Dependency Parsing

Introduction

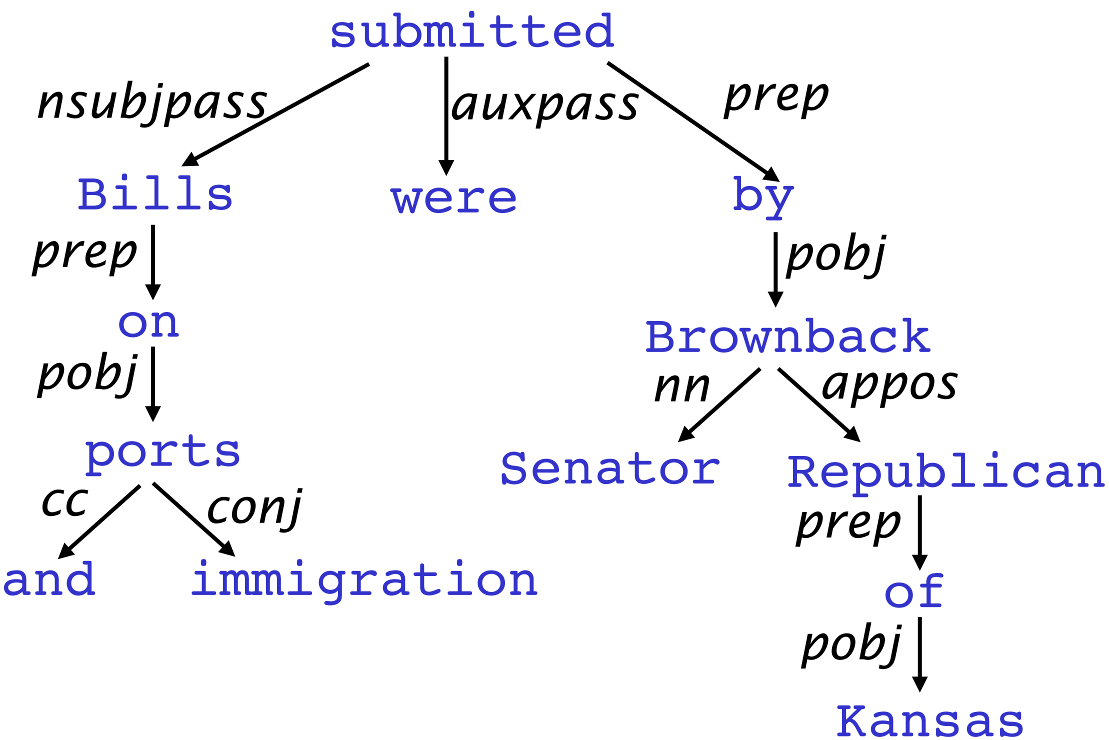
Many slides are adapted from Chris Manning

Dependency Grammar and Dependency Structure

Dependency syntax postulates that syntactic structure consists of lexical items linked by binary asymmetric relations (“arrows”) called dependencies

The arrow connects a head (governor, superior, regent) with a dependent (modifier, inferior, subordinate)

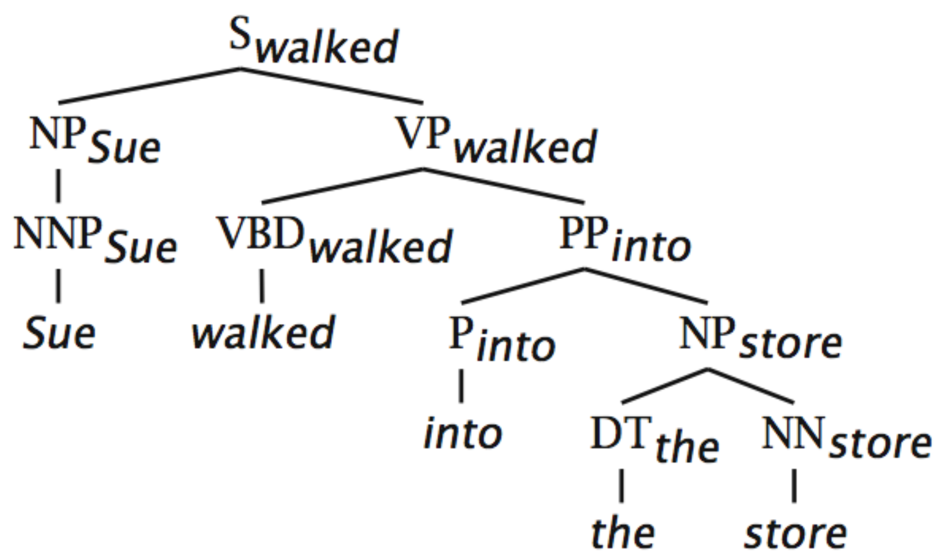
Usually, dependencies form a tree (connected, acyclic, single-head)



Relation between phrase structure and dependency structure

- A dependency grammar has a notion of a head. Officially, CFGs don't.
- But modern linguistic theory and all modern statistical parsers (Charniak, Collins, Stanford, …) do, via hand-written phrasal "head rules":
  - The head of a Noun Phrase is a noun/number/adj/…
  - The head of a Verb Phrase is a verb/modal/….
- The head rules can be used to extract a dependency parse from a CFG parse

- The closure of dependencies give constituency from a dependency tree
- But the dependents of a word must be at the same level (i.e., "flat") – there can be no VP!



Methods of Dependency Parsing

1. Dynamic programming (like in the CKY algorithm)

   You can do it similarly to lexicalized PCFG parsing: an $O(n^5)$ algorithm

   Eisner (1996) gives a clever algorithm that reduces the complexity to $O(n^3)$, by producing parse items with heads at the ends rather than in the middle

2. Graph algorithms

   You create a Maximum Spanning Tree for a sentence

   McDonald et al.'s (2005) MSTParser scores dependencies independently using a ML classifier (he uses MIRA, for online learning, but it could be MaxEnt)

3. "Deterministic parsing"

   Greedy choice of attachments guided by machine learning classifiers

   MaltParser (Nivre et al. 2008) – transition based, shift-reduce

Dependency Conditioning Preferences

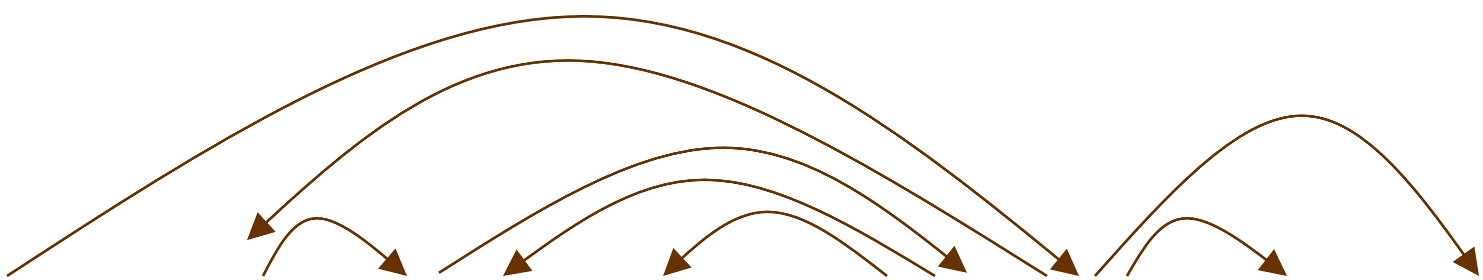
What are the sources of information for dependency parsing?

1. Bilexical affinities [issues → the] is plausible
2. Dependency distance mostly with nearby words
3. Intervening material

    Dependencies rarely span intervening verbs or punctuation

4. Valency of heads

    How many dependents on which side are usual for a head?



ROOT Discussion of the outstanding issues was completed .

Projectivity

- Dependencies from a CFG tree using heads, must be projective
  - There must not be any crossing dependency arcs when the words are laid out in their linear order, with all arcs above the words.
- But dependency theory normally does allow non-projective structures to account for displaced constituents
  - You can't easily get the semantics of certain constructions right without these nonprojective dependencies

Quiz question!

- Consider this sentence:

Retail sales drop in April cools afternoon market trading.

- Which word are these words a dependent of?
  1. sales
  2. April
  3. afternoon
  4. trading

Dependency Parsing

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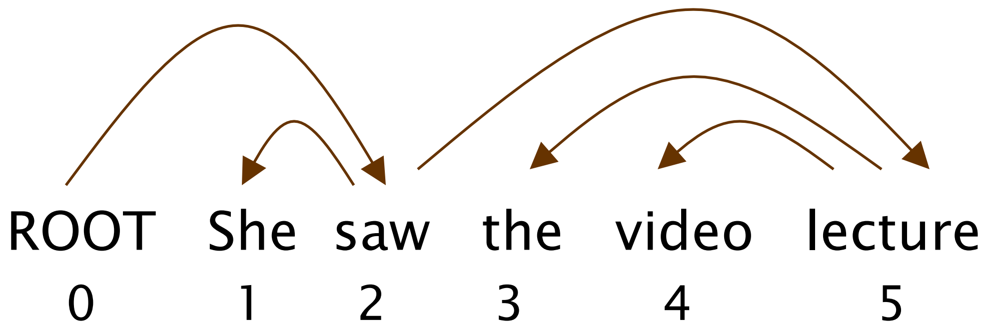
Evaluation

Evaluation of Dependency Parsing: (labeled) dependency accuracy



$$\text{Acc} = \frac{\text{\# correct deps}}{\text{\# of deps}}$$

UAS = 4 / 5 = 80%

LAS = 2 / 5 = 40%

Gold

1	2	She	nsubj
2	0	saw	root
3	5	the	det
4	5	video	nn
5	2	lecture	dobj

Parsed

1	2	She	nsubj
2	0	saw	root
3	4	the	det
4	5	video	nsubj
5	2	lecture	ccomp

Representative performance numbers

- The CoNLL-X (2006) shared task provides evaluation numbers for various dependency parsing approaches over 13 languages
  - Performance varies depending greatly on language/treebank
- Here we give a few UAS numbers for English to allow some comparison to constituency parsing

Parser	UAS%
Sagae and Lavie (2006) ensemble of dependency parsers	92.7
Charniak (2000) generative, constituency	92.2
Collins (1999) generative, constituency	91.7
McDonald and Pereira (2005) – MST graph-based dependency	91.5
Yamada and Matsumoto (2003) – transition-based dependency	90.4

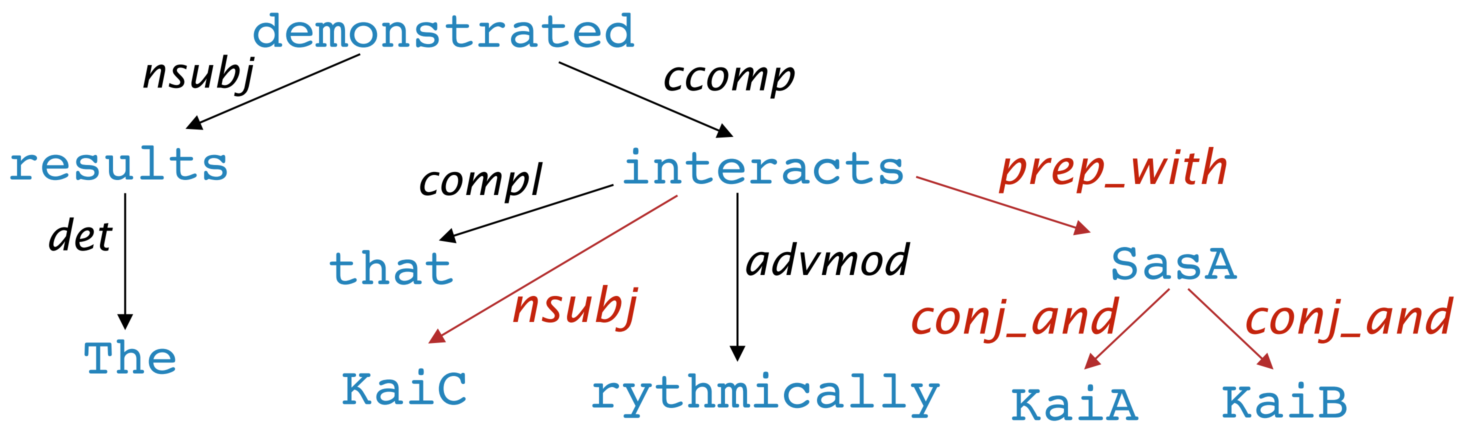
Evaluation

Dependencies encode relational structure

Relation Extraction with Dependencies

Dependency paths identify relations like protein interaction

[Erkan et al. EMNLP 07, Fundel et al. 2007]

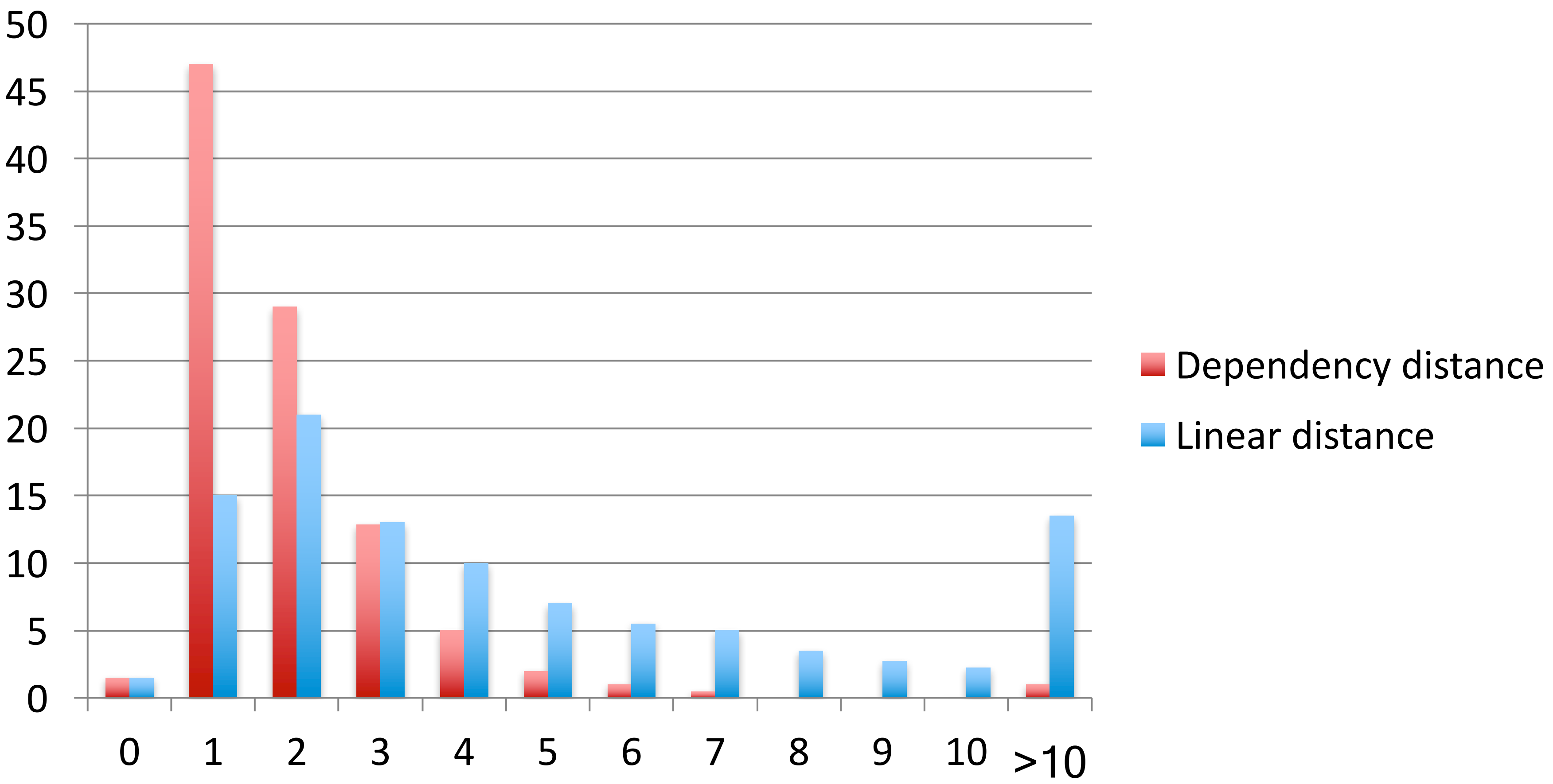


KaiC ←nsubj interacts prep_with→ SasA

KaiC ←nsubj interacts prep_with→ SasA conj_and→ KaiA

KaiC ←nsubj interacts prep_with→ SasA conj_and→ KaiB

BioNLP 2009/2011 relation extraction shared tasks [Björne et al. 2009]



Dependencies encode relational structure

Relation Extraction with Dependencies