

Dependency grammars

Parsing
ISCL-BA-06

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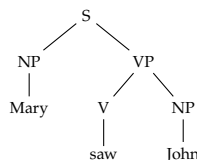
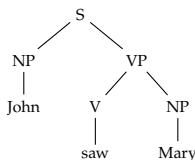
Winter Semester 2020/21

So far ...

a brief summary

- Preliminaries: (formal) languages, grammars and automata
 - Chomsky hierarchy of language classes
 - Expressivity and computational complexity
- Context-free grammars and parsing
 - Top-down, bottom-up, directional, non-directional
 - Chart parsing: Earley, CKY
 - Deterministic parsing: LL/LR grammars and parsers
 - Ambiguity resolution and PCFGs

Why do we need syntactic parsing?



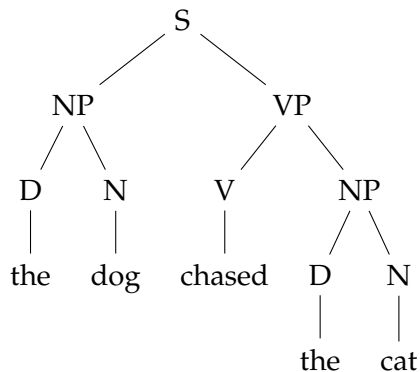
- Syntactic analysis is an intermediate step in (semantic) interpretation of sentences
- It is essential for understanding and generating natural language sentences (hence, also useful for applications like *question answering*, *information extraction*, ...)
- (Statistical) parsers are also used as *language models* for applications like *speech recognition* and *machine translation*
- It can be used for *grammar checking*, and can be a useful tool for linguistic research

Phrase structure (or constituency) grammars

The main idea is that a *span* of words form a natural unit, called a *constituent* or *phrase*.

- Constituency grammars are common in modern linguistics (also in computer science)
- Most are based on a context-free ‘backbone’, extensions or restricted forms are common

Syntactic representation using context-free grammars



```

(S (NP (D (the)) (N (dog)))
  )
  (VP (V (chased))
    (NP (D (the))
      (N (cat))
    )
  )
)
  
```

An exercise

- Write down simple context-free analysis of the following sentence (draw a parse tree, send the bracketed form through chat)

I read a good book during the weekend

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- Repeat the exercise for a (more-or-less direct) translation of the same sentence in another language
- How about the following sentence?

During the weekend I read a good book

space for the exercise

Where do grammars come from?

- Grammars for (constituency) parsing can be either
 - hand crafted (many years of expert effort)
 - extracted from *treebanks* (which also require lots of effort)
 - ‘induced’ from raw data (interesting, but not as successful)
- Current practice relies mostly on treebanks
- Hybrid approaches also exist
- Grammar induction is not common (for practical models), but exploiting unlabeled data for improving parsing is also a common trend

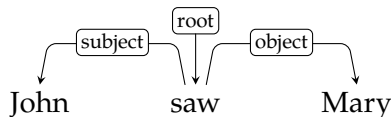
Treebanks

- Treebanks are an important tool for parsing (but also for many linguistic analysis tasks)
- Creating a treebank is a long-term, labor intensive task, with many phases/tasks, including
 - Planning, creating annotation guidelines
 - Annotation
 - Quality assurance
- Example, well-known constituency treebanks
 - Penn Treebank (English, Chinese, Arabic)
 - Tiger treebank (German)
 - TüBA-D/Z (German)
 - Tübingen spoken treebanks (German, English, Japanese)
 - Alpino (Dutch)
 - Talbanken (Swedish)
 - ...

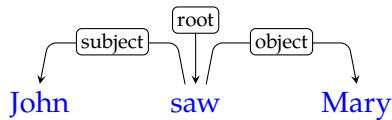
Dependency grammars

introduction

- Dependency grammars gained popularity in linguistics (particularly in CL) rather recently
- They are old: roots can be traced back to Pāṇini (approx. 5th century BCE)
- Modern dependency grammars are often attributed to Tesnière 1959
- The main idea is capturing the relations between words, rather than grouping them into (abstract) constituents

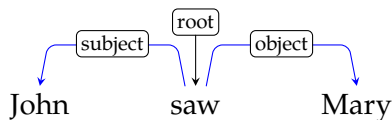


Dependency grammars



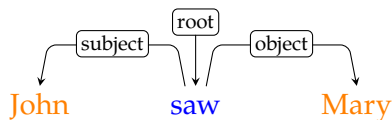
- No constituents, units of syntactic structure are words

Dependency grammars



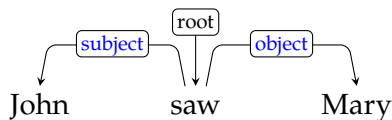
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- The structure of the sentence is represented by *asymmetric, binary* relations between syntactic units

Dependency grammars



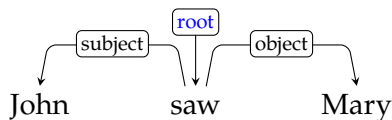
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- Each relation defines one of the words as the **head** and the other as **dependent**

Dependency grammars



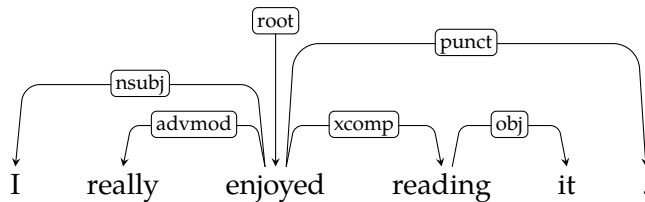
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Dependency grammars

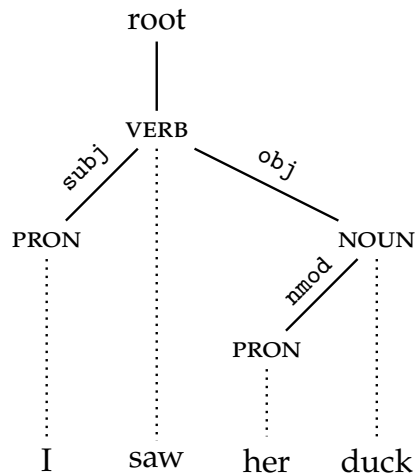
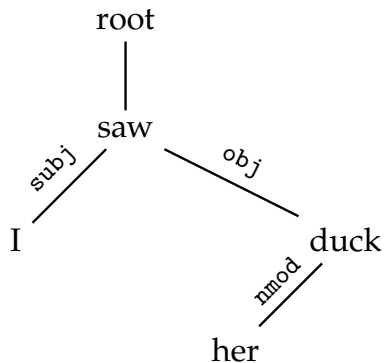


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- Often an artificial *root* node is used for computational convenience

A more realistic example



Dependency grammars: alternative notation



Dependency analyses: definition

A dependency analyses/graph is a tuple (V, A)

V is a set of nodes corresponding to the (syntactic) words (we implicitly assume that words have indexes)

A is a set of arcs of the form (w_i, r, w_j) where

$w_i \in V$ is the head

r is the type of the relation (arc label)

$w_j \in V$ is the dependent

This defines a directed graph.

Dependency grammars: common assumptions

- Every word has a single head
- The dependency graphs are acyclic
- The graph is connected
- With these assumptions, the representation is a tree
- Note that these assumptions are not universal but common for dependency parsing

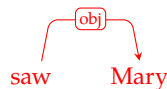
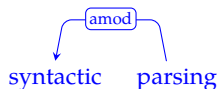
How to determine heads

1. *Head* (H) determines the syntactic category of the *construction* (C) and can often replace C
2. H determines the semantic category of C; the *dependent* (D) gives semantic specification
3. H is obligatory, D may be optional
4. H selects D and determines whether D is obligatory or optional
5. The form and/or position of dependent is determined by the head
6. The form of D depends on H
7. The linear position of D is specified with reference to H

(from Kübler, McDonald, and Nivre 2009, p.3–4)

Issues with head assignment and dependency labels

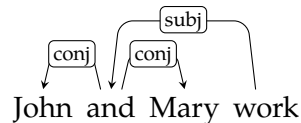
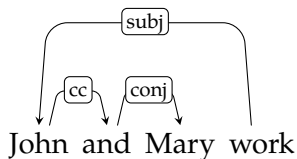
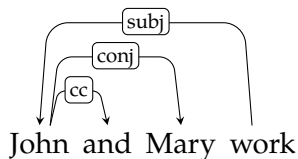
- Determining heads are not always straightforward
- A construction is called *endocentric* if the head can replace the whole construction, *exocentric* otherwise



- It is often unclear whether dependency labels encode syntactic or semantic functions

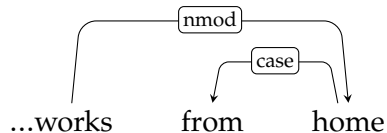
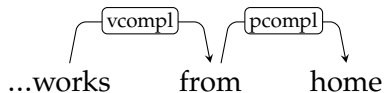
Some tricky constructions

Coordination



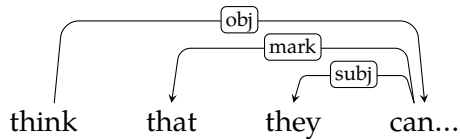
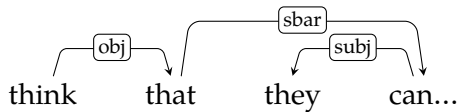
Some tricky constructions

Adpositional phrases



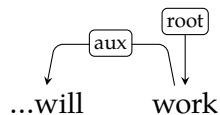
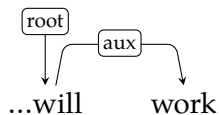
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Subordinate clauses

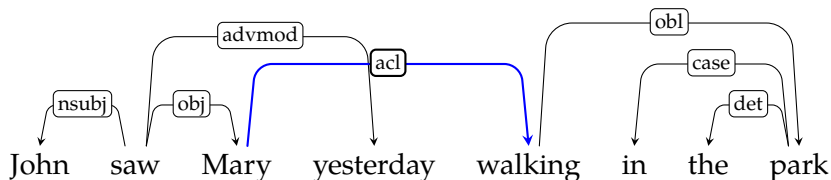


Some tricky constructions

Auxiliaries vs. main verbs



Dependency grammars: projectivity



- If a dependency graph has no crossing edges, it is said to be *projective*, otherwise *non-projective*
- Non-projectivity stems from long-distance dependencies and free word order
- Projective dependency trees can be represented with context-free grammars
- In general, projective dependencies are parseable more efficiently

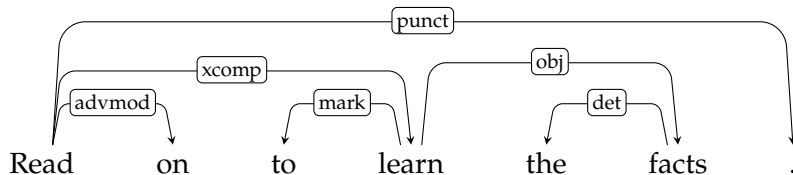
Universal Dependencies project

- Like constituency annotation efforts, most earlier dependency annotations were language- or even project-specific
- This has been a major hurdle for multi-lingual and cross-lingual work
- The Universal Dependencies (UD) project aims to unify dependency annotation efforts as much as possible
- The project releases treebanks (with mostly permissive licenses) for many languages
 - Currently (UD version 2.7) 183 treebanks covering 104 languages

CONLL-X/U format for dependency annotation

Single-head assumption allows flat representation of dependency trees

1	Read	read	VERB	VB	Mood=Imp VerbForm=Fin	0	root
2	on	on	ADV	RB	-	1	advmod
3	to	to	PART	TO	-	4	mark
4	learn	learn	VERB	VB	VerbForm=Inf	1	xcomp
5	the	the	DET	DT	Definite=Def	6	det
6	facts	fact	NOUN	NNS	Number=Plur	4	obj
7	.	.	PUNCT	.	-	1	punct



example from English Universal Dependencies treebank

Back to the exercise

- Analyze of the following sentence with UD dependencies (draw a parse tree, send dependency triplets through chat)

I read a good book during the weekend

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- Repeat, for the following version of the English sentence

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- Repeat, for the following version of the English sentence

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- Repeat the exercise for a another language (same translation as the constituency exercise)

space for the exercise

Dependency parsing

- Dependency parsing has many similarities with context-free parsing (e.g., trees)
- It also has some differences (e.g., number of edges and depth of trees are limited)
- Dependency parsing can be
 - grammar-driven (hand crafted rules or constraints)
 - data-driven (rules/model is learned from a treebank)
- There are two main approaches:
 - Graph-based similar to context-free parsing, search for the best tree structure
 - Transition-based similar to shift-reduce parsing (used for programming language parsing), but using greedy search for the best transition sequence

Grammar-driven dependency parsing

- Grammar-driven dependency parsers typically based on
 - lexicalized CF parsing
 - constraint satisfaction problem
 - start from fully connected graph, eliminate trees that do not satisfy the constraints
 - exact solution is intractable, often employ heuristics, approximate methods
 - sometimes ‘soft’, or weighted, constraints are used
 - Practical implementations exist
- Our focus will be on data-driven methods

Dependency grammars

Advantages and disadvantages

- + Close relation to semantics
- + Easier for flexible/free word order
- + Lots, lots of (multi-lingual) computational work, resources
- + Often much useful in downstream tasks
- + More efficient parsing algorithms
- No distinction between modification of head or the whole ‘constituent’
- Some structures are difficult to annotate, e.g., coordination

Summary

- Dependency grammars are based on *asymmetric, binary* relations between syntactic units
- Focus is on *syntactic functions*, in comparison to *syntactic constituency*
- Dependencies are (typically) labeled
- Dependency analyses are used more in downstream tasks
- Suggested reading: Kübler, McDonald, and Nivre (2009, chapter 1))

Summary

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Next:

- Dependency parsing
 - Transition based
 - Graph based
- Reading suggestion: Jurafsky and Martin (2009, draft chapter 14):
<https://web.stanford.edu/~jurafsky/slp3/14.pdf>, Kübler, McDonald, and Nivre (2009)

Acknowledgments, references, additional reading material



Grune, Dick and Criel 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. URL: <http://web.stanford.edu/~jurafsky/slp3/>.



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