsubscript{1} and stack\textsubscript{2} and place it onto the stack

With its distant orbit, **Mars experiences frigid weather.**
Shift: Remove EDU from front of input buffer and push it onto stack

Reduce(label): assert relation between subtree at stack\(_1\) and subtree at stack\(_2\): remove stack\(_1\) and stack\(_2\) from stack; create a new subtree from stack\(_1\) and stack\(_2\) and place it onto the stack

Surface temperatures average -60 C and can dip to -123 C

With its distant orbit, Mars experiences frigid weather.
Surface temperatures average -60 C

With its distant orbit, Mars experiences frigid weather.

and can dip to -123 C

Shift: Remove EDU from front of input buffer and push it onto stack

Reduce(label): assert relation between subtree at stack_1 and subtree at stack_2: remove stack_1 and stack_2 from stack; create a new subtree from stack_1 and stack_2 and place it onto the stack
Surface temperatures average -60 C.

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Surface temperatures average -60 C.
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Shift: Remove EDU from front of input buffer and push it onto stack

Reduce(label): assert relation between subtree at stack₁ and subtree at stack₂: remove stack₁ and stack₂ from stack; create a new subtree from stack₁ and stack₂ and place it onto the stack

Continue in this way until the buffer is empty and stack has a single tree
• RST builds a rhetorical tree over the entire span of a sentence = **deep** discourse parsing.

• SOTA for getting the labeled relations + heads right (assuming gold EDU): 61.8 F
• The Penn Discourse Treebank encodes a different approach: shallow discourse parsing.

• Rather than focusing on the tree spanning the entire sentence, it focuses on recognizing the structure around discourse connectives.
Discourse connectives

- Discourse connectives are those words and phrases that link together the content or purpose of adjacent spans.

  - John eats porridge for breakfast, while Mary eats muesli.
  - Eat your porridge. Otherwise you’re not going to football practice.
  - You’ve eaten your porridge every day this week. As a result I'm going to give you the iPod I promised you.

Webber et al. 2005
Discourse connectives

- Discourse connectives are binary predicates that require two arguments

<table>
<thead>
<tr>
<th>connective</th>
<th>sense</th>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>and</td>
<td>conjunction</td>
<td>3000</td>
</tr>
<tr>
<td>but</td>
<td>contrast</td>
<td>3308</td>
</tr>
<tr>
<td>if</td>
<td>hypothetical</td>
<td>1223</td>
</tr>
<tr>
<td>when</td>
<td>synchrony</td>
<td>989</td>
</tr>
<tr>
<td>while</td>
<td>contrast, synchrony</td>
<td>781</td>
</tr>
<tr>
<td>so</td>
<td>result</td>
<td>263</td>
</tr>
<tr>
<td>in addition</td>
<td>conjunction</td>
<td>165</td>
</tr>
</tbody>
</table>
Discourse connectives

• Discourse connectives are binary predicates that require two arguments

• [John eats porridge for breakfast] while [Mary eats muesli]
• [Eat your porridge.] Otherwise [you’re not going to football practice.]
• [You’ve eaten your porridge every day this week] As a result [I’m going to give you the iPod I promised you.]

Webber et al. 2005
Discourse connectives

- Those arguments can be in the same sentence as the connective, adjacent sentences, or non-adjacent sentences.

- The federal government suspended sales of U.S. savings bonds because Congress hasn’t lifted the ceiling on government debt.

- Because it operates on a fiscal year, Bear Stearns’s yearly filings are available much earlier than those of other firms.

- Most oil companies, when they set exploration and production budgets for this year, forecast revenue of $15 for each barrel of crude produced.

Prasad et al. 2008
Discourse connectives

- Each discourse connective also is also tagged with its sense. Most words almost always occur with one sense.

<table>
<thead>
<tr>
<th>Temporal</th>
<th>the situations described in the arguments are related temporally (before, after, while, since)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contigency</td>
<td>one argument causally influences the other (because, if, so, since)</td>
</tr>
<tr>
<td>Comparison</td>
<td>highlights prominent differences between arguments (but, however, although)</td>
</tr>
<tr>
<td>Expansion</td>
<td>expand discourse and move exposition forward (in particular, specifically, in other words); conjunction; list (and)</td>
</tr>
</tbody>
</table>
## Discourse connectives

<table>
<thead>
<tr>
<th>coarse sense</th>
<th>fine sense</th>
</tr>
</thead>
<tbody>
<tr>
<td>temporal</td>
<td>Asynchronous, synchrony</td>
</tr>
<tr>
<td>contingency</td>
<td>Cause, pragmatic cuase, condition, pragmatic condition</td>
</tr>
<tr>
<td>comparison</td>
<td>Contrast, pragmatic contrast, concession, pragmatic concession</td>
</tr>
<tr>
<td>expansion</td>
<td>Conjunction, instantiation, restatement, alternative, exception, list</td>
</tr>
</tbody>
</table>
Discourse connectives

• Annotation/prediction task: for all explicit discourse connectives in a text:
  • What is the discourse sense of the connective?
  • What are the spans in the text that correspond to its arguments?
Discourse connectives

I came.

and I saw.

and I conquered.
Discourse connectives

The $6 billion that some 40 companies are looking to raise in the year ending March 31 compares with only $2.7 billion raised on the capital market in the previous fiscal year.

In contrast, in fiscal 1984 before Mr. Gandhi came to power, only $810 million was raised.

Webber et al. 2005
Discourse connectives

The gruff financier recently started socializing in upper-class circles.

For example, last year he attended a New York gala where his daughter made her debut.

Webber et al. 2005
Discourse connectives

John was tired. **As a result** he left early.

John was tired. He left early.

Prasad et al. 2010
Discourse connectives

What is the implicit relationship between sentences with no explicit discourse connector?
SOTA

• CoNLL 2015 shared task on shallow discourse parsing using PDTB

• End-to-end: input = just text; output = PDTB-style discourse annotations (implicit and explicit connectors, their arguments and senses).

http://www.cs.brandeis.edu/~clp/conll15st/results.html
Pipeline

• Connective classifier: identifying explicit discourse connectives
• Argument extractor
• Sense classifier

• For all adjacent sentences, classify its sense into its implicit relation (including NoRel).
<table>
<thead>
<tr>
<th></th>
<th>our parser</th>
<th></th>
<th>Lin’s parser</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P</td>
<td>R</td>
<td>F&lt;sub&gt;1&lt;/sub&gt; (%)</td>
<td>P</td>
</tr>
<tr>
<td>Explicit connective</td>
<td>94.83</td>
<td>93.49</td>
<td><strong>94.16</strong></td>
<td>-</td>
</tr>
<tr>
<td>Explicit Arg1 extraction</td>
<td>51.05</td>
<td>50.33</td>
<td><strong>50.68</strong></td>
<td>-</td>
</tr>
<tr>
<td>Explicit Arg2 extraction</td>
<td>77.89</td>
<td>76.79</td>
<td><strong>77.33</strong></td>
<td>-</td>
</tr>
<tr>
<td>Explicit Both extraction</td>
<td>45.54</td>
<td>44.90</td>
<td><strong>45.22</strong></td>
<td>-</td>
</tr>
<tr>
<td>Explicit only sense</td>
<td>35.52</td>
<td>34.69</td>
<td>34.93</td>
<td>-</td>
</tr>
<tr>
<td>Non-Explicit Arg1 extraction</td>
<td>64.83</td>
<td>69.50</td>
<td>67.08</td>
<td>-</td>
</tr>
<tr>
<td>Non-Explicit Arg2 extraction</td>
<td>66.02</td>
<td>70.78</td>
<td>68.32</td>
<td>-</td>
</tr>
<tr>
<td>Non-Explicit Both extraction</td>
<td>51.20</td>
<td>54.89</td>
<td>52.98</td>
<td>-</td>
</tr>
<tr>
<td>Non-Explicit only sense</td>
<td>53.18</td>
<td>10.45</td>
<td>9.06</td>
<td>-</td>
</tr>
<tr>
<td>All Arg1 extraction</td>
<td>59.20</td>
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Data

• RST Treebank [UCB Library]
  http://digitalassets.lib.berkeley.edu/UCBonly/Ldc/2002T07/LDC2002T07.tgz

• Penn Discourse Treebank 2.0 [UCB Library]
  http://digitalassets.lib.berkeley.edu/UCBonly/Ldc/2008T05/