Towards more efficient parsers

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Ideas

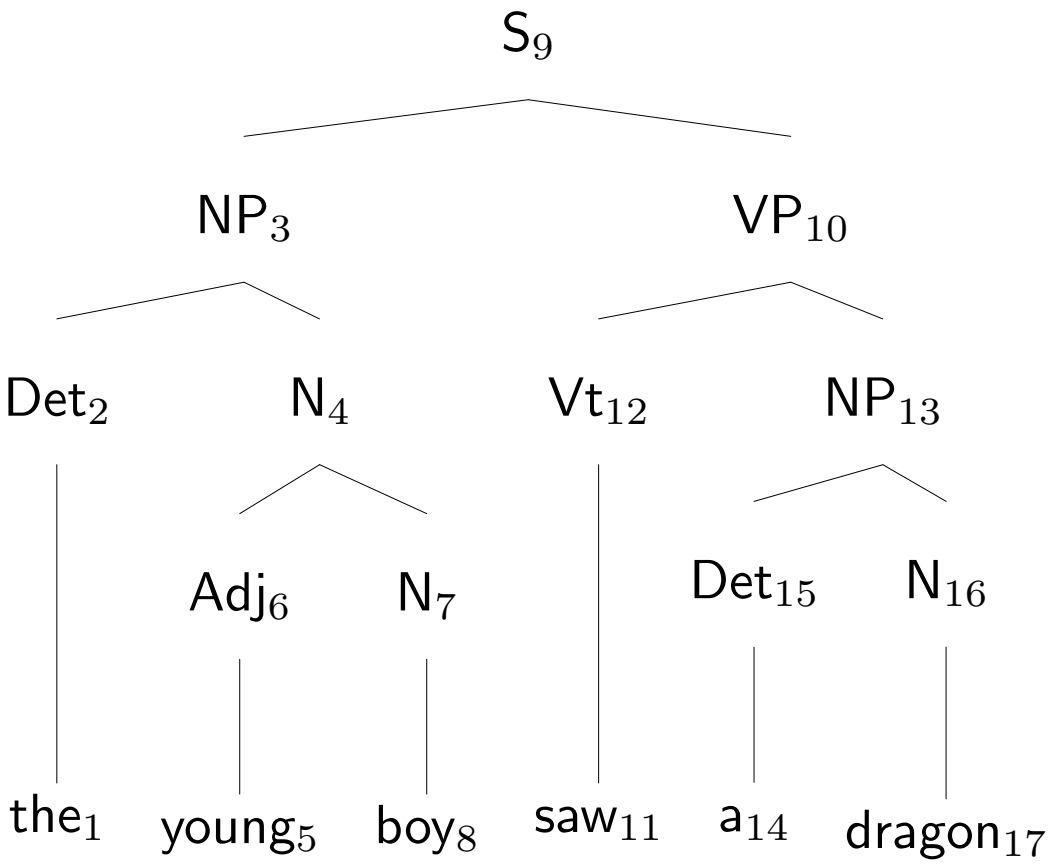
- Combining bottom-up parsing with top-down prediction
  - From shift-reduce to left-corner parsing
  - Adding more top-down filtering: link tables
- Memoization of partial results
  - well-formed substring tables
  - active charts

From shift-reduce to left-corner parsing

- Shift-reduce parsing is not goal directed at all:
  - Reduction of every possible substring,
  - obtaining every possible analysis for it.

- Idea to revise shift-reduce strategy:
  - Take a particular element x (here: the leftmost).
  - x triggers those rules it can occur in, to make predictions about the material occurring around x.

Left-corner, left-right, depth-first tree traversal



S → NP VP
VP → Vt NP
NP → Det N
N → Adj N

Vt → saw
Det → the
Det → a
N → dragon
N → boy
Adj → young

In the figure above, we numbered the mother in the tree at the time the rule is looked up of which it is the left-hand side category. Alternatively, one could number the mother only at the time when the parser tries to prove it's the left corner of something.

A left-corner parser for grammars in CNF using ordinary strings (parser/simple/cnf_lc.pl)

```
:- op(1100,xfx,'--->').

recognise(Phrase, [Word|Rest]) :-
        (Cat ---> [Word]),
        lc(Cat, Phrase, Rest).

lc(Phrase, Phrase, []).

lc(SubPhrase, SuperPhrase, String) :-
        (Phrase ---> [SubPhrase,Right]),
        append(SubString,Rest,String),
        recognise(Right, SubString),
        lc(Phrase, SuperPhrase, Rest).
```

A left-corner parser for grammars in CNF using difference lists to encode the string (parser/simple/cnf_lc_diff_list.pl)

```
:- op(1100,xfx,'--->').

recognise(Phrase, [Word|S0], S) :-
        (Cat ---> [Word]),
        lc(Cat, Phrase, S0, S).

lc(Phrase,Phrase, S, S).

lc(SubPhrase, SuperPhrase, S0, S) :-
        (Phrase ---> [SubPhrase,Right]),
        recognise(Right, S0, S1),
        lc(Phrase, SuperPharse, S1, S).
```

A left-corner parser for grammars in CNF using DCG notation to encode the string (parser/simple/cnf_lc_dcg.pl)

```
:- op(1100,xfx,'--->').

% ?- recognise(s,<list(word)>,[]).

recognise(Phrase) --> [Word],
                      {Cat ---> [Word]},
                      lc(Cat,Phrase).

lc(Phrase,Phrase) --> [].

lc(SubPhrase,SuperPhrase) -->
    {Phrase ---> [SubPhrase,Right]},
    recognise(Right),
    lc(Phrase,SuperPhrase).
```

Problems of basic left-corner approach

- There can be a choice involved in picking a rule which
  - projects a particular word
  - projects a particular phrase

- How do we make sure we only pick a category which is on our path up to the goal?
  - Define a **link table** encoding the transitive closure of the left-corner relation. This is always a finite table!
  - Use it as an **oracle** guiding us to pick a reasonable candidate.

Example for a link table

For a grammar with the following non-terminal rules

```
:- op(1100,xfx,'--->').

  s  ---> [np, vp].          vp ---> [v, np].
  np ---> [det, n].          n  ---> [n, pp].
  pp ---> [p, np].
```

one can define or automatically deduce the link table

```
  link(s,s).      link(np,np).    link(pp,pp).
  link(det,det).  link(n,n).      link(p,p).
  link(np,s).     link(det,np).   link(p,pp).     link(v,vp).
  link(det,s).
```

Using a link table in a left-corner parser

```
:- op(1100,xfx,'--->').

recognise(Phrase) --> [Word],
                      {Cat ---> [Word]},
                      {link(Cat,Phrase)},
                      lc(Cat,Phrase).

lc(Phrase,Phrase) --> [].

lc(SubPhrase,SuperPhrase) -->
    {Phrase ---> [SubPhrase,Right]},
    {link(Phrase,SuperPhrase)},
    recognise(Right),
    lc(Phrase,SuperPhrase).
```