DD2418 Language Engineering
Assignment 1

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All programs should be written in Python 3, unless specified otherwise in the problem instructions. Don't use any external libraries (that are not part of the Python 3 distribution) unless otherwise specified.

Mandatory part

1. Find all the trees derivable from the sentence *"He built the shed with a hammer in the yard behind the house"*, and the grammar:

S	→	NP VP	Pron	→	he
NP	→	Pron	Verb	→	built
NP	→	Det Noun	Prep	→	with
NP	→	Det Noun PP	Prep	→	in
VP	→	Verb NP	Prep	→	behind
VP	→	Verb NP PP	Noun	→	hammer
PP	→	Prep NP	Noun	→	shed
Det	→	the	Noun	→	yard
Det	→	a	Noun	→	house

   For each tree, explain what a semantically sensible interpretation of the tree might be (if there is a sensible interpretation). In particular: Where is the shed? Where is the hammer? Where is the yard?

2. Consider the grammar:

S	→	NP VP	PP	→	Prep NP
S	→	VP NP	Noun	→	time
NP	→	Noun	Noun	→	flies
NP	→	Det Noun	Noun	→	arrow
NP	→	Noun Noun	Verb	→	time
NP	→	Noun PP	Verb	→	flies
VP	→	Verb	Verb	→	like
VP	→	Verb NP	Prep	→	like
VP	→	Verb PP	Det	→	an

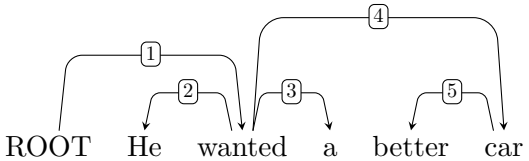
   (a) Convert the grammar into a weakly equivalent Chomsky normal form grammar.

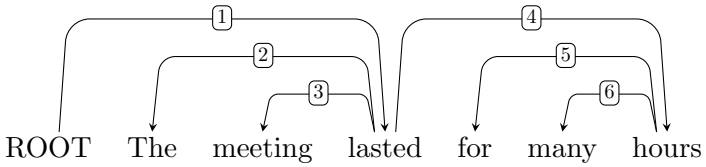
   (b) Using your new grammar, use the CKY algorithm to parse the sentence "*time flies like an arrow*". Show your completed parse table as result.

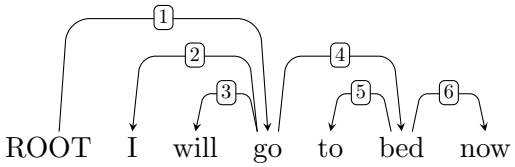
   (c) How many correct analyses of the sentence can you find? Explain how you can retrieve these analyses from the parse table.

   (d) Draw the syntax trees corresponding to your analyses in (c).

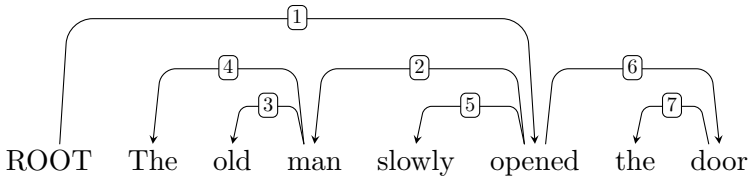
3. Each of these dependency trees has one edge which is incorrect. Decide which one, and explain how it should be drawn instead.

(a)


(b)


(c)


4. Below is a correct dependency tree, but with the labels missing. For each of the labels 1–7, determine the appropriate relation label. (`https://universaldependencies.org/u/dep/` has a list of all labels).



5. (Dependency parsing) Transition-based parsing is an efficient way of producing dependency trees from a sentence. Your task in this problem is to fill in some missing parts of a transition-based dependency parser.

   (a) First go to the `DepParser` folder, and type:

   ```
   pip install -r requirements.txt
   ```

   Now complete the method `valid_moves` in the `Parser` class so that it, given a parser configuration (the contents of the buffer, the stack, and the partially built tree), returns the list of valid moves (shift (SH), left-arc (LA), right-arc (RA)) in that configuration.

   (b) Complete the method `move` so that it, given a parser configuration, returns the resulting configuration after the move has been carried out (the new contents of the buffer and the stack, and the new partially built tree). After you have done this, run `step_by_step.sh` (or `.bat`) to make sure that it works.

(c) Finally, extend the method `compute_correct_move` so that it, given a parser configuration and the correct final tree, computes the correct move for the parser to make in that configuration. Run the script `compute_correct_moves.sh` (or `.bat`), and compare the output to the file `correct_moves_en-ud-dev.conllu`.

Optional part

6. (CKY parsing) The CKY algorithm is an efficient method of analyzing sentences according to a grammar in Chomsky Normal Form (CNF).

   (a) First go to the CKY folder, and type:

   ```
   pip install -r requirements.txt
   ```

   Now extend the method `parse` in the `CKY` class so it produces a CKY parse table from an input sentence. For instance, running the script `run_cky_parser_1`, which parses the sentence "*giant cuts in welfare*" given the grammar in the file `grammar.txt`, should result in:

   ```
   +--------------+----------------+----------+--------------------+
   | ['NP', 'JJ'] | ['NP']         | []       | ['S', 'NP', 'NP'] |
   | []           | ['NP', 'Verb'] | []       | ['NP', 'VP']      |
   | []           | []             | ['Prep'] | ['PP']            |
   | []           | []             | []       | ['NP']            |
   +--------------+----------------+----------+--------------------+
   ```

   (b) Extend the method `print_trees` so that it prints all parse trees derivable from a certain cell in the parse table, rooted with a given symbol. For instance, the two trees derivable from the topmost rightmost cell, rooted with 'NP', are

   ```
   NP(JJ(giant), NP(NP(cuts), PP(Prep(in), NP(welfare))))
   NP(NP(JJ(giant), NP(cuts)), PP(Prep(in), NP(welfare)))
   ```

   and the only tree derivable from the same cell, rooted with 'S', is:

   ```
   S(NP(giant), VP(Verb(cuts), PP(Prep(in), NP(welfare))))
   ```