CS 294-5: Statistical Natural Language Processing

Parsing: Search

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General Problem

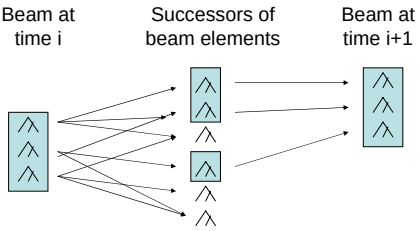
- Someone gives you a PCFG G
- For any given sentence you might want to:
  - Find the best parse according to G
  - Find a bunch of reasonable parses
  - Find the total probability of all parses
- Techniques:
  - Beam search
  - Agenda-based search
  - The CKY algorithm

Beam Search

- State space search
  - States are partial parses
  - Find a way to ensure that all parses of a sentence have the same number N steps
    - Leftmost top-down CFG derivations in CNF
    - Shift-reduce derivations in CNF
    - (Use a binary grammar, or binarize what you've got)

Beam Search

- Time-synchronous beam search



Kinds of Beam Search

- Constant beam size K
- Constant beam width
  - Additive
  - Multiplicative
- Sometimes do fancier stuff, like try to keep beam diverse
- Beam search can be made very fast
- No measure of how optimal it is
  - Correct hypothesis trick

Agenda-Based Parsing

- For general grammars
- Start with a table recording $\delta(X,i,j)$
  - The best score of a parse of X over [i,j]
  - All entries start at ∞
  - Can be a sparse or dense map
  - Sometimes record backtraces, too
- Step I: Hit the lexicon
  - For each word w, and each tag t, set $\delta(t,i,j)$ = tag-score(w,t)

Agenda-Based Parsing

- Keep a list of edges called an agenda
  - Edges are triples [X,i,j]
  - Agenda is a priority queue
- Every time some $\delta(X,i,j)$ lowers:
  - Stick the edge [X,i,j] into the agenda
  - Update the backtrace for $\delta(X,i,j)$

Agenda-Based Parsing

- Step II: While agenda not empty:
  - Get the "next" edge [X,i,j] from the agenda
  - Fetch all compatible neighbors [Y,j,k] or [Z,k,i]
    - Compatible means there are rules $A \rightarrow XY$ or $B \rightarrow ZX$
  - Build parent edges [A,i,k] or [B,k,j]
    - $\delta(A,i,k) \leq \delta(X,i,j) + \delta(Y,j,k) + P(XY|A)$
    - If we've improved $\delta(A,i,k)$, stick [A,i,k] on the agenda
  - Also project unary rules:
- When do we know we have a parse for the root?

Agenda-Based Parsing

- Open questions:
  - Agenda priority: What did "next" mean?
  - Efficiency: how do we do as little work as possible?
  - Optimality: how do we know when we find the best parse of a sentence?
- If we use $\delta(X,i,j)$ as the priority:
  - Each edge goes on the agenda at most once
  - When an edge pops off the agenda, its best parse score is known (why?)
- This is basically uniform cost search

Speeding Up Agenda Parsers

- Two options for doing less work
  - The optimal way: A* Parsing
  - The ugly (but possibly faster) way: Best-First Parsing

CKY Parsing

- Assuming:
  - You've got a lot of memory
  - You're willing to do exhaustive parsing
  - Your grammar is in CNF
- There's an easy solution: CKY parsing

Next Time

- Grammars beyond PCFGs
- Reading:
  - M+S 11 (over next few classes)
  - J+M 12 (over next few classes)