Admistrivia

- Implement a streaming algorithm for HM 4.
- Please read chapter 13 and 14 for next time

Why parse?

What is the advantage of generating a parse tree over simple POS?

- POS is easy HMM and fast (it is a local problem)
- Parsing is difficult
- But, knowing whether it is “man bites dog” vs “dog bites man” is important.
- Finding the “subject” is not a local property.
- Hence must parse the entire sentence.
Top down recursion: scalar case

Recursive algorithm:
(see hand notes)

Top down recursion: vector case

Recursive algorithm:
(see hand notes)

Interesting probabilities

• Note really interested in ”Probably of sentence.”
• Want probably of parse given sentence
• Like function estimation: estimate the point? Or estimate the function?

Speed hack: Trick from Fubinichi

\[ f(n) = f(n - 1) + f(n - 2) \]

Try a calculation:

\[ f(10) = f(9) + f(8) \]
\[ = (f(8) + f(7)) + (f(7) + f(6)) \]
\[
= ((f(7) + f(6) + f(6) + f(5)) + ((f(6) + f(5) + f(5) + f(4)))
= \ldots
\]

It will have about a thousand terms when we are done! Here is a “cute trick”:

\[
\begin{align*}
    f(10) &= f(9) + f(8) \\
    f(9) &= f(8) + f(7) \\
    f(8) &= f(7) + f(6) \\
    f(7) &= f(6) + f(5) \\
    f(6) &= f(5) + f(4) \\
\end{align*}
\]

\[
= \ldots
\]

Now only 10 equations in 10 unknowns. Solve it by back substitution. Called “caching” in computer science.

**What should we cache?**

- Any sequence of words can possibly equal a “term”
- So mark each possible sequence with any term it might equal.
- Simple recursion: Check all subdivisions and see if it makes up a new term.
- A total of \(n^2\) possible points to cache
- Each takes at most \(n\) time to compute if it is one of the \(k\) possible terms
- Total complexity: $n^3k$
- Called CKY

**Table form**

- Words across the top.
- Upper right hand corner is target
- “POS” on diagonal (they are now cached)

**Variation: Earley and Chart**

- Different orders of evaluation
- Allows slightly more intelligence
- Even a little context can come in
- But most sentence parsing is still $n^3$ with real systems.