Incremental Semantic Interpretation of Dialogue Contributions

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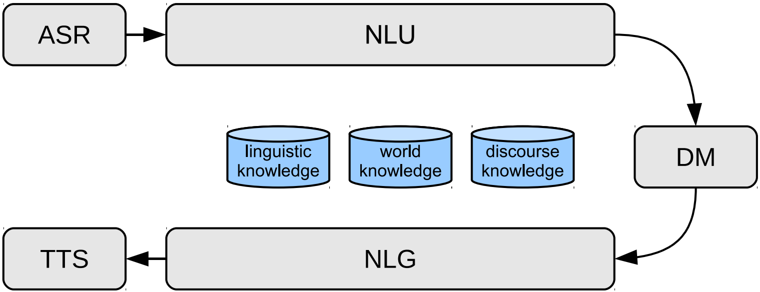
Kolloquium Linguistik, Universität Bielefeld, 07.11.2012

Outline

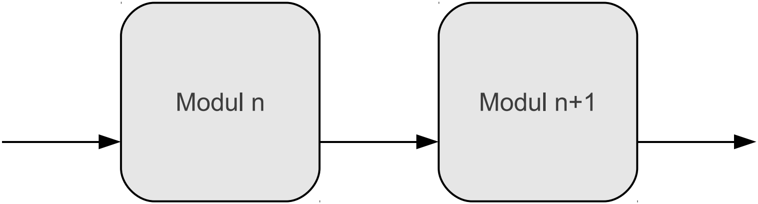
Introduction: Spoken Dialogue Systems



Introduction: Incremental Processing

Incrementality, Schlangen and Skantze [2009], citing Levelt [1989]

Each processing component is triggered into activity by a minimal amount of its characteristic input.



information flow between two modules

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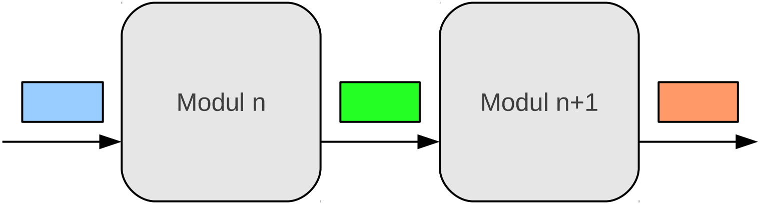

non-incremental information flow

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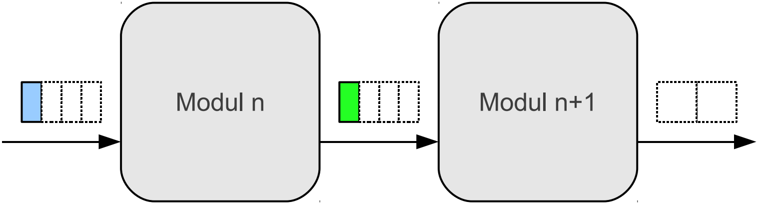

incremental information flow: *early propagation*

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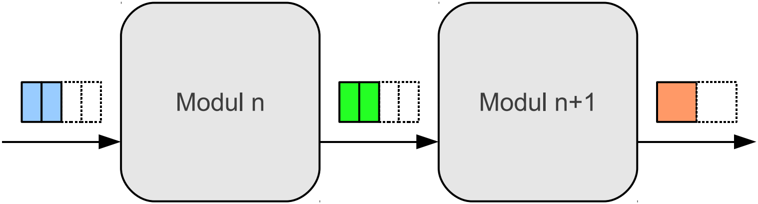

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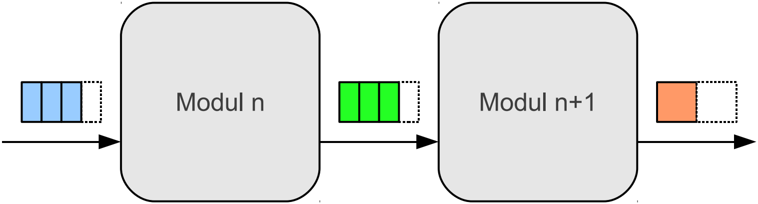

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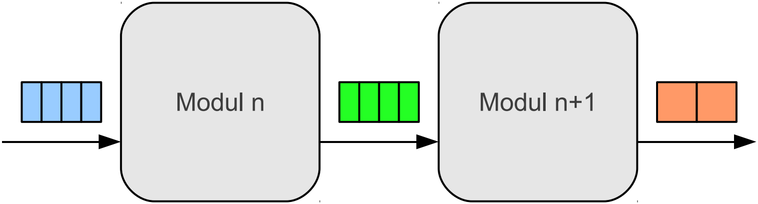

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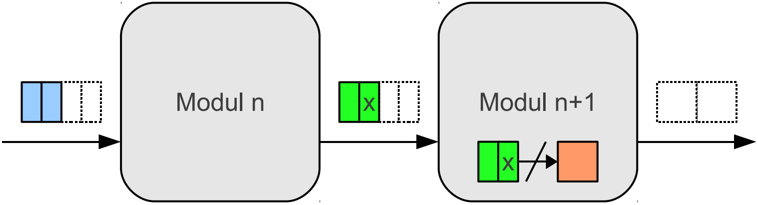

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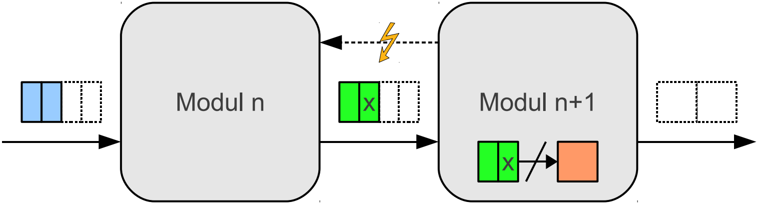

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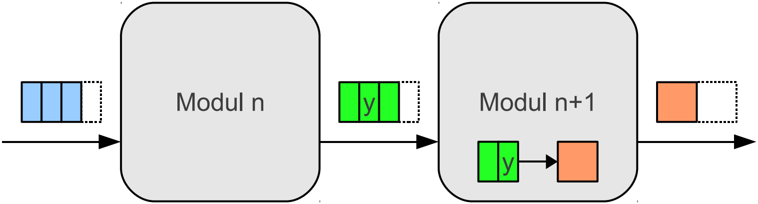

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1. psycho-linguistic plausibility Tanenhaus and Brown-Schmidt [2008]
   - reference resolution, early disambiguation etc
2. descriptive adequacy
   - backchannel feedback
     intervening corrections, clairifications, completions
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     efficiency (by interaction): reduce workload
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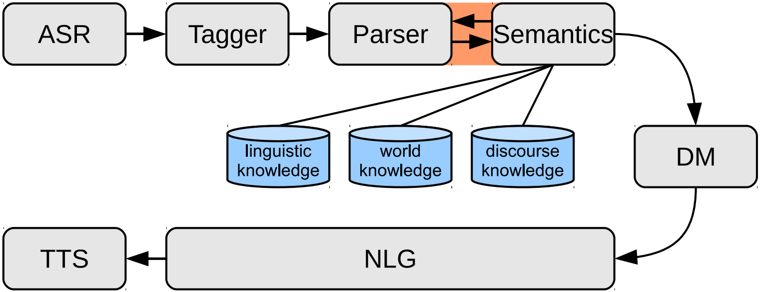
Introduction: Aims of the Approach



Goal: Prune semantically implausible syntactic readings, i.e. readings without referential success.

Related Work

- Purver et al. [2011] - incremental semantic construction within Dynamic Syntax, centered on grammaticality, rather monolithic
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Theory: Incremental Semantic Construction

Incrementality in Semantic Construction

- Goal: for an input find a semantic representation that is maximally informative and open to combination with further semantic increments
- three factors that influence *a syntax driven* incremental semantic construction
  1. type of syntactic structure building (top-down-parsing, bottom-up-parsing)
  2. type of syntactic structure (left- or right-branching)
  3. type of semantic structure interpretation (bottom-up, top-down)

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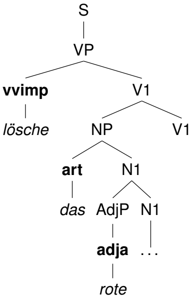
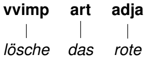
Incrementality in Semantic Construction

- Roark [2001]: *rooted & connected* structures are essential for incremental interpretation
- usually only provided by top-down-parsers
- drawbacks: many hypotheses, problems with left-recursion
- Roark presents solutions for both problems:





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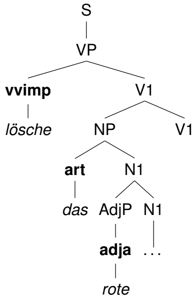

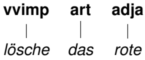

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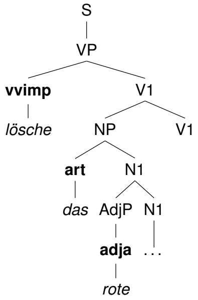

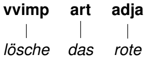

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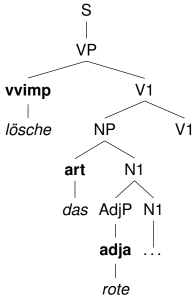

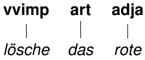

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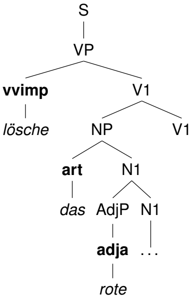

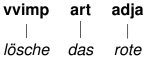

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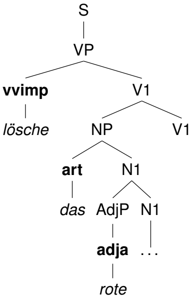
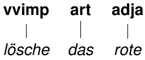
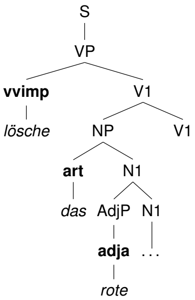




Tree-Interpretation: Bottom up?



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- need to underspecify open nodes
- need to re-interpret the whole tree every time it expands

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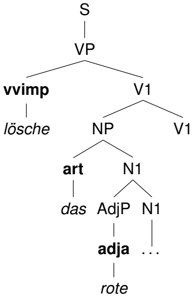

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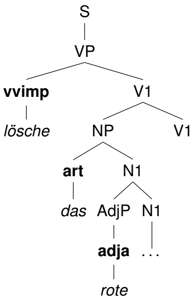

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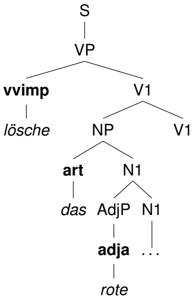

Tree-interpretation top-down, left-to-right:

- linearise semantic combination in parallel to the top-down expansion of the tree
- every expansion of a non-terminal node adds a rule-specific construction semantic increment
  (parser action: predict)
- every recognition of a terminal node adds a lexical semantic increment
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- no need to underspecify open nodes
- no need to re-interpret the tree
- *monotonic growth, synchronised with parsing*

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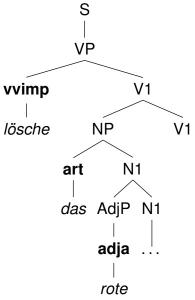

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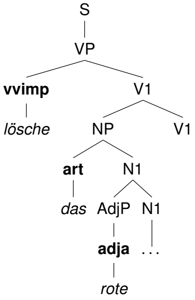

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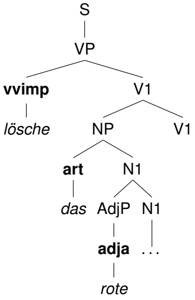

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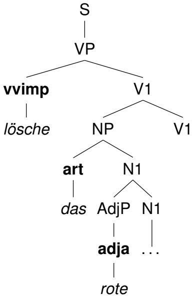

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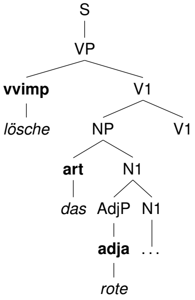

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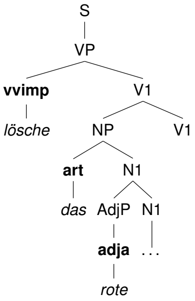

Tree-interpretation top-down, left-to-right:

- linearise semantic combination in parallel to the top-down expansion of the tree
- every expansion of a non-terminal node adds a rule-specific construction semantic increment
  (parser action: predict)
- every recognition of a terminal node adds a lexical semantic increment
  (parser action: match)

- no need to underspecify open nodes
- no need to re-interpret the tree
- *monotonic growth, synchronised with parsing*

RMRS introduction

- representation language: first order predicate logic with generalized quantifiers, sortal variables
- scope underspecification: break up into elementary predications with labels and holes, standard conjuction, add scope constraints
- underspecification of predicate argument structure: break up further into elementary predications with anchors, characteristic variable and argument-relations

Every dog chases a cat.
every(x, dog(x), exist(y, cat(y), chase(x,y)))
exist(y, cat(y), every(x, dog(x), chase(x,y)))

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$$
\begin{array}{l}
\langle h_0, \\
\{\ell_1\text{:every}(x, h_1, h_2), \\
\ell_2\text{:dog}(x), \\
\ell_3\text{:chase}(e, x, y), \\
\ell_4\text{:some}(y, h_3, h_4), \\
\ell_5\text{:cat}(y)\ \}, \\
\{h_1 =_q \ell_2, h_3 =_q \ell_5\}\rangle
\end{array}
$$

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$$\begin{array}{l}
\langle\ h_0, \\
\{\ \ell_1{:}a_1{:}\mathrm{every}(),\ \mathsf{BV}(a_1, x_1),\ \mathsf{RSTR}(a_1, h_1),\ \mathsf{BODY}(a_1, h_2), \\
\ell_2{:}a_2{:}\mathrm{dog}(x_1), \\
\ell_3{:}a_3{:}\mathrm{chase}(e_1),\ \mathsf{ARG}_1(a_3, x_1),\ \mathsf{ARG}_2(a_3, x_2), \\
\ell_4{:}a_4{:}\mathrm{some}(),\ \mathsf{BV}(a_4, x_2),\ \mathsf{RSTR}(a_4, h_3),\ \mathsf{BODY}(a_4, h_4), \\
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\begin{aligned}
&\langle\ h_0,\\
&\{\ \ell_1{:}a_1{:}\mathrm{every}(),\ \mathsf{BV}(a_1,x_1),\ \mathsf{RSTR}(a_1,h_1),\ \mathsf{BODY}(a_1,h_2),\\
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\end{aligned}
$$

RMRS forward composition

- classic RMRS Copestake [2007] uses a *set of named slot* to represent the open positions, the syntax-semantic interface picks the right slot to fill
- only one slot of each sort open
- however, left recursive rules in incremental processing may require to have multiple slots of the same sort open
- therefore we reinterpret the slots as a stack of unnamed slots, where only the top element can be filled

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$[\ell_3{:}a_3{:}e_1]\ \{\ [\ell_5{:}a_5{:}x_2]np-arg\ \}$
$\ell_1{:}a_1{:}\text{every}(),\ \mathsf{BV}(a_1,x_1),\ \mathsf{RSTR}(a_1,h_1),\ \mathsf{BODY}(a_1,h_2),\ h_1 =_q \ell_2,$
$\ell_2{:}a_2{:}\text{dog}(x_1),$
$\ell_3{:}a_3{:}\text{chase}(e_1),\ \mathsf{ARG}_1(a_3,x_1),\ \mathsf{ARG}_2(a_3,x_2),$
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$[\ell_6{:}a_6{:}e_6]\ \{\ \}\ \ell_6{:}a_6{:}\text{cat}(x_6)$

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$[\ell_3{:}a_3{:}e_1]\ \{\ \}$
$\ell_1{:}a_1{:}\text{every}()$, $\mathsf{BV}(a_1, x_1)$, $\mathsf{RSTR}(a_1, h_1)$, $\mathsf{BODY}(a_1, h_2)$, $h_1 =_q \ell_2$,
$\ell_2{:}a_2{:}\text{dog}(x_1)$,
$\ell_3{:}a_3{:}\text{chase}(e_1)$, $\mathsf{ARG}_1(a_3, x_1)$, $\mathsf{ARG}_2(a_3, x_2)$,
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$\ell_6{:}a_6{:}\text{cat}(x_6)$, $\ell_6 = \ell_5$, $a_6 = a_5$, $x_6 = x_2$

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RMRS forward composition

RMRS structure under construction with a stack of slots

An RMRS structure under construction is a 6-tuple $\langle GT, H, S, R, C, E \rangle$,

- with GT the global top hole h_0,
- with H the hook $[\ell{:}a{:}i]$, consisting of the local top label ℓ, the anchor a and the index i,
- with S the stack of slots of the form $[\ell_n{:}a_n{:}i_n]$,
- with R the bag of EPs and argument relations,
- with C the bag of constraints and
- with E the set of variable equalities.

RMRS forward composition

Forward slot filling combination

Given two RMRSs, one being the functor $rmrs_f = \langle GT_f, H_f, S_f, R_f, C_f, E_f \rangle$ with the top slot $\mathrm{top}(S_f) = [\ell_f{:}a_f{:}i_f]$ and one being the argument $rmrs_a = \langle GT_a, H_a, S_a, R_a, C_a, E_a \rangle$ with its hook $H_a = [\ell_a{:}a_a{:}i_a]$, the slot filling combination $rmrs_f \triangleleft rmrs_a$ yields an RMRS $rmrs = \langle GT, H, S, R, C, E \rangle$, s.t.

- $GT = GT_f = GT_a$
- $H = H_f$
- $S = \text{merge-stacks}(S_a, \mathrm{pop}(S_f))$
- $R = R_f \cup R_a$
- $C = C_f \cup C_a$
- $E = E_f \cup E_a \cup \{\ell_f = \ell_a, a_f = a_a, i_f = i_a\}$

Basic slotfilling combinators

$$
\begin{array}{lcl}
[-] & = & [\ell{:}a{:}u]\ \{\ \}\ . \\
[\circ] & = & [\ell{:}a{:}u]\ \{\ [\ell{:}a{:}u]\ \}\ . \\
[=] & = & [\ell{:}a{:}u]\ \{\ [\ell{:}a{:}u][\ell{:}a{:}u]\ \}\ . \\
[+] & = & [\ell{:}a{:}u]\ \{\ [\ell_1{:}a_1{:}u][\ell{:}a{:}u]\ \}\ . \\
[+\!\!.\,] & = & [\ell{:}a{:}u]\ \{\ [\ell{:}a{:}u][\ell_1{:}a_1{:}u]\ \}\ . \\
[+\ell] & = & [\ell{:}a{:}u]\ \{\ [\ell{:}a_1{:}u][\ell{:}a{:}u]\ \}\ .
\end{array}
$$

A worked example: a toy grammar

S	$\rightarrow$	S **kon** S	$[\mathrm{Conj}]$
S	$\rightarrow$	VP	$[\mathrm{Arg1}] \triangleleft [\mathrm{adr}]$
VP	$\rightarrow$	**vvimp** V1	$[=]$
V1	$\rightarrow$	NP0 V1	$[\mathrm{Arg2}]$
V1	$\rightarrow$	V1 AdvP	$[\dotplus]$
V1	$\rightarrow$	V1 PP	$[\dotplus]$
V1	$\rightarrow$	ϵ	$[-]$
PP	$\rightarrow$	**appr** NP	$[\mathrm{PP}]$
AdvP	$\rightarrow$	**adv**	$[\mathrm{Adv}]$
AdjP	$\rightarrow$	**adja**	$[\mathrm{Adj}]$

NP0	$\rightarrow$	PP NP0	$[+]$
NP0	$\rightarrow$	NP	$[\circ]$
NP	$\rightarrow$	**pper**	$[\circ]$
NP	$\rightarrow$	**art** N2	$[\mathrm{Q}]$
N2	$\rightarrow$	N1	$[\circ]$
N2	$\rightarrow$	N1 NP	$[\dotplus]$
N1	$\rightarrow$	AdjP N1	$[+\ell]$
N1	$\rightarrow$	N1 PP	$[\dotplus]$
N1	$\rightarrow$	N1 AdvP	$[\dotplus]$
N1	$\rightarrow$	**nn**	$[\circ]$

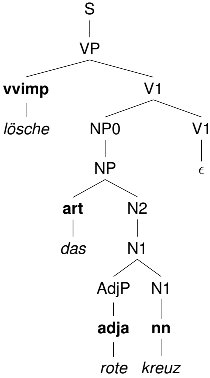
A worked example: semantic macros

$$
\begin{array}{lcll}
[\text{Arg1}] & = & [\ell{:}a{:}u] & \{\,[\ell_1{:}a_1{:}x_1][\ell{:}a{:}u]\,\}\ \mathsf{ARG}_1(a, x_1) \\
[\text{Arg2}] & = & [\ell{:}a{:}u] & \{\,[\ell_1{:}a_1{:}x_1][\ell{:}a{:}u]\,\}\ \mathsf{ARG}_2(a, x_1) \\
[\text{Arg3}] & = & [\ell{:}a{:}u] & \{\,[\ell_1{:}a_1{:}x_1][\ell{:}a{:}u]\,\}\ \mathsf{ARG}_3(a, x_1) \\
[\text{adr}] & = & [\ell{:}a{:}x] & \{\ \}\ \ell{:}a{:}\text{addressee}(x) \\
[\text{Q}] & = & [\ell{:}a{:}x] & \{\,[\ell{:}a{:}e_1][\ell_2{:}a_2{:}x]\,\}\ \mathsf{BV}(a, x), \\
 & & & \mathsf{RSTR}(a, h_1),\ \mathsf{BODY}(a, h_2),\ h_1 =_q \ell_2 \\
[\text{PP}] & = & [\ell{:}a{:}u] & \{\,[\ell_1{:}a_1{:}e_1][\ell_2{:}a_2{:}x_2]\,\}\ \mathsf{ARG}_1(a_1, u), \\
 & & & \mathsf{ARG}_2(a_1, x_2) \\
[\text{Adj}] & = & [\ell{:}a{:}x] & \{\,[\ell{:}a_1{:}e_1]\,\}\ \mathsf{ARG}_1(a_1, x) \\
[\text{Adv}] & = & [\ell{:}a{:}u] & \{\,[\ell_1{:}a_1{:}e_1]\,\}\ \mathsf{ARG}_1(a_1, u) \\
[\text{Conj}] & = & [\ell{:}a{:}u] & \{\,[\ell_1{:}a_1{:}u_1][\ell{:}a{:}u][\ell_3{:}a_3{:}u_3]\,\} \\
 & & & \mathsf{LEFT}_i(a, u_1),\ \mathsf{LEFT}_\ell(a, h_1), \\
 & & & \mathsf{RIGHT}_i(a, u_3),\ \mathsf{RIGHT}_\ell(a, h_3), \\
 & & & h_1 =_q \ell_1,\ h_3 =_q \ell_3
\end{array}
$$

A worked example: generic lexical entries

adja:	$[\ell{:}a{:}e]$	$\{\ \}$	$\ell{:}a{:}\_lemma(e)$
adv:	$[\ell{:}a{:}e]$	$\{\ \}$	$\ell{:}a{:}\_lemma(e)$
appr:	$[\ell{:}a{:}e]$	$\{\ \}$	$\ell{:}a{:}\_lemma(e)$
art:	$[\ell{:}a{:}u]$	$\{\ \}$	$\ell{:}a{:}\_lemma()$
kon:	$[\ell{:}a{:}u]$	$\{\ \}$	$\ell{:}a{:}\_lemma(u)$
nn:	$[\ell{:}a{:}x]$	$\{\ \}$	$\ell{:}a{:}\_lemma(x)$
pper	$[\ell{:}a{:}x]$	$\{\ \}$	$\ell{:}a{:}\mathrm{pper}(x)$
vvimp:	$[\ell{:}a{:}e]$	$\{\ \}$	$\ell{:}a{:}\_lemma(e)$

A worked example: derivation



$[\circ]$
$\lhd$ [Arg1] $\lhd$ [adr] $\lhd$ [=] $\lhd$ $[\![$*lösche*$]\!]$
$\lhd$ [Arg2] $\lhd$ $[\circ]$ $\lhd$ [Q] $\lhd$ $[\![$*das*$]\!]$
$\lhd$ $[\circ]$ $\lhd$ $[+\ell]$ $\lhd$ [Adj] $\lhd$ $[\![$*rote*$]\!]$
$\lhd$ $[\circ]$ $\lhd$ $[\![$*kreuz*$]\!]$
$\lhd$ $[-]$

$[\ell_0{:}a_0{:}e_0]\ \{\ \}$
$\ell_0{:}a_0{:}\_\text{löschen}(e_0)$, $\mathsf{ARG}_1(a_0, x_2)$, $\mathsf{ARG}_2(a_0, x_4)$,
$\ell_2{:}a_2{:}\text{addressee}(x_2)$,
$\ell_4{:}a_4{:}\_\text{def\_q}()$, $\mathsf{BV}(a_4, x_4)$, $\mathsf{RSTR}(a_4, h_1)$, $\mathsf{BODY}(a_4, h_2)$, $h_1 =_q \ell_7$,
$\ell_7{:}a_{10}{:}\_\text{rot}(e_{10})$, $\mathsf{ARG}_1(a_{10}, x_4)$,
$\ell_7{:}a_7{:}\_\text{kreuz}(x_4)$

A worked example: derivation

$$[\circ]$$

$$\begin{array}{c} \text{S} \\ | \\ \ldots \end{array}$$

$$[\ell_0{:}a_0{:}u_0]\ \{\ [\ell_0{:}a_0{:}u_0]\ \}\ .$$

A worked example: derivation

S
|
VP
|
...

$[\circ]$
$\triangleleft$ [Arg1]

$[\ell_0{:}a_0{:}u_0]\ \{\ [\ell_2{:}a_2{:}x_2][\ell_0{:}a_0{:}u_0]\ \}$
$\mathsf{ARG}_1(a_0, x_2)$

A worked example: derivation

S

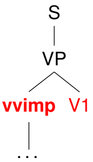
VP

...

$[\circ]$
$\lhd\ [\mathrm{Arg1}] \lhd\ [\mathrm{adr}]$

$[\ell_0{:}a_0{:}u_0]\ \{\ [\ell_0{:}a_0{:}u_0]\ \}$
$\mathsf{ARG}_1(a_0, x_2),\ \ell_2{:}a_2{:}\mathrm{addressee}(x_2)$

A worked example: derivation



$[\circ]$
$\lhd\ [\mathrm{Arg1}] \lhd\ [\mathrm{adr}] \lhd\ [=]$

$[\ell_0{:}a_0{:}u_0]\ \{\ [\ell_0{:}a_0{:}u_0][\ell_0{:}a_0{:}u_0]\ \}$
$\mathsf{ARG}_1(a_0, x_2),\ \ell_2{:}a_2{:}\mathrm{addressee}(x_2)$

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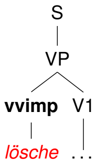
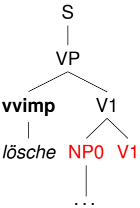


$$[\circ]$$
$$\lhd\ [\mathrm{Arg1}] \lhd\ [\mathrm{adr}] \lhd\ [=] \lhd\ [\![\textit{lösche}]\!]$$

$$[\ell_0{:}a_0{:}e_0]\ \{\ [\ell_0{:}a_0{:}e_0]\ \}$$
$$\ell_0{:}a_0{:}\text{\_löschen}(e_0),\ \mathrm{ARG}_1(a_0, x_2),$$
$$\ell_2{:}a_2{:}\mathrm{addressee}(x_2)$$

A worked example: derivation



$[\circ]$
$\lhd$ [Arg1] $\lhd$ [adr] $\lhd$ [=] $\lhd$ $[\![$*lösche*$]\!]$
$\lhd$ [Arg2]

$[\ell_0{:}a_0{:}e_0]\ \{\ [\ell_4{:}a_4{:}x_4][\ell_0{:}a_0{:}e_0]\ \}$
$\ell_0{:}a_0{:}\text{\_löschen}(e_0)$, $\text{ARG}_1(a_0, x_2)$, $\text{ARG}_2(a_0, x_4)$,
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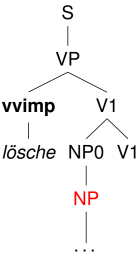

$[\circ]$
$\lhd\ [\text{Arg1}] \lhd\ [\text{adr}] \lhd\ [=] \lhd\ [\![\textit{lösche}]\!]$
$\lhd\ [\text{Arg2}] \lhd\ [\circ]$

$[\ell_0{:}a_0{:}e_0]\ \{\,[\ell_4{:}a_4{:}x_4][\ell_0{:}a_0{:}e_0]\,\}$
$\ell_0{:}a_0{:}\_\text{löschen}(e_0)$, $\mathsf{ARG}_1(a_0, x_2)$, $\mathsf{ARG}_2(a_0, x_4)$,
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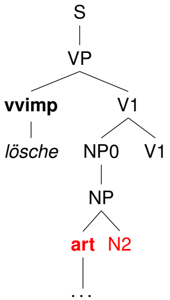
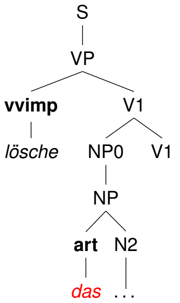


$$
\begin{array}{l}
[\circ] \\
\lhd\ [\mathrm{Arg1}] \lhd\ [\mathrm{adr}] \lhd\ [=] \lhd\ [\![\textit{lösche}]\!] \\
\lhd\ [\mathrm{Arg2}] \lhd\ [\circ] \lhd\ [\mathrm{Q}]
\end{array}
$$

$$
\begin{array}{l}
[\ell_0{:}a_0{:}e_0]\ \{\ [\ell_4{:}a_4{:}e_6][\ell_7{:}a_7{:}x_4][\ell_0{:}a_0{:}e_0]\ \} \\
\ell_0{:}a_0{:}\_\text{löschen}(e_0),\ \mathsf{ARG}_1(a_0, x_2),\ \mathsf{ARG}_2(a_0, x_4), \\
\ell_2{:}a_2{:}\text{addressee}(x_2), \\
\mathsf{BV}(a_4, x_4),\ \mathsf{RSTR}(a_4, h_1),\ \mathsf{BODY}(a_4, h_2),\ h_1 =_q \ell_7
\end{array}
$$

A worked example: derivation



$[\circ]$
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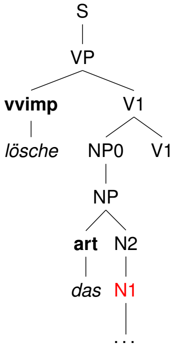
$\lhd\ [\mathrm{Arg2}] \lhd\ [\circ] \lhd\ [\mathrm{Q}] \lhd\ [\![\textit{das}]\!]$

$[\ell_0{:}a_0{:}e_0]\ \{\ [\ell_7{:}a_7{:}x_4][\ell_0{:}a_0{:}e_0]\ \}$
$\ell_0{:}a_0{:}\mathrm{\_löschen}(e_0)$, $\mathsf{ARG}_1(a_0, x_2)$, $\mathsf{ARG}_2(a_0, x_4)$,
$\ell_2{:}a_2{:}\mathrm{addressee}(x_2)$,
$\ell_4{:}a_4{:}\mathrm{\_def\_q}()$, $\mathsf{BV}(a_4, x_4)$, $\mathsf{RSTR}(a_4, h_1)$, $\mathsf{BODY}(a_4, h_2)$, $h_1 =_q \ell_7$

A worked example: derivation



$$[\circ]$$
$$\lhd\ [\text{Arg1}] \lhd\ [\text{adr}] \lhd\ [=] \lhd\ [\![\textit{lösche}]\!]$$
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$$\lhd\ [\circ]$$

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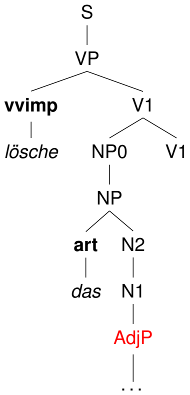

$$[\circ] \\ \lhd\ [\mathrm{Arg1}] \lhd\ [\mathrm{adr}] \lhd\ [=] \lhd\ [\![\textit{lösche}]\!] \\ \lhd\ [\mathrm{Arg2}] \lhd\ [\circ] \lhd\ [\mathrm{Q}] \lhd\ [\![\textit{das}]\!] \\ \lhd\ [\circ] \lhd\ [+\ell]$$

$$[\ell_0{:}a_0{:}e_0]\ \{\ [\ell_7{:}a_8{:}x_4][\ell_7{:}a_7{:}x_4][\ell_0{:}a_0{:}e_0]\ \}$$
$$\ell_0{:}a_0{:}\text{\_löschen}(e_0),\ \mathsf{ARG}_1(a_0, x_2),\ \mathsf{ARG}_2(a_0, x_4),$$
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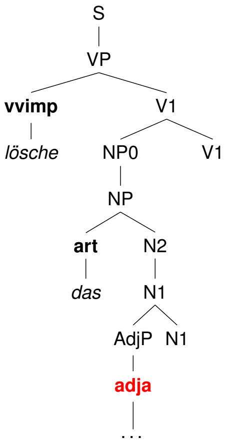

$[\circ]$
$\lhd$ $[\text{Arg1}] \lhd$ $[\text{adr}] \lhd$ $[=] \lhd$ $[\![\textit{lösche}]\!]$
$\lhd$ $[\text{Arg2}] \lhd$ $[\circ] \lhd$ $[\text{Q}] \lhd$ $[\![\textit{das}]\!]$
$\lhd$ $[\circ] \lhd$ $[+\ell] \lhd$ $[\text{Adj}]$

$[\ell_0{:}a_0{:}e_0]$ $\{$ $[\ell_7{:}a_{10}{:}e_{10}][\ell_7{:}a_7{:}x_4][\ell_0{:}a_0{:}e_0]$ $\}$
$\ell_0{:}a_0{:}\text{\_löschen}(e_0)$, $\text{ARG}_1(a_0, x_2)$, $\text{ARG}_2(a_0, x_4)$,
$\ell_2{:}a_2{:}\text{addressee}(x_2)$,
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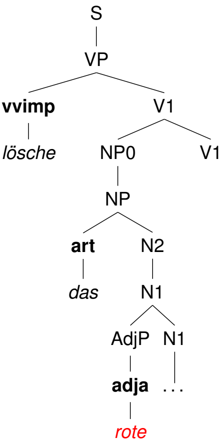

$$
\begin{array}{l}
[\circ] \\
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\lhd\ [\mathrm{Arg2}] \lhd\ [\circ] \lhd\ [\mathrm{Q}] \lhd\ [\![\textit{das}]\!] \\
\lhd\ [\circ] \lhd\ [+\ell] \lhd\ [\mathrm{Adj}] \lhd\ [\![\textit{rote}]\!]
\end{array}
$$

$$
\begin{array}{l}
[\ell_0{:}a_0{:}e_0]\ \{\ [\ell_7{:}a_7{:}x_4][\ell_0{:}a_0{:}e_0]\ \} \\
\ell_0{:}a_0{:}\_\mathrm{löschen}(e_0),\ \mathsf{ARG}_1(a_0, x_2),\ \mathsf{ARG}_2(a_0, x_4), \\
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\ell_4{:}a_4{:}\_\mathrm{def\_q}(),\ \mathsf{BV}(a_4, x_4),\ \mathsf{RSTR}(a_4, h_1),\ \mathsf{BODY}(a_4, h_2),\ h_1 =_q \ell_7, \\
\ell_7{:}a_{10}{:}\_\mathrm{rot}(e_{10}),\ \mathsf{ARG}_1(a_{10}, x_4)
\end{array}
$$

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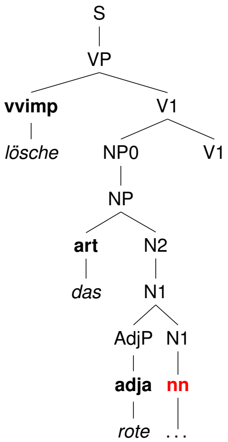

$[\circ]$
$\triangleleft$ $[\text{Arg1}] \triangleleft$ $[\text{adr}] \triangleleft$ $[=] \triangleleft$ $[\![\textit{lösche}]\!]$
$\triangleleft$ $[\text{Arg2}] \triangleleft$ $[\circ] \triangleleft$ $[\text{Q}] \triangleleft$ $[\![\textit{das}]\!]$
$\triangleleft$ $[\circ] \triangleleft$ $[+\ell] \triangleleft$ $[\text{Adj}] \triangleleft$ $[\![\textit{rote}]\!]$
$\triangleleft$ $[\circ]$

$[\ell_0{:}a_0{:}e_0]\ \{\ [\ell_7{:}a_7{:}x_4][\ell_0{:}a_0{:}e_0]\ \}$
$\ell_0{:}a_0{:}\text{\_löschen}(e_0)$, $\text{ARG}_1(a_0, x_2)$, $\text{ARG}_2(a_0, x_4)$,
$\ell_2{:}a_2{:}\text{addressee}(x_2)$,
$\ell_4{:}a_4{:}\text{\_def\_q}()$, $\text{BV}(a_4, x_4)$, $\text{RSTR}(a_4, h_1)$, $\text{BODY}(a_4, h_2)$, $h_1 =_q \ell_7$,
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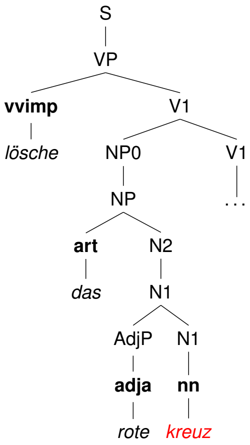

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$[\ell_0{:}a_0{:}e_0]$ $\{ [\ell_0{:}a_0{:}e_0] \}$
$\ell_0{:}a_0{:}\_\text{löschen}(e_0)$, $\text{ARG}_1(a_0, x_2)$, $\text{ARG}_2(a_0, x_4)$,
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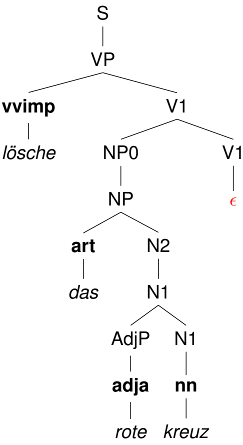

$$
\begin{array}{l}
[\circ] \\
\triangleleft\ [\mathrm{Arg1}] \triangleleft\ [\mathrm{adr}] \triangleleft\ [=] \triangleleft\ [\![\textit{lösche}]\!] \\
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\triangleleft\ [-]
\end{array}
$$

$$
\begin{array}{l}
[\ell_0{:}a_0{:}e_0]\ \{\ \} \\
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\ell_7{:}a_{10}{:}\_\text{rot}(e_{10}),\ \mathsf{ARG}_1(a_{10}, x_4), \\
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\end{array}
$$

Further work

Grammar transformation can increase the parsing performance:

1. left-factored grammars
   - delay rule identification for rules with equal first childs
   - transform semantic rules accordingly (in theory yes, automatically no)
   - no further refinements to the semantic construction needed
2. left-corner transformed grammars

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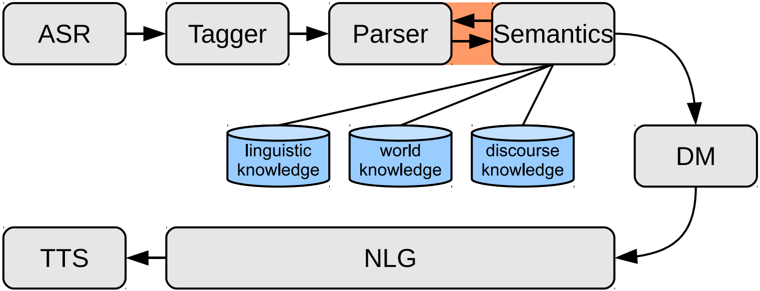
Recapitulation

- incrementality: early propagation
- incrementality: interaction / feedback
- top-down left-to-right tree interpretation
- monotonous, incremental construction

Application: Incremental Reference Feedback

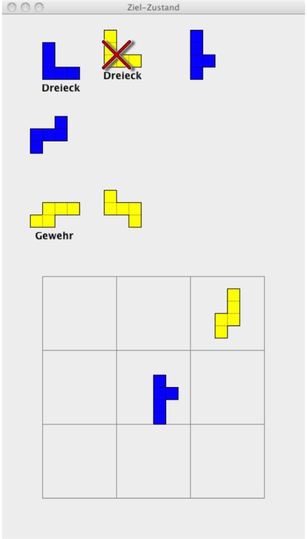
Joint work with Timo Baumann, Okko Buß, and David Schlangen

Idea



Incremental top-down parser, RMRS construction and reference resolution have been implemented in the InproTK Schlangen et al. [2010] for the Pentamino domain Fernández and Schlangen [2007].

Setting: Domain



Pentamino puzzle domain:

- Task oriented dialogue, instructor gives commands to a constructor in order to realise a desired state of the world
- Selecting, moving, deleting, rotating and mirroring of the puzzle pieces

Setting: Domain

A corpus collected in a WOz experiment:

- 20 participants, 284 games
- about 3000 utterances (each with dumped world state) of which. . .
- about 1600 have semantic annotation from the wizards next action, of which. . .
- about 1000 are free of pronouns.
- small command language, yet free and spontanous speech

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Beispiele

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und leg es nach ganz unten
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und im uhrzeigersinn drehen

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   - run transcript versus offline recognition
2. Tagger
3. Grammar
4. Parser
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   - simplified version of Roark [2001]
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Compare the gold semantic annotation with the resolving world object according to. . .

1. Just Syntax (JS)
   - single-best derivation of only syntax
2. External Filtering (EF)
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Results: Accuracy

		JS	EF	SPI	CIF
transcript	-1	563	518	364	363
	0	197	198	267	268
	1	264	308	392	392
	str.acc.	25.7%	30.0%	38.2%	38.2%
	rel.acc.	44.9%	49.3%	64.2%	64.3%
	incr.scr	-1567.66	-1248.26	-535.862	-503.75
	avg.incr.scr	-1.52	-1.22	-0.52	-0.49
recognition	-1	362	348	254	255
	0	122	121	173	173
	1	143	158	196	195
	str.acc.	22.6%	25.0%	31.0%	30.8%
	rel.acc.	41.2%	44.1%	58.3%	58.1%
	incr.scr	-1905.76	-1729.77	-1105.43	-1075.62
	avg.incr.scr	-1.86	-1.69	-1.01	-1.05

Results: Efficiency

	readings	expansions	degrades	pruned deriv.	survived deriv.
no interaction	2186	247052	0	0	69510
interaction	1934	210137	140626	7310	60654
	88%	85%			87%

(for the transcript only, with robust parser operations activated)

Discussion

- grammar does not cover all that is wanted
- yet, there'll always be strange constructions in spontanous speech
- semantic gold featured a discourse-history oracle: 30% of the corpus utterances had a semantic annotation without including a proper NP ("und nochmal drehen bitte"). -30% strict -10% relaxed max accuracy
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Recapitulation

- incrementality: early propagation
- incrementality: interaction / feedback
- top-down left-to-right tree interpretation
- monotonous, incremental construction
- feedback improves NLUs accuracy and efficiency

Future Work

- write better grammar, train grammar
- probabilistic reference resolution
- optimise parameters
- automatic semantic rule aquisition
- VP advisoring
- experiment in a larger domain, more complex language

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Thank You!

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