LING 388: Language and Computers

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Lecture 13
Administrivia

• Another Homework on recursion
  – Homework 5
  – due next **Wednesday** by midnight...
Left to Right Recursive Transformation

1. np → np, pp.
2. np → det, nn.

np → det, nn, v.
v → pp, v.
v → pp.
np → det, nn.

np(np(D,N,V)) → det(D), nn(N), v(V).
v(v(PP,V)) → pp(PP), v(V).
v(v(PP)) → pp(PP).
np(np(D,NN)) → det(D), nn(NN).
We developed the following rules:

1. $\text{sentence}(s(X,Y)) \rightarrow \text{np}(X), \text{vp}(Y)$.
2. $\text{pp}(\text{pp}(X,Y)) \rightarrow \text{in}(X), \text{np}(Y)$.
3. $\text{np}(\text{np}(X)) \rightarrow \text{prp}(X)$.
4. $\text{np}(\text{np}(\text{nnp}(\text{mary}))) \rightarrow \text{[mary]}$.
5. $\text{np}(\text{np}(\text{nnp}(\text{john}))) \rightarrow \text{[john]}$.
6. $\text{np}(\text{np}(\text{nnp}(\text{bill}))) \rightarrow \text{[bill]}$.
7. $\text{np}(\text{np}(D,NN)) \rightarrow \text{det}(D), \text{nn}(NN)$.
8. $\text{np}(\text{np}(D,NN,V)) \rightarrow \text{det}(D), \text{nn}(NN), \text{v}(V)$.
9. $\text{v}(\text{v}(PP,V)) \rightarrow \text{pp}(PP), \text{v}(V)$.
10. $\text{v}(\text{v}(PP)) \rightarrow \text{pp}(PP)$.
11. $\text{v2}(\text{v2}(PP,V2)) \rightarrow \text{pp}(PP), \text{v2}(V2)$.
12. $\text{v2}(\text{v2}(PP)) \rightarrow \text{pp}(PP)$.
13. $\text{vp}(\text{vp}(V,NP,V2)) \rightarrow \text{verb}(V), \text{np}(NP), \text{v2}(V2)$.
14. $\text{vp}(\text{vp}(V,X)) \rightarrow \text{verb}(V), \text{np}(X)$.
15. $\text{vp}(\text{vp}(V,X)) \rightarrow \text{verb}(V), \text{sbar}(X)$.
16. $\text{sbar}(\text{sbar}(X,S)) \rightarrow \text{c}(X), \text{sentence}(S)$.
17. $\text{c}(\text{in}(\text{that})) \rightarrow \text{[that]}$.
18. $\text{in}(\text{in}(\text{with})) \rightarrow \text{[with]}$.
19. $\text{a}(\text{jj}(\text{big})) \rightarrow \text{[big]}$.
20. $\text{a}(\text{jj}(\text{shiny})) \rightarrow \text{[shiny]}$.
21. $\text{a}(\text{jj}(\text{red})) \rightarrow \text{[red]}$.
22. $\text{prp}(\text{prp}(\text{i})) \rightarrow \text{[i]}$.
23. $\text{prp}(\text{prp}(\text{me})) \rightarrow \text{[me]}$.
24. $\text{nn}(\text{nn}(\text{boy})) \rightarrow \text{[boy]}$.
25. $\text{nn}(\text{nn}(\text{limp})) \rightarrow \text{[limp]}$.
26. $\text{nn}(\text{nn}(\text{telescope})) \rightarrow \text{[telescope]}$.
27. $\text{nn}(\text{nn}(\text{bus})) \rightarrow \text{[bus]}$.
28. $\text{nn}(\text{nn}(\text{A,NN})) \rightarrow \text{a}(A), \text{nn}(NN)$.
29. $\text{verb}(\text{vbd}(\text{noticed})) \rightarrow \text{[noticed]}$.
30. $\text{verb}(\text{vbd}(\text{saw})) \rightarrow \text{[saw]}$.
31. $\text{det}(\text{dt}(\text{the})) \rightarrow \text{[the]}$.
32. $\text{det}(\text{dt}(\text{a})) \rightarrow \text{[a]}$.

Left recursive np $\rightarrow$ np, pp and vp $\rightarrow$ vp, pp adjunction rules transformed into right recursive rules involving v and v2, respectively.

grammar-transformed.pl
Last Time

1. \texttt{sentence}(s(X,Y)) \rightarrow \texttt{np}(X), \texttt{vp}(Y).
2. \texttt{pp}(pp(X,Y)) \rightarrow \texttt{in}(X), \texttt{np}(Y).
3. \texttt{np}(np(X)) \rightarrow \texttt{prp}(X).
4. \texttt{np}(np(nnp(mary))) \rightarrow [mary].
5. \texttt{np}(np(nnp(john))) \rightarrow [john].
6. \texttt{np}(np(nnp(bill))) \rightarrow [bill].
7. \texttt{np}(np(D,NN)) \rightarrow \texttt{det}(D), \texttt{nn}(NN).
8. \texttt{np}(np(np(X,Y),Z)) \rightarrow \texttt{det}(X), \texttt{nn}(Y), \texttt{pp}(Z).
9. \texttt{vp}(vp(V,X)) \rightarrow \texttt{verb}(V), \texttt{np}(X).
10. \texttt{vp}(vp(V,\texttt{NP},PP)) \rightarrow \texttt{verb}(V), \texttt{np}(\texttt{NP}), \texttt{pp}(PP).
11. \texttt{vp}(vp(V,X)) \rightarrow \texttt{verb}(V), \texttt{sbar}(X).
12. \texttt{sbar}(sbar(X,S)) \rightarrow \texttt{c}(X), \texttt{sentence}(S).
13. \texttt{c}(\texttt{in}(that)) \rightarrow [that].
14. \texttt{in}(\texttt{in}(with)) \rightarrow [with].
15. \texttt{a}(\texttt{jj}(\texttt{big})) \rightarrow [big].
16. \texttt{a}(\texttt{jj}(\texttt{shiny})) \rightarrow [shiny].
17. \texttt{a}(\texttt{jj}(\texttt{red})) \rightarrow [red].
18. \texttt{prp}(prp(i)) \rightarrow [i].
19. \texttt{prp}(prp(me)) \rightarrow [me].
20. \texttt{nn}(nn(\texttt{boy})) \rightarrow [boy].
21. \texttt{nn}(nn(\texttt{limp})) \rightarrow [limp].
22. \texttt{nn}(nn(\texttt{telescope})) \rightarrow [telescope].
23. \texttt{nn}(nn(\texttt{bus})) \rightarrow [bus].
24. \texttt{nn}(nn(\texttt{A},NN)) \rightarrow \texttt{a}(A), \texttt{nn}(NN).
25. \texttt{verb}(vbd(\texttt{noticed})) \rightarrow [noticed].
26. \texttt{verb}(vbd(saw)) \rightarrow [saw].
27. \texttt{det}(dt(\texttt{the})) \rightarrow [\texttt{the}].
28. \texttt{det}(dt(a)) \rightarrow [a].

Quick Fix grammar
grammar-quickfix.pl
Step 4

• Step 4:
  – Compare the transformed grammar parses with those obtained using the “Quick Fix” grammar on the NP
    • *a boy with a telescope with a limp*
    • number of parses?
    • attachment of the PPs?
<table>
<thead>
<tr>
<th>Modification Relations</th>
<th>Quick Fix</th>
<th>PP adjunction to NP/PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>telescope → boy, limp → boy</td>
<td></td>
<td>✅</td>
</tr>
<tr>
<td>telescope → see, limp → see</td>
<td></td>
<td>✅</td>
</tr>
<tr>
<td>telescope → boy, limp → see</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>telescope → see, limp → telescope</td>
<td>✅</td>
<td>✅</td>
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<tr>
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<td>✅</td>
<td>✅</td>
</tr>
</tbody>
</table>

**Example:** I saw the boy with a telescope with a limp
Left to Right Recursive Transformation

Structures are right branching
They have extra v and v2 nodes
Step 5

- **Step 5:**
  - in step 4, we obtained a right recursive parse
  - Modify your natural language grammar to produce a left recursive parse following the template on the right...
  - Test your grammar

- **Example:**
  - \(x(x(z,V)) \rightarrow [z], v(V)\).
  - \(v(v(y,V)) \rightarrow [y], v(V)\).
  - \(v(v(v)) \rightarrow [y]\).
  - \(x(x(z)) \rightarrow [z]\).

- **Modified grammar:**

\[
\begin{align*}
1. & x(X) \rightarrow [z], v(X,x(z)). \\
2. & v(V,X) \rightarrow [y], v(V,x(X,y)). \\
3. & v(x(X,y),X) \rightarrow [y]. \\
4. & x(x(z)) \rightarrow [z].
\end{align*}
\]
Homework 5

• Regular sentence:
  – the rat ate the cheese

• Object relative clause construction:
  – object of the sentence is missing
  – "moves" to become a new head noun
  – the cheese (that) the rat ate
  – [NP [NP the cheese] [S [NP the rat][VP [VBD ate]]]]
Homework 5

• Subject relative clause construction:
  – subject "moves" to become a new head noun
  – the rat that ate the cheese
  – \([_{NP [_{NP the rat}]}]_{SBAR that [_{S ___}]}_{VP[_{VBD ate}]}_{NP the cheese}]]]]

```
NP
  NP
    DT the
    NN rat
  SBAR
    WDT that
    WHNP
    S
      VP
        VBD ate
        NP
          DT the
          NN cheese
```
Homework 5

• Implement another kind of recursion:
  – Object relative clauses
    • the cat that saw the rat that saw the cheese that ...
    • \([_{NP \text{the cat}} [_{SBAR \text{that}} [_{S \text{saw}} [_{NP \text{the rat}} [_{SBAR \text{that}} [_{S \text{saw}} [_{NP \text{the cheese that}} ... ]]]]]]]\]
    • the cheese that the rat ate
    • the cheese that the rat that the cat saw ate
    • the cheese that the rat that the cat that the dog chased saw ate
Homework 5

- Other kinds of recursion, e.g.
  - Object relative clauses
    - *the cheese that the rat ate*
Homework 5

- Other kinds of recursion, e.g.
  - Object relative clauses
    - *the cheese that the rat that the cat saw ate*
Homework 5

- *the cheese that the rat that the cat saw ate was rotten.*
Homework 5

• the cheese that the rat that the cat that the dog chased saw ate was rotten.
Homework 5

• Use grammar.pl as the starting point
• Submit your revised grammar.
• Submit your runs