L95: Natural Language Syntax and Parsing
7) Parsing Accuracy

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Reminder...

We have looked at:

- grammars (PCFG, dependency, CCG)
- parsing algorithms (dynamic, deterministic, heuristic)
- parse scoring models (Bayesian, log-linear, cost-functions)
- methods for selecting n-best parses (beams, agendas)

But what do we need to do to make the parser as accurate as possible...?
Reminder: PCFGs have some shortcomings

When we looked at PCFGs we noted two sources of inaccuracy:

- The **independence** assumption: unable to model structural dependency across the tree as a whole
  - The choice of how a non-terminal expands depend on the location in the parse tree.
  - In English, subject NPs are more likely to be pronouns (≈ 90%), and objects NPs are more likely to be non-pronominal (≈ 60%)

- Lack of **lexical specificity**: unable to model the structural behaviour specific to a lexical item
  - E.g. *VP*-attachment of *PP*s are more common in English
  - We will always get *some people like beer in cold glasses* wrong
  - Also lack of subcategorisation
  - And co-ordination
Reminder: PCFGs have some shortcomings

Lack of **lexical specificity**: these co-ordinated trees have the same probability...

From Jurafsky and Martin version 3, following Collins

**Today will we look as how to get around these issues.**
Relax independence by splitting non-terminals

For the pronoun issue, intuition is that we need more NP rules: instead of $NP \rightarrow PRP$ we need two rules:

- $NP_{subject} \rightarrow PRP$
- $NP_{object} \rightarrow PRP$

How can we implement this without a semantic treebank? by annotating non-terminals with their parent nodes

![Diagram showing tree structures for sentences with subjects and objects](From Jurafsky and Martin version 3)
Parent annotation helps in several scenarios

- Other examples of parent annotation:
  - e.g. differentiating between adverbs by annotating pre-terminals with their parents
  - e.g. subordinating conjunctions, while, as, if, occur under under $S$

- Where parent annotation can’t help we could split on other features (i.e. hand write rules for specific feature scenarios)

- See https://nlp.stanford.edu/manning/papers/unlexicalized-parsing.pdf for some discussion
A trade-off between splitting and training

- Splitting non-terminals increases the grammar size
- Increased grammar size means less data per rule instance for MLE
- split and merge techniques automatically searches for the optimal splits by **maximising the likelihood** of the training set (e.g. Petrov et al. 2006)
non-terminal splitting example in class
Lexicalised-PCFGs include lexical info in the grammar.

Collins and Charniak parsers use lexicalised-PCFGs:

- Lexicalisation can include both the head word token and its part-of-speech.

```
TOP
  \[S(dumped,VBD)\]
  \[\text{NP(workers,NNS)}\]
  \[\text{NNS(workers,NNS)}\]
  \[\text{VBD(dumped,VBD)}\]
  \[\text{VP(dumped,VBD)}\]
  \[NP(sacks,NNS)\]
  \[PP(into,P)\]
    \[\text{NP(bin,NN)}\]
      \[\text{DT(a,DT)}\]
      \[\text{NN(bin,NN)}\]
    \[\text{P(into,P)}\]
      \[\text{NNS(sacks,NNS)}\]
      \[\text{sacks}\]
      \[\text{into}\]
    \[\text{VP(dumped,VBD)}\]
      \[\text{dumped}\]
      \[\text{VP(dumped,VBD)}\]
    \[\text{TOP}\]
  \[\text{NP(sacks,NNS)}\]
  \[\text{NP(workers,NNS)}\]
```

From Jurafsky and Martin version 3.
Lexicalised-PCFGs include lexical info in the grammar

- For each rule one of the RHS daughters is the head.
- The head information for the LHS of the rule is the same as the RHS head.
- Pre-terminal rules always have a probability of 1.
- All other rule probabilities need to be calculated ...
  ... but the data available per rule is now very sparse.
**Collins** handles sparsity by *generating* the RHS of rules.

- RHS of every rule consists of a **head** plus all the non-terminals to the head’s **left** and all the non-terminals to the head’s **right**

  \[ LHS \rightarrow L_m \ldots L_1 H R_1 \ldots R_n \]

- To use a rule we:
  - first **generate the head**,  
  - then all the **left dependents** from the head outwards  
  - and finally all the **right dependents** from the head outwards

- We imagine a **STOP** non-terminal at the edges of the rule

  \[ LHS \rightarrow STOP L_m \ldots L_1 H R_1 \ldots R_n STOP \]
Rule probability is the **product** of all generated pieces

- Remember that for PCFGs: $P(A \rightarrow B) = P(B|A)$

- For lexicalised PCFGs: $A \rightarrow STOP \ L_m \ldots \ L_1 \ H \ R_1 \ldots \ R_n \ STOP$
  - The probability of the head $H$ with associated word $h_w$ and tag $h_t$ given the parent, $A$ is:
    $$P(H(w_h, t_h)) = P(H(h_w, h_t)|A, h_w, h_t)$$
  - The probability of modifiers to the left of the head is:
    $$\prod_{i=1}^{m+1} P(L_i(lw_i, lt_i)|A, H, h_w, h_t)$$
  - The probability of modifiers to the right of the head is:
    $$\prod_{i=1}^{n+1} P(R_i(rw_i, rt_i)|A, H, h_w, h_t)$$

where $L_{m+1} = STOP$ and $R_{n+1} = STOP$
lexicalised-PCFG rule probability estimation in class
Collins models have other conditional features

- Collins 1 includes a distance metric in the conditional probabilities
- Collins 2 includes conditioning on subcategorisation and argument/adjunct

In training Collin’s interpolates three models:
- fully lexicalised (conditioning on the head word and tag),
- just the head tag
- unlexicalized
Remember **Coarse-to-fine** strategy, Charniak

We can now understand better Charniak’s **coarse-to-fine** parsing strategy:

1. produce a parse forest using simple version of the grammar  
   i.e. find possible parses using coarse-grained non-terminals, e.g. $VP$
2. refine most promising of coarse-grained parses using complex grammar  
   i.e with feature-based, lexicalised non-terminals, e.g. $VP[\text{buys}/\text{VBZ}]$

- **Coarse-grained step** can be **efficiently parsed** using e.g. CKY
- But the simple grammar **ignores contextual features** so best parse might not be accurate
- **Output a pruned packed parse** forest for the parses generated by the simple grammar (using a beam threshold)
- **Evaluate remaining parses with complex grammar** (i.e. each coarse-grained state is split into several fine-grained states)
Next time

- Unification Based Grammars and Parsing