Dependency Parsing

Outline

Two formalisms for syntactic structure: Phrase structure and dependencies

Two algorithms for dependency parsing

- Transition based dependency parsing
- Graph based dependency parsing

Evaluating dependencies

Dependency parsing

- Input: Sentence, tokenized + a dummy ROOT word
- Output: A dependency tree
  - Each word in the sentence is a node
  - Every word (except ROOT) should have an incoming edge indicating its head word
  - Only one word should be a dependent of ROOT
  - There are no cycles

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- Dependency theory also allows arrows to cross
  - Trees no arrows cross are called projective
  - Otherwise, they are called non-projective

Projective parse tree: No crossing dependency arcs when the words are laid out in their linear order, with all arcs above the word

Two families of parsing algorithms

Transition-based parsing

Graph based parsing

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- A generalization of the idea of shift-reduce parsing
- Greedily build attachments, using classifiers to decide which attachments to perform next
- Before neural networks: MaltParser (Nivre et al 2008)
- After neural networks: Chen and Manning (2014), Kipperwaser and Goldberg (2017)

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- Score all possible pairs of dependencies using a classifier
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Other algorithms exist as well. E.g. Eisner's algorithm is a dynamic programming approach

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A dependency tree is a tree whose words are nodes. Every word in a sentence has to be reachable from the root of the tree

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Scoring trees: The edge factored model

Trees can be arbitrarily large because sentences can be arbitrarily large

We need a scoring scheme that can account for this

The edge factored model: The score for a tree is the sum of scores of all its edges

$$score(t, S) = \sum_{e \in t} edge\text{-}score(e)$$

The modeling problem: Scoring edges

Any edge in the dependency tree is the tripe (head, dependent, label)

The scoring function can be any neural network.

Dozat and Manning (2017) trained two neural networks:

1. One computes the probability that there is an edge from word i to word j i.e., $P(i \rightarrow j)$
2. Another assigns a label to an edge, i.e., $P(label \mid i \rightarrow j)$

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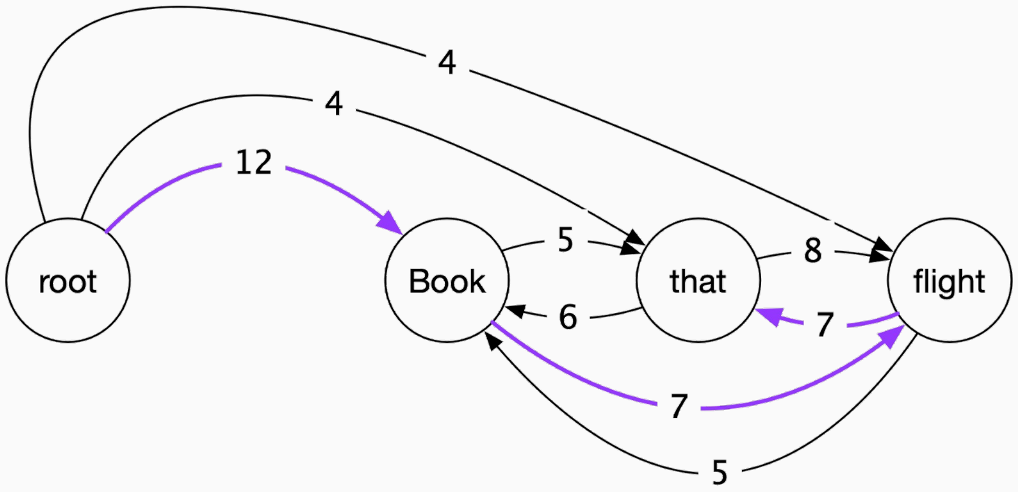

Image from Jurafsky and Martin’s book

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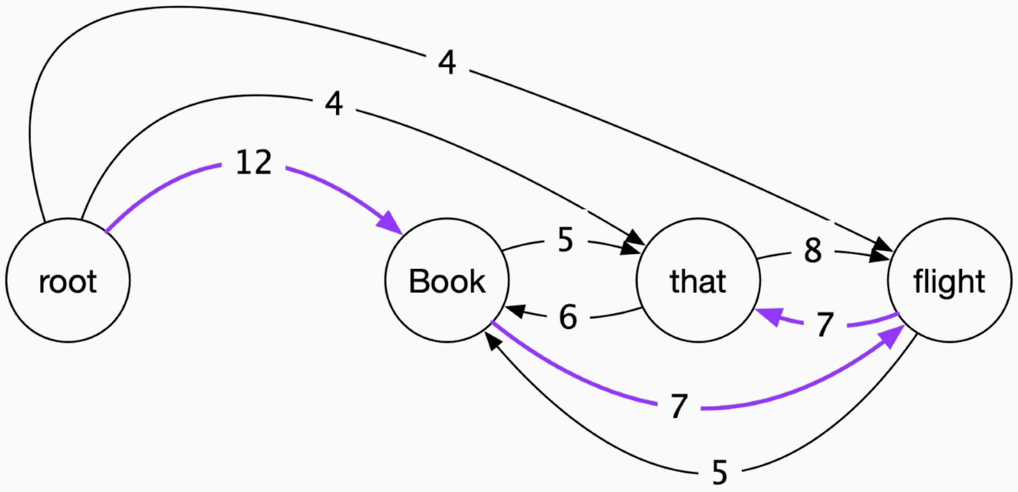

The standard solution: The Chu-Liu Edmonds algorithm

Image from Jurafsky and Martin’s book

Comparing transition- and graph-based parsing

- Computational Complexity
  - Graph based parsing is quadratic in the input length
  - Transition based parsing is linear in sentence length
- Projectivity
  - Graph based parsing can produce non-projective parse trees
  - Transition based parsing can only produce projective trees without additional cleanup
  - Tends to be a smaller issue English than for many languages
- Accuracy
  - Graph based parsers can be better on dependency arcs where the head is far from the dependent