IA165

Combinatory Logic for Computational Semantics

Spring 2012

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Formal semantic analysis of aspecto-temporal relation

- Many works based on the analysis of temporal relations (Asher and Vieu 2005; Grosz and Sidner 1986; Lascarides and Asher 1993; Mann and Thompson 1987) assume that a text (or discourse) has hierarchical structures
- Representing this structure is quite different in various theories (SDRT, CAG,)
- The Segmented Discourse Representation Theory (SDRT) (Asher 1993) is anchored in the formal semantics to study the complex interplay between the semantic contribution of propositions with their components and the segmentation of discourse. → dynamical and theoretical tool for the analysis of discourse

(Asher, 1993; Asher and Vieu, 2005; Descles *et al.*, 2011)

- Combinators allow to introduce and define new operators which mark the aspecto-temporal relation. → "<u>aspecto-temporal operators</u>"

We show the aspecto-temporal relation of the given text in the SDRT and define the aspecto-temporal operators by means of the combinators
→ propose a formal semantic analysis by taking into account of the aspecto-temporal relation in the text
→ establish the temporal relations between sentences

- Preliminary works

1) Introduce the SDRT (Asher, 1993; variant of the DRT by Kamp)

2) Introduce the derived combinators: the powers of a combinator and the deferred combinators

General introduction to SDRT

- Method of modelling dialogue
- SDRT (Asher 1993, Asher & Lascarides 2003)

  - task:

  compute pragmatically preferred interpretation of discourse / model pragmatic competence → more than what grammar outputs, less than full belief revision

  - for dialogue

  → SDRT: logic(s) for representing & reasoning about cognitive states

- The SDRT defines a set of speech-act labels, $\pi_1, \dots \pi_n$, related by discourse relations R

  → each speech-act label is associated with a 'discourse constituent', which is either simple–the logical formula representing a simple clause– or complex –a SDRS representing a discourse segment.

- Discourse relations used in SDRT for modelling dialogue

  : Background, Continuation, Parallel, Contrast, Topic, Precondition, Commentary, etc.

  : relations used for temporal structuring → Narration, Result, Elaboration, Explanatation

relations used for temporal structuring

→ Narration, Result, Elaboration, Explanatation

These relations are appeared where the clause α presents in the text before β .

– Narration(α,β): The event described in β is a consequence of the event described in α;

– Result(α,β) : the event described in α caused the event or state described in β;

– Elaboration(α,β) : β's event is part of α's;

– Explanation (α,β): the event describe in β explains why α's event happened.

(1) Fred had a great evening last night ($\pi 1$). He had a great meal ($\pi 2$). He ate salmon ($\pi 3$). He devoured lots of cheese ($\pi 4$). He then won a dancing competition ($\pi 5$).

(Asher and Lascarides 2003)

Discourse relations

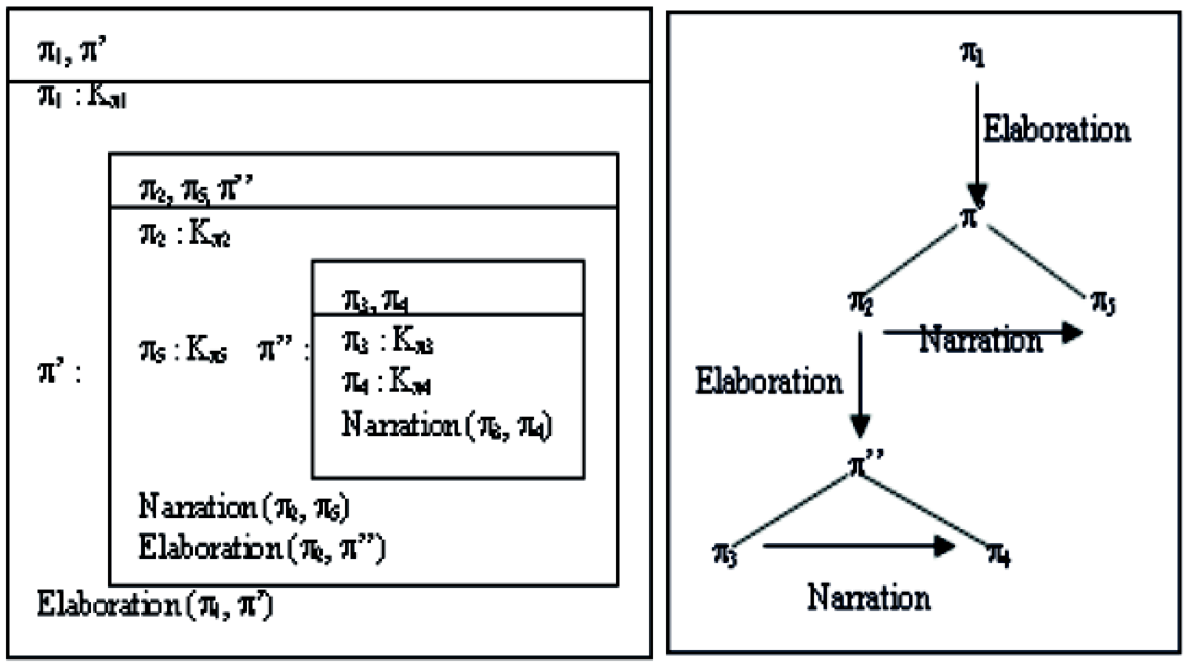
- Elaboration links the first clause ($\pi 1$) to the rest of the discourse ($\pi 2 - \pi 5$);

- Narration links the message of great meal to the dancing competition, i.e. ($\pi 2$) and ($\pi 5$);

- Elaboration links the message of great meal to two following clause, i.e. ($\pi 3$) and ($\pi 4$).

(1) Fred had a great evening last night (π1). He had a great meal (π2). He ate salmon (π3). He devoured lots of cheese (π4). He then won a dancing competition (π5).

(Asher and Lascarides 2003)



Clauses (π3-π4) elaborate the meal (π2), which in turn elaborates the evening (π1). (π5) also elaborates the evening, but unlike (π3-π4) it doesn't elaborate the meal. Rather, it forms a narrative with (π2).

- <u>Hypothesis for the computational and semantic representation of the temporality</u>

The temporality of language can not be described without taking account of the aspectuality. All aspectual notions imply an underlying temporality;

→ most of situations require topological relations between open closed boundaries of intervals compounded by instants.

(show the examples of the topological relations on the board)

Definition of the aspecto-temporal operators

- To analyze semantically the expressions of linguistic temporality, a predicative relation, noted 'Λ (lexis)' (see Culioli 1999), is aspectualized as a **state**, or an **event**, or a **process** (Comrie 1976; Desclés 1980; 1990b; Mourelatos 1981) in using aspectual operators $STATE_O$, $EVEN_F$ and $PROC_J$ which are actualized on topological intervals of instants:

(i) $STATE_O$ (Λ) is developed on the topological open interval 'O' and is true for each instant of 'O';

(ii) $EVEN_F$ (Λ) is developed on the closed interval 'F' and is true at the right closed boundary 'δ(F)';

(iii) $PROC_J$ (Λ) is developed on the interval 'J' with a left–closed boundary 'γ(J)' and right–open boundary 'δ(J)' and is true at each instant 't' of 'J' before the right open boundary of 'δ(J)' ($t < δ(J)$)

- Example of <u>event, state, process</u>

STATE: *The air smells of jasmine.*

PROC: *It's snowing.*

EVENT: *He crossed the street upon seeing her.*

(1) Fred had a great evening last night (π1). He had a great meal (π2). He ate salmon (π3). He devoured lots of cheese (π4). He then won a dancing competition (π5).

(Asher and Lascarides 2003)

π1.1. Last night (reform: All that follows occurred last night): Temporal Framework, $STATE_{O1}$ (state)

π1.2. Fred had a great evening : $EVEN_{F1}$ (event)

π2. He had a great meal: $EVEN_{F2}$ (event)

π3. He ate salmon: $EVEN_{F3}$ (event)

π4. He devoured lots of cheese: $EVEN_{F4}$ (event)

π5. He then won a dancing competition: $EVEN_{F5}$ (event)

Definition of the speech act operator "I-am-saying"

: a result of a functional composition of the two operators: "I-SAY" and "$PROC_{J0}$"

$$PROC_{J0}\ ((I\text{-}SAY)\ (\&\ (ASP_{I}\ (\Lambda))\ [I\ REP\ J^{0}]))$$

comment:

the aspectual process $PROC_{J0}$ is applied on the result of the application of (I-SAY) on a conjunction of an aspectualized predicative relation ASP_{I} (Λ) and a temporal relation [I REP J^{0}] between the interval I related to the predicative relation and an interval J^{0} related to enunciative process.

p1.1. $PROC_{J0}$ (I-SAY (& ($STATE_{O1}$ (All that follows occurred last night)) [$\delta(O^1) < \delta(J^0)$])

p1.2. $PROC_{J0}$ (I-SAY (& ($EVEN_{F1}$ ((have (a great evening))(Fred))) [$\delta(F^1) < \delta(J^0)$])

p2. $PROC_{J0}$ (I-SAY (& ($EVEN_{F2}$ ((have (a great meal))(Fred))) [$\delta(F^2) < \delta(J^0)$])

p3. $PROC_{J0}$ (I-SAY (& ($EVEN_{F3}$ ((eat (salmon)) (x)))[$\delta(F^3) < \delta(J^0)$])

p4. $PROC_{J0}$ (I-SAY (& ($EVEN_{F4}$ ((devour (lots of cheese))(x))) [$\delta(F^4) < \delta(J^0)$])

p5. $PROC_{J0}$ (I-SAY (& ($EVEN_{F5}$ ((win (a dancing competition)) (x))) [$\delta(F^5) < \delta(J^0)$])

Derived combinators

- The powers of a combinator: X^n

Given a combinator X,

$$X^0 =_{def} I$$

$$X^1 =_{def} X$$

$$X^{n+1} =_{def} X \bullet X^n$$

$B^2 = B \bullet B = BBB$

$B^3 = B \bullet B^2 = B \bullet (BBB) = BBBBB$

$B^4 = B \bullet B^3 = B \bullet (BBBBB) = BBBBBBB$

<u>Application:</u>

$B^2\ f\ x\ y\ z \geq B(Bf)xyz \geq Bf(xy)z \geq f(xyz)$

$C^2\ f\ x\ y \geq C(Cf)xy \geq Cfyx \geq fxy$

$W^2\ f\ x \geq W(Wf)x \geq Wfxx \geq fxxx$

$K^2\ f\ x\ y \geq K(Kf)xy \geq Kfy \geq f$

- The deferred combinators: X_n

X(k) defers the action of X by K steps

$$X_{(k)} f X_1 \ldots X_{m+k} \geq f x_1 \ldots x_k X_1' .. X_n'$$

<u>*Application:*</u>

$C_{(k)}$ interchanges x_{k+1} and x_{k+2}; $W_{(k)}$ causes a repetition of x_{k+1}; and $K_{(k)}$ causes the cancellation of x_{k+1}

$$B_{(k)} f x_1 x_2 \ldots x_k x_{k+1} x_{k+2} \geq_\beta f x_1 x_2 \ldots x_k (x_{k+1} x_{k+2})$$

$$C_{(k)} f x_1 x_2 \ldots x_k x_{k+1} x_{k+2} \geq_\beta f x_1 x_2 \ldots x_k x_{k+2} x_{k+1}$$

$$W_{(k)} f x_1 x_2 \ldots x_k x_{k+1} \geq_\beta f x_1 x_2 \ldots x_k x_{k+1} x_{k+1}$$

$$K_{(k)} f x_1 x_2 \ldots x_k x_{k+1} \geq_\beta f x_1 x_2 \ldots x_k$$

$$I_{(k)} f x_1 x_2 \ldots x_k \geq_\beta f x_1 x_2 \ldots x_k$$

Next week...

- Continue about the application of the combinators to natural language analysis: **aspecto-temporal analysis**