Introduction, administrivia

Parsing
ISCL-BA-06

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Seminar für Sprachwissenschaft

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What is parsing?

- *Parsing* is the task of analyzing a string of symbols to discover its (inherent) structure
- Typically, the structure (and the valid strings in the language) is defined by a *grammar*
- The output of a parser is a structured representation of the input string, often a tree
- *Recognition* is an intimately related task which determines whether a given string is in a language

Ingredients of a parser

(for natural language parsing)

- A formal grammar defining a language of interest
- An algorithm that (efficiently) verifies whether a given string is in the language (recognizer) and enumerate the grammar rules used for verification (parser)
- A system for ambiguity resolution (very limited coverage in this course)

Grammars

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$V \rightarrow$ chased	$D \rightarrow$ the	$N \rightarrow$ cat	$N \rightarrow$ dog

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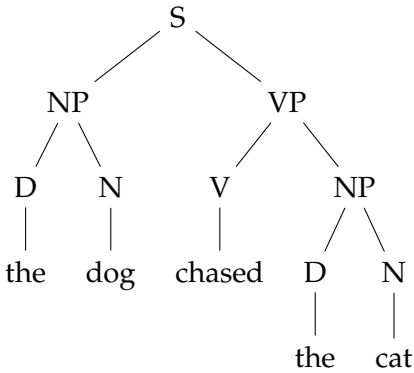
- The most commonly studied type of grammars are *phrase structure grammars*
- Analysis using a (type of) phrase structure grammars result in *constituency* or *phrase structure* trees



$S \rightarrow NP\ VP$ $\quad NP \rightarrow D\ N$ $\quad VP \rightarrow V\ NP$

$V \rightarrow$ chased $\quad D \rightarrow$ the $\quad N \rightarrow$ cat $\quad N \rightarrow$ dog

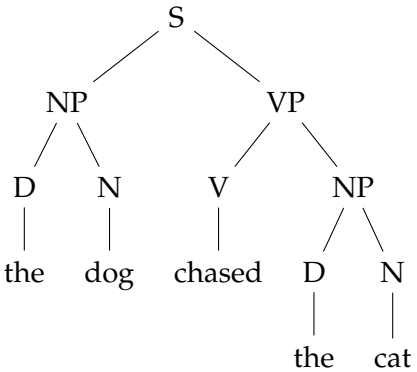
Formal languages and natural languages

> *There is in my opinion no important theoretical difference between natural languages and the artificial languages of logicians.*
>
> — *Richard Montague, in "Universal Grammar" (1970)*

- Formal grammars are equally important for linguistics as they are important for computer science
- Historically, there has been very strong connections between linguistics and computer science
- The formal languages (that originate in linguistics) has important theoretical consequences for computer science as well

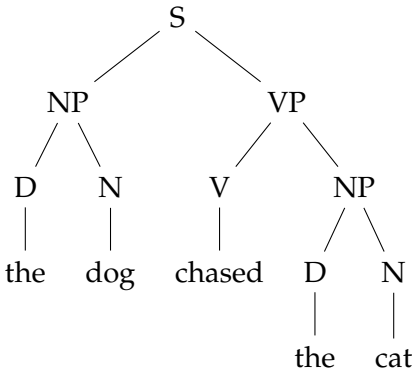
Why study parsing?

- In general, it is a intermediate step for interpreting sentences



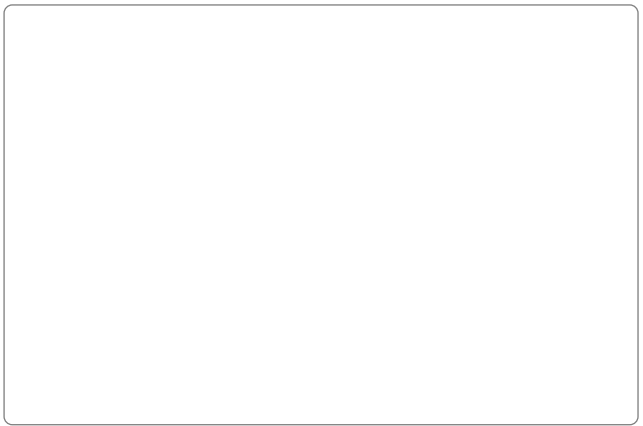
Why study parsing?

- In general, it is a intermediate step for interpreting sentences
- Applications include:
  - Compiler construction
  - Grammar checking
  - Sentiment analysis
  - Information (e.g., relation) extraction
  - Argument mining
  - ...



Why is parsing difficult?

computational complexity (of searching through all binary trees)



words	search space
1	1
2	

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words	search space
1	1
2	1
3	

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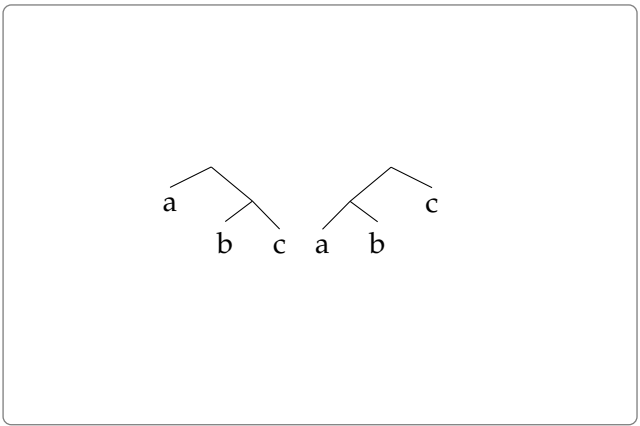

words	search space
1	1
2	1
3	2
4	

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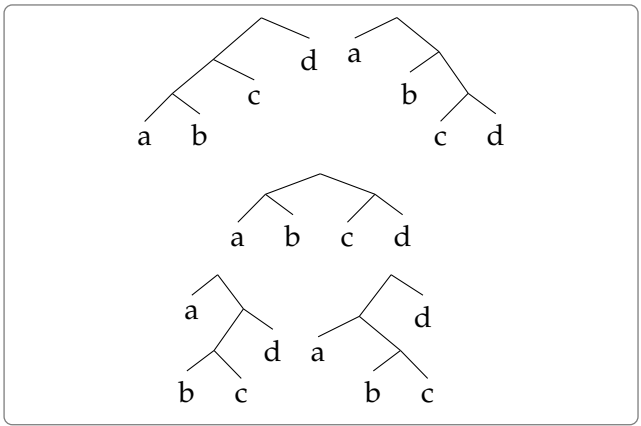

words	search space
1	1
2	1
3	2
4	5
5	

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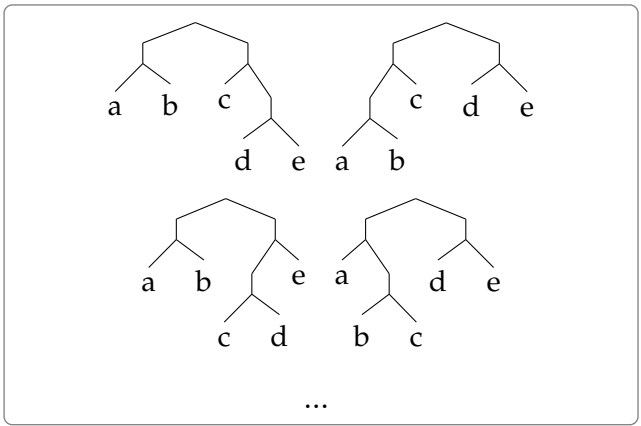

words	search space
1	1
2	1
3	2
4	5
5	14
10	

Why is parsing difficult?

computational complexity (of searching through all binary trees)

Not enough space for trees.

words	search space
1	1
2	1
3	2
4	5
5	14
10	4862
15	

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words	search space
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20	

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words	search space
1	1
2	1
3	2
4	5
5	14
10	4862
15	2 674 440
20	1 767 263 190
25	

Why is parsing difficult?

computational complexity (of searching through all binary trees)

- In short: combinatorial expansion.
- Most of what we study in this course is ways to limit this search space based on the grammar at hand

words	search space
1	1
2	1
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5	14
10	4862
15	2 674 440
20	1 767 263 190
25	1 289 904 147 324

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Fun exercise: try to systematically produce all binary bracketings of a given number of words.

Why is parsing difficult?

ambiguity (for natural languages) – examples from newspaper headlines

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Most of the above are lexical ambiguities, but structural ambiguity is also common in natural languages.

Why is parsing difficult?

more on ambiguities

What is in this course?

A bird's eye view

- Grammars, languages, automata, computation
- Parsing as search: bottom-up, top-down
- Chart parsing: CKY, Earley
- Table driven/deterministic parsing: LL/LR/SLR/GLR parsers
- Probabilistic (context-free) parsing
- Dependency grammars
- Dependency parsing: MST, transition-based parsing

Literature

- *Parsing Techniques: A Practical Guide*. Grune and Jacobs (2007)
- *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition*. Jurafsky and Martin (2009)
- *Dependency Parsing*. Kübler, McDonald, and Nivre (2009)

Practical information

- Lectures Mon/Thu 8:30, online, synchronous via Zoom
- Course web page at `https://iscl-parsing2020.github.io/`
- The class sessions include lectures and exercises, but exact division is unclear
- Most assignments are mostly pencil-and-paper exercises, there will also be practical assignments, but no programming exercises in this course
- Please obtain a GitHub account if you do not have one. We will use GitHub for some of the exercises (more on this later)
- Please register to the Moodle page of the course, and pay attention to the announcements posted there

Prerequisites

You should have already taken

- Linguistic fundamentals
- Data Structures and Algorithms for CL I
- Data Structures and Algorithms for CL II

  effectively, you need to know some linguistics and formal thinking

  programming skills/knowledge is useful, it is not required for this course

Evaluation

- Final exam at the end of the semester
- Assignments (not graded, but required)
  - (Almost) weekly pencil-and-paper exercises
  - Three bigger, group assignments:
    - Writing a grammar for a subset of English
    - Writing a small constituency treebank
    - Creating a small dependency treebank

Your first assignment

- Your first assignment is available at `https://iscl-parsing2020.github.io/a0/`
- Please complete as soon as you can (it is easy)
- In summary: introduce yourself, and provide 5 grammatical and 5 ungrammatical sentences
- We will use the data gathered for future practical assignments

Acknowledgments, references, additional reading material

- This set of slides are based on earlier slides by Kurt Eberle, which in turn was based on slides by Helmut Schmid
- Some of the (later) examples are inspired by, or sometimes verbatim borrowings from, the material listed below
- The artwork ("pretty little girl's school") is from Speculative Grammarian (`http://specgram.com/CLIII.4/school.gif`).

Grune, D. and C.J.H. Jacobs (2007). *Parsing Techniques: A Practical Guide*. second. Monographs in Computer Science. The first edition is available at `http://dickgrune.com/Books/PTAPG_1st_Edition/BookBody.pdf`. Springer New York. ISBN: 9780387689548.

Jurafsky, Daniel and James H. Martin (2009). *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition*. second. Pearson Prentice Hall. ISBN: 978-0-13-504196-3.

Kübler, Sandra, Ryan McDonald, and Joakim Nivre (2009). *Dependency Parsing*. Synthesis lectures on human language technologies. Morgan & Claypool. ISBN: 9781598295962.