Motivation for Tree Adjoining Grammars: introduction to sentential structure

Why should we have formal explicit models of language structure, especially in an age of deep learning and learned representations?

Intuition suggests that such structure exists.
We may want to recover this structure to pass down downstream applications.
Inductive bias (?): Limit the search space.
You should now what your options are, even if you choose not to use such models.

What are some language characteristics we should try to capture?

1. The president put $40 billion into department A’s budget but only $40 into department B’s
2. cashiers put baskets in boxes
3. cashiers put boxes in baskets
4. cashiers put boxes and baskets that had lovely bows and were practical ->
   \([baskets \text{ that had lovely bows and were practical}]\) is like \(baskets\)
5. * cashiers put boxes in put -> only certain types of things can be put in certain positions
6. * cashiers put baskets
7. * cashiers put in boxes
8. cashiers put baskets in boxes ->

   \([[\text{cashiers}]] \text{ noun phrase (NP), or subject}
   \([[\text{put}]] \text{ V, or main verb}
   \([[\text{baskets}]] \text{NP, or direct object}
   \([[\text{in}]] \text{preposition } [[\text{boxes}]] \text{NP, prepositional phrase (PP), or location}
   \(figsize{\text{V, or main verb}})
   \(figsize{\text{S, or sentence; “main word” is the predicate’s verb}})
Can we reuse a pre-existing, well-known, efficient formalism?

Example context-free grammar (CFG) fragment
Finite set of categories (e.g., VP), including distinguished start symbol S, finite disjoint set of terminals (e.g., “put”), finite set of decomposition rules, each with the left hand side = exactly one nonterminal.

9. $VP \rightarrow V \ NP \ PP$ (decomposable categories are uppercase by convention)
10. $V \rightarrow \text{put}$ (terminals are in lowercase by convention)
11. $V \rightarrow \text{destroy}$

Parse trees are induced, or the parse trees themselves induce the sentence

Handling local restrictions (let’s be clever engineers)

Lexical information (characteristics of individual words, or lexical items) is important.

12. she puts boxes in baskets versus * cashiers puts boxes in baskets
13. they put boxes in baskets versus * cashiers put they in baskets - > case mismatch
("subject" v. "direct object")
14. ?? cashiers put sleep in baskets

15. Lexical entry for "put" includes: subcategorization is (1: NP that is "puttable" 2: PP that is a location)

16. $VP \rightarrow V \ NP \ PP$
   - VP agreement = V agreement
   - V’s subcat 1 = NP
   - V’s subcat 2 = PP

(using “=“ loosely as “is consistent with”/"unifies with")

Handling gaps in question inversion

17. what do the cashiers put in the baskets?
18. where do the cashiers put the boxes?
19. * the cashiers put in the baskets - > if there’s a gap, there must be a filler
20. * what do the cashiers put the boxes - > the WH "filler“ has to match the gap’s characteristics

21. $S_{question} \rightarrow NP_{an} \ AUX \ NP \ VP$
   - AUX agreement = NP agreement
   - VP gapinfo = NP_{an}.gapinfo
   - VP has an NP gap
   - NP_{an} is not null

22. NP -> <null trace>
   - NP must have nondefault gapinfo

Add to 16:
   - VP gapinfo = NP gapinfo
   - PP no gap allowed