Combining Deep NLP with Temporal Extraction

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Last year's presentation

- Context: the Portuguese grammar LXGram
- Implementation of an **analysis of tense and aspect**
- Integration with an external **temporal extraction system**

Motivation

- Temporal meaning is often dependent on **extra-linguistic information**

This year's presentation

- Recap of the same topics
- **Evaluation results**
- **Questions raised** by this approach

Outline

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Semantic representation of tense

- Event variables, like other DELPH-IN HPSGs
- Temporal indices t stand for time intervals/points
- An *at* relation between the event variable and the event time
- Speech time/utterance time: subtype *now*
- Temporal relations between temporal indices

Example

O gato está doente. "The cat is ill."
$\_o\_q(x_1, \_gato\_n(x_1), \_doente\_a(\mathbf{e}, x_1) \wedge at(e, t) \wedge include(t, now))$

O gato adoeceu. "The cat fell ill."
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Semantic representation of aspect

- Aspectual operators in the semantic representations
- Introduced by
  - Rules for tense (e.g. present tense constrains the clause to be a state)
  - Lexical items (e.g. *stop*/*finish*)

Example

O gato está doente. "The cat is ill."
$\_o\_q(x_1, \_gato\_n(x_1),$
$\textbf{asp-op}(e_1\{state : +\}, e_2, \_doente\_a(e_2, x_1)) \wedge at(e_1, t) \wedge include(t, now))$

O gato adoeceu. "The cat fell ill."
$\_o\_q(x_1, \_gato\_n(x_1),$
$\textbf{asp-op}(e_1\{culmination : +\}, e_2, \_adoecer\_v(e_2, x_1)) \wedge at(e_1, t) \wedge before(t, now))$

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Outline

Combination with Temporal Extraction

Temporal extraction

- Resources with temporal annotations available
- Systems can be built to automatically annotate text with temporal information
- These systems can be used to expand the MRSs with further information about time
- Useful to add information that is difficult to process by the grammar

Combination with Temporal Extraction

Temporal extraction systems can take advantage of extra-grammatical information

- Calendar systems and arithmetic operations
  - E.g. what date does the time expression "two days before" refer to?
- Logic properties of temporal relations
  - Some relations follow from others; e.g. temporal precedence is transitive
- Pragmatics and knowledge of the world
  - E.g. causal relations

Difficult to model in TDL

Combination with Temporal Extraction

Temporal Annotation: TimeML

- Temporal expressions:

  <TIMEX3 tid="t15" value="1998-02-27">*Friday*</TIMEX3>

- Event terms:

  <EVENT eid="e6">*gave*</EVENT>

- Temporal relations:

  <TLINK eventID="e6" relType="BEFORE" relatedToTime="t15"/>

Example

The mayor of Moscow has allocated funds to build a museum in honor of Mikhail Kalashnikov, the Russian who gave his name to the world's most widely wielded weapon, according to a news agency report *Friday*.

Combination with Temporal Extraction

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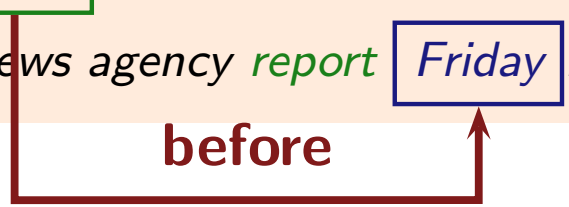
Example

The mayor of Moscow has allocated funds to build a museum in honor of Mikhail Kalashnikov, the Russian who gave his name to the world's most widely wielded weapon, according to a news agency report Friday.



Combination with Temporal Extraction

Current temporal extraction technology can

- **Recognize** time expressions
- **Normalize** time expressions
- Recognize **event terms**
- Recognize **temporal relations**
- **Classify** temporal relations

Combination with Temporal Extraction

Relevance of temporal extraction to deep NLP

- Precisely describe time intervals mentioned in text
- Check the consistency of the temporal relations included in the MRSs
- Correct temporal relations on the basis of extralinguistic criteria

Combination with Temporal Extraction

Post-process the MRSs output by LXGram

1. Add the normalized representation of the speech time
2. Correct the temporal relations if necessary
3. Add normalized representations of other dates and times

Combination with Temporal Extraction

1 Add the normalized representation of the speech time

- A feature T-VALUE is appropriate for temporal indices
- It holds the normalized value of the time interval that the index represents
- In the MRSs produced by LXGram it is left underspecified, or filled in with the value *speech-time*
- Post-processing replaces this value with the normalized value of the corresponding <TIMEX3>

Example

Choveu. "It rained."

h1, e2
{ h3: at_rel(e2, t4)
h3: before(t4, now5 { t-value: ~~*speech-time*~~ 2012-07-03T12:00:00 })
h3: aspectual-operator_rel(e2, e6, h7)
"rain" → h7: _chover_v_rel(e6)
{ h1 =q h3 }

Combination with Temporal Extraction

2 Correct or specify the temporal relations if necessary

- Vague forms: gerund, conditional, pluperfect, ...
- Future and conditional as some sort of irrealis mood:
  - *Quem será/seria?*
    (lit: "Who will/would it be?")
    "I wonder who that is/was."
  - *Hosni Mubarak terá entrado em coma.*
    (lit. "H. Mubarak will have entered in coma.")
    "H. M. alledgedly/apparently entered a coma."
- Other difficulties: present with future semantics, historical present, ...

Combination with Temporal Extraction

3 Add normalized representations of other dates and times

- In some cases, additional temporal relations between times and events are added

Example

Choveu hoje. "It rained today."

h1, e2

{ h3: at_rel(e2, t4)

h3: before(t4, t5 { t-value: ~~*speech time*~~ 2012-07-03T12:00:00 })

h3: aspectual-operator_rel(e2, e6, h7)

"rain" → h7: _chover_v_rel(e6)

"today" → h7: _hoje_a_rel(e9, e6, t8 { t-value: 2012-07-03 })

→ h7: include(t8, t4) }

{ h1 =q h3 }

Outline

Evaluation

Setup

- Data: TimeBankPT, a corpus of Portuguese with TimeML-like annotations
  - Training + testing data
- Three tested elements:
  1. Grammar
  2. Temporal extractor, trained with training data of TimeBankPT
  3. System combining the two
- Sentences not parsed by the grammar ignored

Results

	Grammar	Extractor	Combined System
Time expressions			
Recognition	n/a	88%	88%
Normalization	n/a	84%	84%
Events and times			
Mentioned times	n/a	57%	57%
Speech time	75%	83%	94%

Discussion

- The combined system matches or outperforms the isolated components
- When classifying temporal relations between events and the speech time, the combined system beats the grammar and the temporal extractor
  - The grammar is tricked by the difficult cases presented above
  - The extractor misses some events (and therefore some relations involving them)

Outline

Issues

Interesting issues

- We did not use Heart of Gold
  - HoG can merge RMRSs coming from different components
  - In principle it could be used (future work)
- Ad-hoc combination
  - Post-processing MRSs: what other tasks would do this as well?
  - What do they have in common?
- Non-monotonicity
  - Some information in the MRSs is destroyed/replaced when combining the two components
- Semantic representations require two LTOP-like features (or unary rules at the clausal level or other questionable solutions)

Issues

Semantic representations require two LTOP-like features

Example

"They laugh for hours" / *Eles riem-se durante horas.*

$habitual(laugh(e, THEY') \wedge for(e, HOURS')) \wedge at(e, t) \wedge incl(t, now)$

- Present tense constrains the clause to be a state
- "Laugh" is lexically a process/activity
- *For* adverbials are functions from processes/activities to culminated processes/accomplishments
- One possible function from accomplishments to states is the *habitual* aspectual operator
- Effect: reading of a series of repeating but complete laughing events

Issues

Semantic representations require two LTOP-like features

Example

"They laugh for hours" / *Eles riem-se durante horas.*

$habitual(laugh(e, THEY') \wedge for(e, HOURS')) \wedge at(e, t) \wedge incl(t, now)$

Problem:

- The *habitual* aspectual operator introduced by the present tense outscopes the *for* adverbial
- Present tense is handled by a lexical rule
- *For* adverbials combine with the head they modify in syntax
- Scopal adverbs outscope the *habitual* aspectual operator: "They possibly laugh for hours."

Issues

Semantic representations require two LTOP-like features

Example

"They laugh for hours" / *Eles riem-se durante horas.*

$habitual(laugh(e, THEY') \wedge for(e, HOURS')) \wedge at(e, t) \wedge incl(t, now)$

- Need to keep track of two LTOP features
- This is a considerable departure from the standard way of composing the semantics
- How does this affect generation?

- Alternatives don't look much better
  - Unary rules at the clausal level introduce the operators
  - Stuff that selects for clauses introduces them

Outline

Final Remarks

Summary

- HPSG implementation of tense and aspect
- It combines much of what is said in the literature
- It makes some of the temporal and aspectual meaning of sentences explicit
- Integration with an external component dedicated to process time phenomena
- Combined results improve results of the grammar and the temporal extraction system
- Temporal phenomena seem to challenge some of our assumptions