CSCI-UA 472 Artificial Intelligence

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Homework 08

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Problem 1

Solution to A

Consider the following PCFG in Chomsky Normal Form:

S → NP VP [0.6]
S → Noun VP [0.3]
S → NP Verb [0.1]
NP → Adj Noun [0.7]
NP → AdjList Noun [0.3]
VP → Verb Noun [0.5]
VP → Verb NP [0.3]
VP → Verb Adv [0.2]
AdjList → Adj Adj [1.0]

Lexicon:
Noun → "fast" [0.1]
Noun → "fish" [0.6]
Noun → "swim" [0.2]
Verb → "fast" [0.1]
Verb → "fish" [0.8]
Verb → "long" [0.1]
Verb → "swim" [0.6]
Adj → "fast" [0.5]
Adj → "long" [0.5]
Adv → "fast" [0.8]
Adv → "long" [0.2]

A. Trace the workings of the CYK algorithm on the sentence "long fast fish swim" in the style of the example on the course web site.

B. What are the two possible parse trees for this sentence?

Solution to Problem 1

Solution to A:

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Iterations of line 4
Create the following leaves:

i=1
A. [Verb | 1 | 1 | long   | ---- | --- | 0.1]
B. [Adj  | 1 | 1 | long   | ---- | --- | 0.5]
C. [Adv  | 1 | 1 | long   | ---- | --- | 0.2]

i=2
D. [Noun | 2 | 2 | fast   | ---- | --- | 0.1]
E. [Verb | 2 | 2 | fast   | ---- | --- | 0.1]
F. [Adj  | 2 | 2 | fast   | ---- | --- | 0.5]
G. [Adv  | 2 | 2 | fast   | ---- | --- | 0.8]

i=3
H. [Noun | 3 | 3 | fish   | ---- | --- | 0.6]
I. [Verb | 3 | 3 | fish   | ---- | --- | 0.8]

i=4
J. [Noun | 4 | 4 | swim   | ---- | --- | 0.2]
K. [Verb | 4 | 4 | swim   | ---- | --- | 0.6]


length=2
i=1
j=2
 M=NP
    k=1
       Create node L. [NP | 1 | 2 | --- | --- | --- | 0]
       Rule NP → Adj Noun [0.7]
       Combination of B & D and prob of rule has probability 0.5 * 0.1 * 0.7 = 0.035
       Change L to be [NP | 1 | 2 | --- | B | D | 0.035]
 M=VP
    k=1
       Create node M. [VP | 1 | 2 | --- | --- | --- | 0]
       Rule VP → Verb Noun [0.5]
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       Combination of A & D and prob of rule has probability 0.1 * 0.1 * 0.5 = 0.005
       Change M to be [VP | 1 | 2 | --- | A | D | 0.005]

       Rule VP → Verb Adv [0.2]
       Combination of A & G and prob of rule has probability 0.1 * 0.8 * 0.2 = 0.016
       Change M to be [VP | 1 | 2 | --- | A | G | 0.016]
 M=AdjList
    k=1
        Create node N. [AdjList | 1 | 2 | --- | --- | --- | 0]
        Rule AdjList → Adj Adj [1.0]
        Combination of B & F and prob of rule has probability 0.5 * 0.5 * 1.0 = 0.25
        Change N to be [AdjList | 1 | 2 | --- | B | F | 0.25]

i=2
j=3
 M=NP
     k=1
        Create node O. [NP | 2 | 3 | --- | --- | --- | 0]
        Rule NP → Adj Noun [0.7]
        Combination of F & H and prob of rule has probability 0.5 * 0.6 * 0.7 = 0.21
        Change O to be [NP | 2 | 3 | --- | F | H | 0.21]
 M=VP
     k=1
        Create node P. [VP | 2 | 3 | --- | --- | --- | 0]
        Rule VP → Verb Noun [0.5]
        Combination of E & H and prob of rule has probability 0.1 * 0.6 * 0.5 = 0.03
        Change P to be [VP | 2 | 3 | --- | E | H | 0.03]

i=3
j=4
 M=VP
     k=1
        Create node Q. [VP | 3 | 4 | --- | --- | --- | 0]
        Rule VP → Verb Noun [0.5]
        Combination of I & J and prob of rule has probability 0.8 * 0.2 * 0.5 = 0.08
        Change Q to be [VP | 1 | 2 | --- | I | J | 0.08]

length=3
i=1
j=3
M=S
    k=1
       No rules apply.
    k=2
       Create node R. [S | 1 | 3 | --- | --- | --- | 0]
```

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       Rule S → NP Verb [0.1]
       Combination of L & I and prob of rule has probability 0.035 * 0.8 * 0.1 = 0.0028
       Change R to be [S | 1 | 3 | --- | L | I | 0.0028]
M=NP
    k=1
       No rules apply.
    k=2
       Create node S. [NP | 1 | 3 | --- | --- | --- | 0]
       Rule NP → AdjList Noun [0.3]
       Combination of N & H and has probability 0.25 * 0.6 * 0.3 = 0.045
       Change S to be [NP | 1 | 3 | --- | N | H | 0.045]
 M=VP
    k=1
        Create node T. [VP | 1 | 3 | --- | --- | --- | 0]
        Rule VP → Verb NP [0.3]
        Combination of A & O and has probability 0.1 * 0.21 * 0.3 = 0.0063
        Change T to be [VP | 1 | 3 | --- | A | O | 0.0063]

i=2
j=4
 M=S
     k=1
        Create node U. [S | 2 | 4 | --- | --- | --- | 0]
        Rule S → Noun VP [0.3]
        Combination of D & Q and has probability 0.1 * 0.08 * 0.3 = 0.0024
        Change U to be [S | 2 | 4 | --- | D | Q | 0.0024]

    k=2
        Rule S → NP Verb [0.1]
        Combination of O & K and has probability 0.21 * 0.6 * 0.1 = 0.0126
        Change U to be [S | 2 | 4 | --- | O | K | 0.0126]

length=4
 i=1
 j=4
  M=S
      k=1
        No rules apply.
      k=2
         Create node V. [S | 1 | 4 | --- | --- | --- | 0]
         Rule S → NP VP [0.6]
         Combination of L & Q and has probability 0.035 * 0.08 * 0.6 = 0.00168
         Change V to be [S | 1 | 4 | --- | L | Q | 0.00168]

      k=3
```
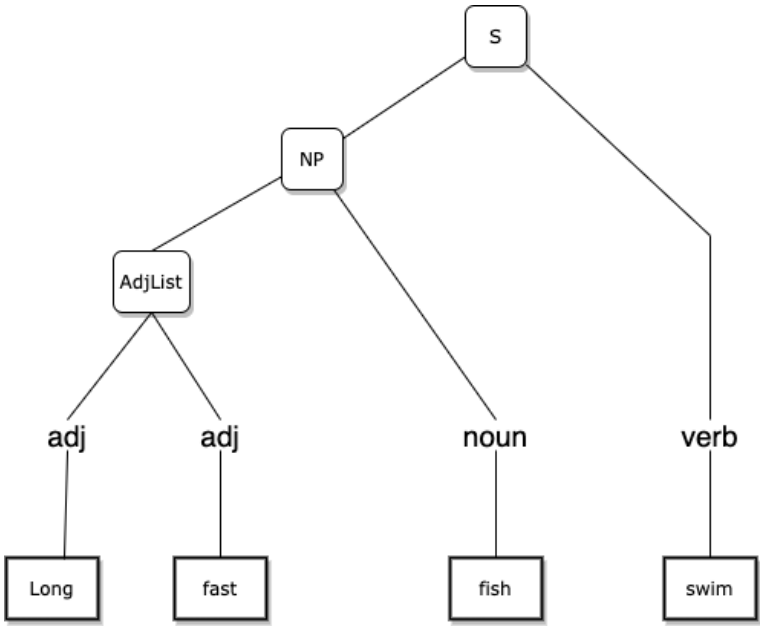
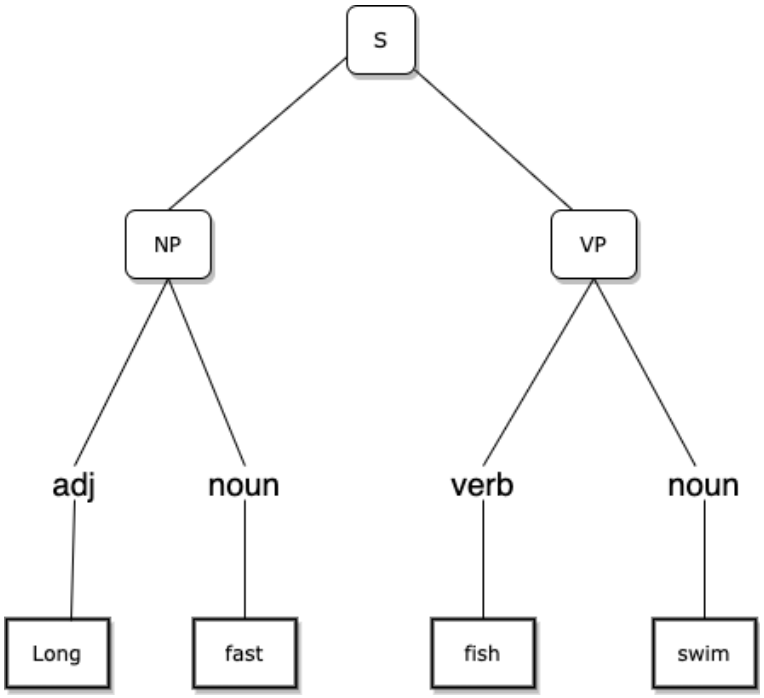

```
        Rule S → NP Verb [0.1]
        Combination of T & K and has probability 0.045 * 0.6 * 0.1 = 0.0027
        Change V to be [S | 1 | 4 | --- | T | K | 0.0027]

Done. Termination!

Final tree:
                S
                    NP
                        AdjList
                               Adj Long
                               Adj fast
                        Noun  fish
                    Verb swim
```

Solution to B:
Using the "Final Tree" from part A obtained by the CYK algorithm, the parse tree yielded is as follows:



Based on the last iteration, second possible parse tree could look like this but it is has lower probability.



End of Assignment. Thank you!