

IA165

Combinatory Logic for Computational Semantics

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Summing up: last lecture

- How to apply the combinators to natural language analysis

1) using introduction and elimination rules by beta-reduction of combinators: control heuristic of combinatorial application and bracketing

2) using a syntactic tool for controlling the application of combinators

: CCG assumes the preliminary steps to find a well-structured normal form, that is, a formal semantic structure

Remind...1

- The combinator C

: expresses the conversion, that is, the permutation of two arguments of an binary operator.

: takes one functor f and two arguments x and y . The elimination of the combinator C by β -reduction allows to converse the position of the argument x with y .

$$Cfxy \xrightarrow{\beta} fyx$$

The introduction and elimination rule of the combinator C

$$\frac{((Cf)(x))(y)}{(f(y))(x)}$$

$$\frac{(f(y))(x)}{(Cf)(x)(y)}$$

Remind...2

Associativity of the combinatory logic

$$x(yz) = xyz$$

$$Bxyz = (Bxy)z$$

Proof

$$\begin{aligned} ((X \cdot Y) \cdot Z) x &\geq B(BXY)Zx \geq BXY(Zx) \geq X(Y(Zx)) \leq X(BYZx) \\ &\leq BX(BYZx) = X(Y \cdot Z) \end{aligned}$$

Short introduction to "Passivization"

- Consider the following sentences

a. The man **has been killed**.

b. One **has killed** him.

→ Invariant of meaning

→ Relation between two sentences

a'. **unary passive** predicate (has-been-killed)

b'. **active transitive** predicate (have-killed)

- active agent corresponds optional *by* phrase in passive; passivization is a form of 'intransitivation';
 - same semantic role (e.g. agent) - (1)
 - some differences (e.g. case) - (2)
- other complements are unaffected;
- changes to morphosyntax of verb (aux **be** plus passive participle)

(1) Kim stole the most expensive picture.

(1') The most expensive picture was stolen by Kim

(2) He saw her.

(2') She was seen by him.

- Definition of the operator of passivisation 'PASS'

$$[PASS = B \Sigma C]$$

where B and C are the combinator of composition and of conversion and where Σ is the existential quantifier which, by applying to a binary predicate, transforms it into the unary predicate.

$$\Sigma(E^1 E^2) \rightarrow (E^1 x E^2)$$

Formal semantic analysis of the "Passivization"

- | | |
|---|---------------------------|
| 1/ has-been-killed (the-man) | hypothesis |
| 2/ [has-been-killed=PASS(has killed)] | passive lexical predicate |
| 3/ PASS (has-killed)(the-man) | repl.2.,1. |
| 4/ [PASS = B Σ C] | definition of 'PASS' |
| 5/ B Σ C (has-killed)(the-man) | repl.4.,3. |
| 6/ Σ (C(has-killed))(the-man) | [e-B] |
| 7/ (C(has-killed)) x (the-man) | [e- Σ] |
| 8/ (has-killed)(the-main) x | [e-C] |
| 9/ [x in the agentive subject position = one] | definition of 'one' |
| 10/ (has-killed)(the-man)one | repl.9.,8., normal form |

We establish the paraphrastic relation between the passive sentence with expressed agent and its active counterpart:

The man has been killed by the enemy



The enemy has killed the man

Relation between give-to and receive-from

z gives y to x



x receives y from z

The lexical predicate “*give-to*” has a predicate converse associated to “*receive-from*”;

[receive-from z y x = give-to x y z]

Anna gave a DVD to Nancy

Nancy received a DVD from Anna



z gave y to x → (gave_to x y z)

x received y from z → (received_from z y x)

Prove the following relation
[[(receive-from) z] y x = give-to x y z]

1/ (receive-from) z y x

2/ C((receive-from) z) x y

3/ BC(receive-from) z x y

4/ C(BC(receive-from)) x z y

5/ C(C(BC(receive-from)) x) y z

6/ BC(C(BC(receive-from))) x y z

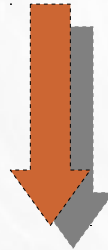
7/ [give-to=BC(C(BC(receive-from)))]

8/ give-to x y z

x: Anna
y: a DVD
z: Nancy

x lead y \rightarrow (lead y) x
y follow x \rightarrow (follow x) y

x chase y \rightarrow (chase y) x
y flee x \rightarrow (flee x) y



Combinator **C** of conversion

$(f(x)) y \rightarrow (Cf) y x$

What is the semantic relations between these couples of sentences? (Show in the classwork)

Multilingual examples of Passives-1

- Passive transformation In Czech

Transformation T1

(a) $[NP^1]_{NOM} - [V^1_{lex}]_{fin} - [NP^2]_{ACC} \Rightarrow$ (b)

(b) $[NP^2]_{NOM} - [V^2be]_{fin} - [V^1lex]_{part} - [NP^1]_{INSTR}$

Examples

(a) Petr sliboval Pavlovi, že přijde \Rightarrow (b)

Peter_{NOM} promised Paul_{DAT} that arrives_{3SM} \Rightarrow (b)

‘Peter promised to Paul that he arrives.’

(b) Pavlovi bylo slibováno (Petrem), že přijde

Paul_{DAT} was promised (Peter_{INSTR}) that arrives_{3SN}

‘It was promised to Peter (by Paul) that he arrives.’

Multilingual examples of Passive-2

Consider the following relation:

bylo-slibováno and sliboval

x sliboval y

$\rightarrow ((\text{sliboval } y) x)$

\Downarrow

y bylo-slibovano (by x)

$\rightarrow (\text{bylo-slibovano}) y$

We need to define the operator of the passivisation

$[\text{PASS}=\text{B } \Sigma \text{ C} = \Sigma \bullet \text{C}]$

- Formal analysis of the passivisation in Czech

1/ bylo-slibováno y (by x=Petrem)

2/ [bylo-slibováno=PASS (sliboval)]

3/ PASS (sliboval) y

4/ B Σ C (sliboval) y

5/ Σ (C sliboval) y

6/ (C sliboval) x' y

7/ [x'= agentive subject]

8/ sliboval y x'

[bylo-slibováno Pavlovi] =
Passivisation of [sliboval Pavlovi Petr]

Next week...

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