Formal versus statistical enrichment of grammars

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Computational linguistics

. . . driven by empirical evaluation, benchmarks

Progress means . . .

- Improve on benchmark
- Challenge benchmark

Statistical Parsing

Many `inconvenient' aspects of treebank annotation typically ignored:

- non-local relations
- function tags
- morphology
- multiple parents

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Goal

given a treebank, fully reproduce its annotations with an automatically-induced statistical parser

Treebank annotation

PTB:

```
(S (NP-SBJ-1 (DT A) (NN record) (NN date) )
  (VP (VBZ has) (RB n't) (VP (VBN been)
    (VP (VBN set) (NP (-NONE- *-1) )))) (. .) )
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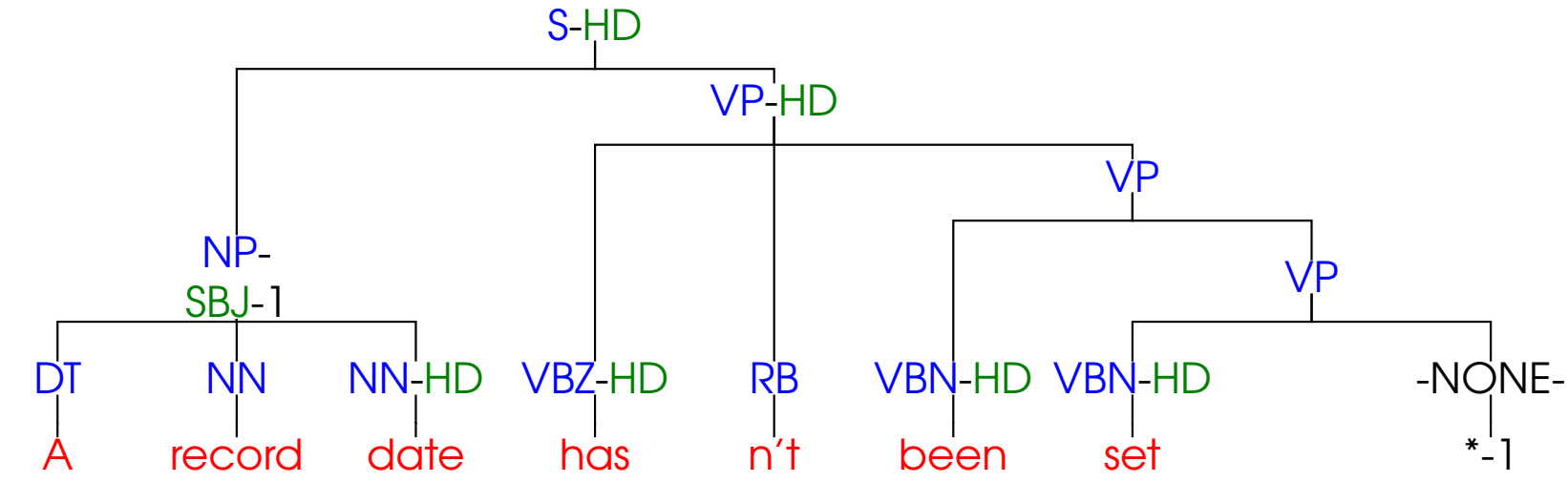
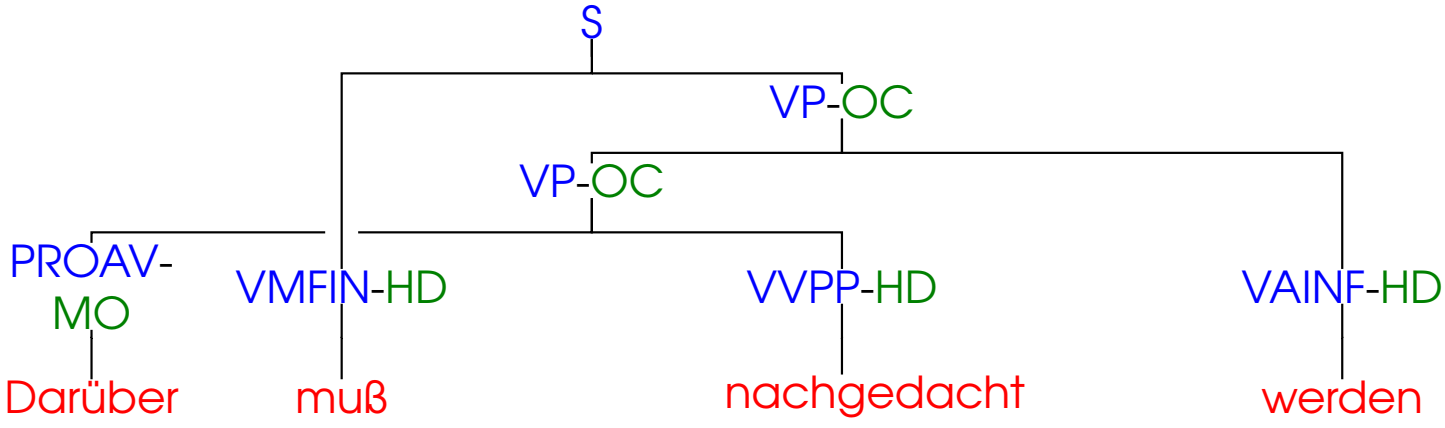
Negra:

%% word	cat	morph	func	parent
Darüber	PROAV	--	MO	500
muß	VMFIN	3.Sg.Pres.Ind	HD	502
nachgedacht	VVPP	--	HD	500
werden	VAINF	--	HD	501
.	$.	--	--	0
#500	VP	--	OC	501
#501	VP	--	OC	502
#502	S	--	--	0

Treebank annotation





Grammar enrichment

Formal

A grammar formalism that

- precisely matches the generative capacity of natural language
- is specifically designed to produce the desired linguistic analyses

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Statistical

Heuristic approach:

- add extra information by augmenting labels
- apply pre- and postprocessing steps
- exploit regularities in corpus, e.g. co-occurrence of elements, automatic state splits, &c.

Chomsky (1965):

Competence system of rules describing idealized knowledge of language

Performance language behavior affected by ambiguity, errors, reaction times, frequency effects

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Competence system of rules describing idealized knowledge of language

Performance language behavior affected by ambiguity, errors, reaction times, frequency effects

Scha (1990):

- Difficult to write descriptively adequate grammar by hand.
- Problem of ambiguity; need to know relative plausibility of analyses.

Ergo, we need
"performance-models of language (...), which take into account statistical properties of actual language use."

Traditional parsing approach

1. Pick a grammar with the right linguistic & computational properties (competence)
2. Apply pruning if necessary (performance)
3. Add a probabilistic disambiguation component (performance)
4. Evaluate quality of model (performance)

Formal language theory

Definition

A *formal grammar* characterizes a language as a set of sentences and their structures.

Chomsky hierarchy:

Type 0: Unrestricted: Model-Theoretic Syntax, e.g., HPSG

Type 1: Context-Sensitive: Mildly Context-Sensitive, e.g., TAG, CCG, LCFRS

Type 2: Context-Free: PCFG, proj. dependency grammar

Type 3: Regular: finite-state technology

Domain of locality

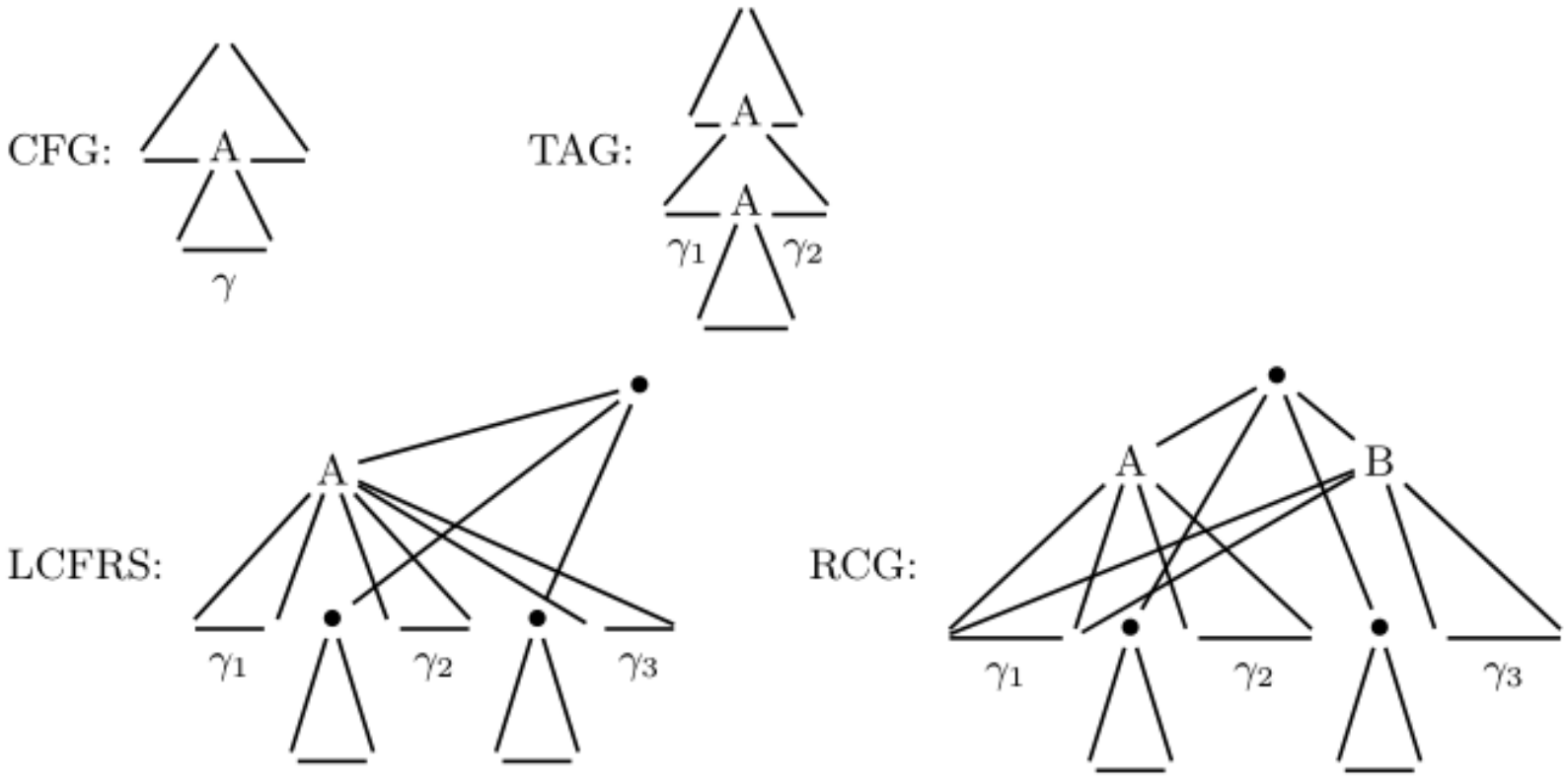
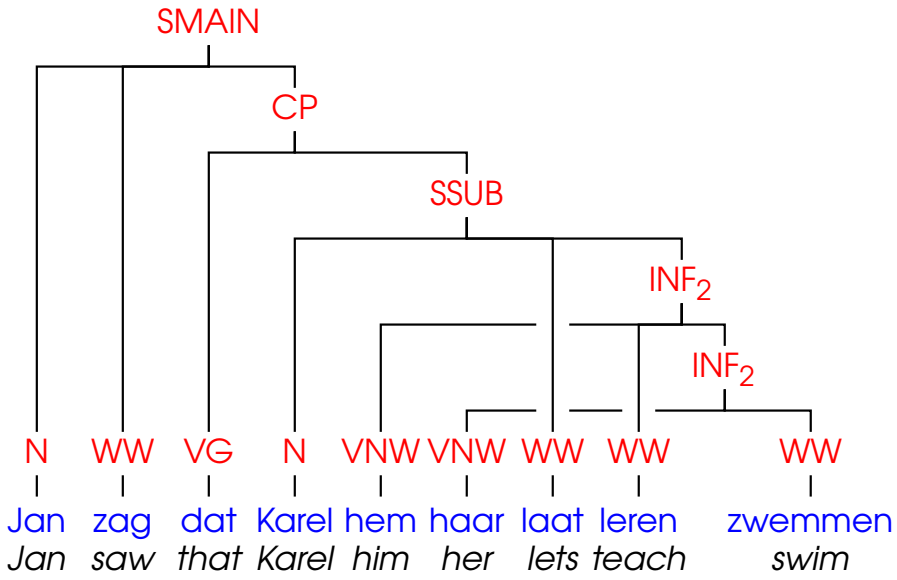


Fig. 1.1. Yields of non-terminals in different formalisms

Figure: Kallmeyer (2010): Parsing beyond CFG, p. 3

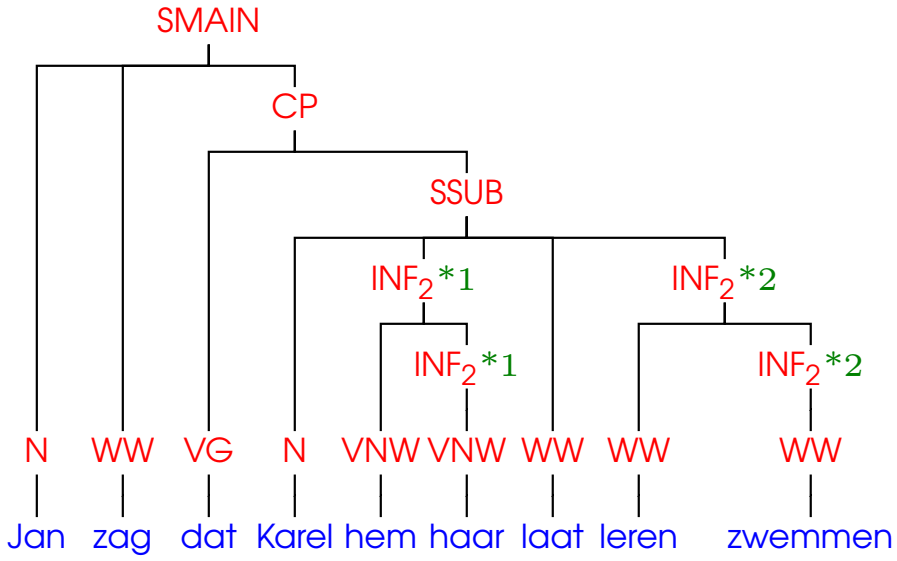
Long-Distance Dependencies



"Jan saw that Karel lets him teach her to swim."

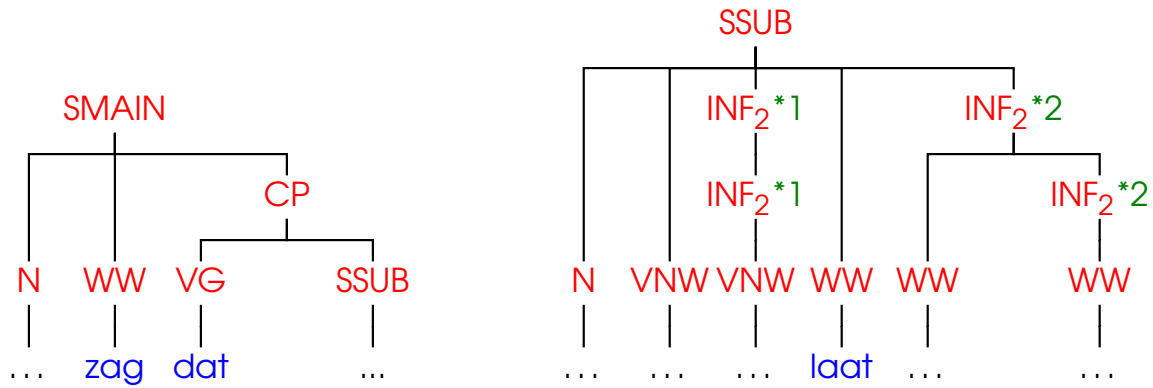
- Cross-serial dependencies are beyond context-free
- Can be captured by mildly context-sensitive grammars

CFG approximation



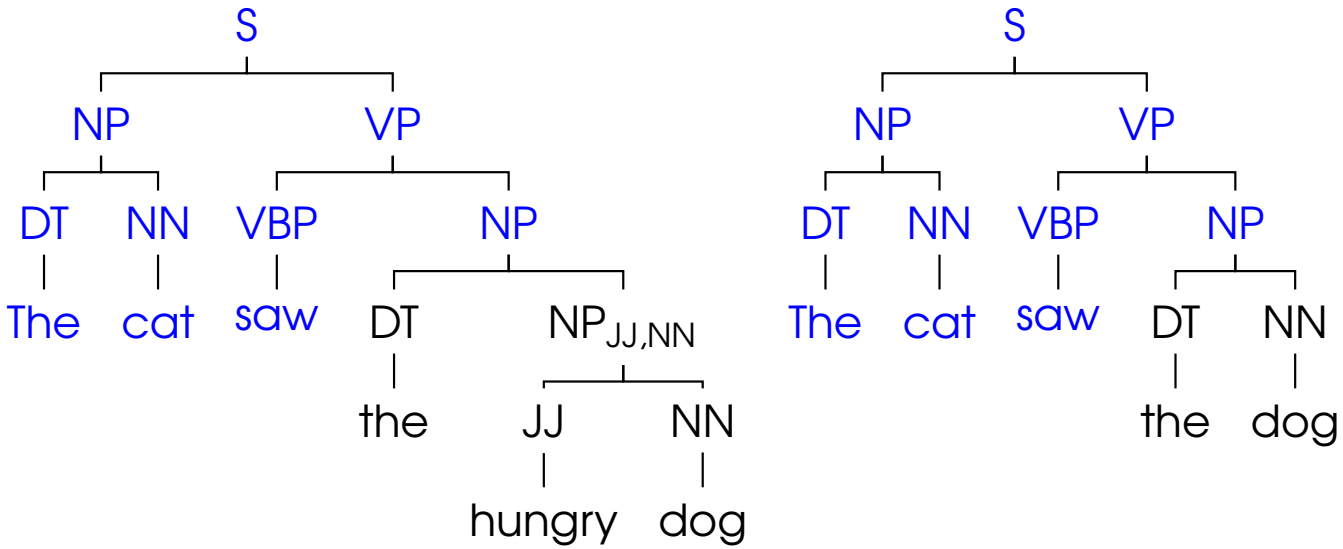
- Alternatively, long-distance dependencies can be encoded in the labels

Non-locality w/DOP fragments



- With DOP tree fragments,
  complex linguistic phenomena can be captured
  statistically instead of formally

Grammar induction: 2DOP



- Induce a Tree-Substitution Grammar from treebank
- Heuristic: recurring tree fragments are building blocks
- Compare pairs of trees
  and extract common fragments

Sangati & Zuidema (2011). Accurate parsing w/compact TSGs: Double-DOP

Function labels

Syntactic categories (form): NP, VP, S, ...

Function labels (function): SBJ, OBJ, TMP, LOC, ...

- Classifier:
  - Blaheta & Charniak (2000), Assigning Function Tags to Parsed Text
- Integrate in grammar:
  - Gabbard et al. (2006), Fully parsing the Penn treebank
  - Fraser et al. (2013), Knowledge sources for constituent parsing of German

Evaluation: function tag accuracy over correctly parsed labeled bracketings.

Can DOP handle discontinuity without LCFRS?

Negra dev set, gold tags:

Split-PCFG

⇓

PLCFRS

⇓

PLCFRS Double-DOP

77.7 % F1

41.5 % EX

Split-PCFG

⇓

Split-Double-DOP

Can DOP handle discontinuity without LCFRS?

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Split-PCFG

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PLCFRS Double-DOP

77.7 % F1

41.5 % EX

Split-PCFG

⇓

Split-Double-DOP

78.1 % F1

42.0 % EX

Answer: Yes!

Fragments can capture discontinuous contexts

Importance of probabilities

What happens when probabilities of fragments are randomly shuffled?

Negra parsing	F1
PLCFRS treebank grammar	65.9
2DOP	77.7
2DOP, shuffled probabilities	74.1

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Conclusion

co-occurrence of productions more important than frequency effects.

Parsing results

Parser	F1	EX	func
GERMAN: Tiger			
Dep: HaNi2008	75.3	32.6	
2DOP: Cr et al	**78.2**	**40.0**	93.5
Dep: FeMa2015	82.6	45.9	
ENGLISH: WSJ			
PLCFRS: EvKa2011	79.0		
2DOP: Cr et al, WSJ	**87.0**	34.4	86.3
2DOP: SaZu2011, no disc.	87.9	33.7	
DUTCH: Lassy			
2DOP: Cr et al	76.6	34.0	92.8

HaNi: Hall & Nivre (2008); SaZu: Sangati & Zuidema (EMNLP 2011);
EvKa: Evang & Kallmeyer (IWPT 2011);
FeMa: Fernández-González & Martins (ACL 2015);
Cr et al: van Cranenburgh, Scha, Bod (JLM 2016).

Conclusion

Linguistically rich: non-local relations, function tags

Efficiency: CFG base grammar, tree fragment extraction

Competence: idealized rules

Performance: actual language use

Tree fragments increase the abilities of a performance model w.r.t. discontinuous constituents, without increasing formal complexity.


KEEP
CALM
because
THIS TOO
SHALL PARSE

DEMO

https://lang.science.uva.nl/parser/

References

- Remko Scha (1990). Language theory and language technology; competence and performance, in Q.A.M. de Kort and G.L.J. Leerdam, editors, *Computertoepassingen in de Neerlandistiek*, pp. 7–22. English translation: `http://iaaa.nl/rs/LeerdamE.html`
- van Cranenburgh, Scha, Bod (2016) Data-Oriented Parsing with Discontinuous Constituents and Function Tags. *Journal of Language Modelling*, vol. 4, no. 1, pp. 57-111. `http://dx.doi.org/10.15398/jlm.v4i1.100`