Parsing I

Jurafsky and Martin, Chapters 10, 13

Miriam Butt
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Parsing Strategies

Starting with a given string and a given grammar, a parser has several strategic options.

Left-to-Right vs. Right-to-Left

Bottom-Up vs. Top-Down

Parsing Strategies

N V Adv Det N | Time flies like an arrow. | Adj N V Det N

Left-to-Right

Start with the left edge of the string and work rightwards.

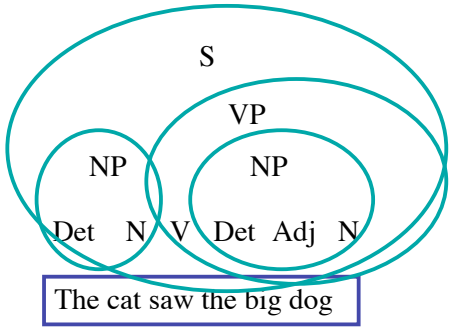
Right-to-Left

Start with the right edge of the string and work leftwards.

Need a Lexicon with (minimally) POS Information

Parsing Strategies
Bottom Up

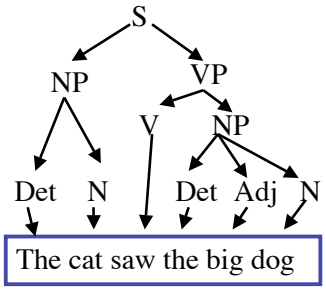
Start with the terminal elements, try to identify their POS and build them into constituents permitted by the grammar.



Parsing Strategies
Top down

Start with the top level phrase structure rule, expand it and try to fit the terminal elements with a possible expansion of the phrase structure rule.

1. S → NP VP
2. NP → Det Adj N
3. NP → N
4. NP → Det N
5. VP → V
6. VP → V NP
7. Det → {the|The}
8. N → {cat|dog}
9. Adj → big
10. V → saw



Complexity

- How Complex is a given Problem?
- What formal mechanisms best model this complexity?

Natural Language: used to be thought of as a sort of "code". That is hard, but regular.

Now: mind-bogglingly complex.

But: is it an unsolvable problem?

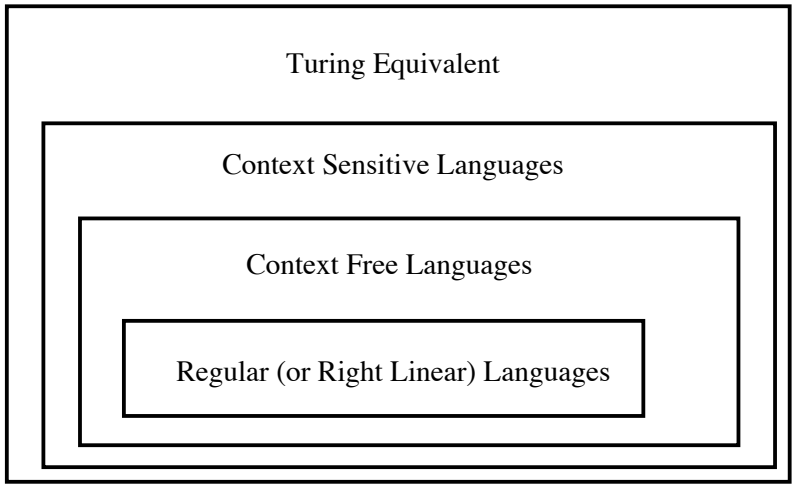
Generative Power

Chomsky defined a theory of language (syntax) in terms of **generative** linguistics.

Given a set of rules and a lexicon, what well-formed expressions can we generate and do those adequately cover the empirical data we observe?

"One grammar is of greater generative power or complexity than another if it can define a language that the other cannot define." (J&M p. 478)

The Chomsky Hierarchy



Natural Language

Is it regular? Overall no.

But, subparts of it are: phonology and morphology (can be treated via FST which are known to be regular, Kaplan and Kay 1994, Karttunen 2002).

How can we tell if a language is not regular?

The Pumping Lemma

The Pumping Lemma

Let L be an infinite regular language. Then there are strings x, y, and z, such that $y \neq \varepsilon$ and $xy^nz \in L$ for $n \geq 0$.

If a language is regular, it can be modeled by a FSA.

If you have a string which is longer than the fixed number of, the FSA must have a loop.

$a^n b^n$ is not a part of this language (see J&M p. 484)

Natural Language

Center Embedding:

Natural Language contains strings like:

The cat likes tuna fish.
The cat the dog chased likes tuna fish.
The cat the dog the rat bit chased likes tuna fish.
The cat the dog the rat the elephant admired bit chased likes tuna fish.

$a^n b^{n-1}$ so, not a regular language

Natural Language

Is it context-free? No.

Evidence from **cross-serial dependencies** in Swiss German spoken in Zurich (Huybregts1984, Shieber 1985)

$x_1 x_{2...} x_n ...$ $y_1 y_{2...} y_n$

So: non context-free language: $a^n b^m c^n d^m$

Swiss German

Jan säit das

mer em Hans/**Dat** es huus/**Acc** hälfed/**Dat** aastriche/**Acc**

mer d'chind/**Acc** em Hans/**Dat** es huus/**Acc** haend wele laa/**Acc** hälfe/**Dat** aastriche/**Acc**.

The number of verbs requiring dative/accusative must equal the number of datives/accusatives

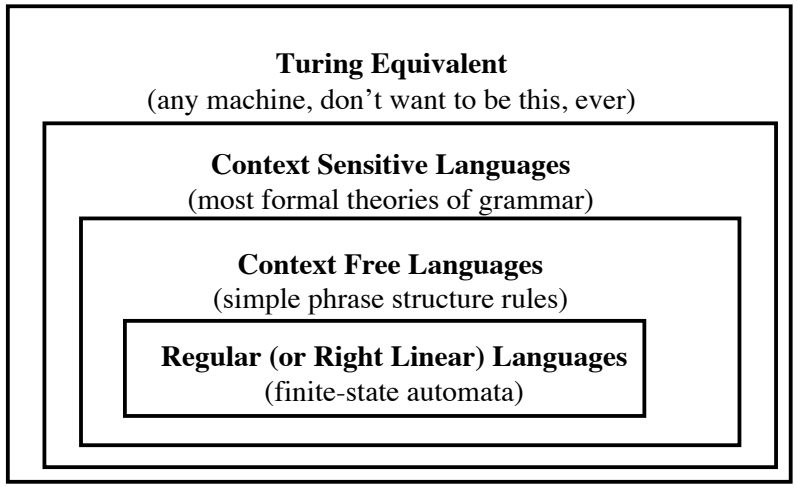
$a^n b^m c^n d^m$ so, not a context-free language

Natural Language

So, Natural Language turns out to be a very hard problem: an **NP-complete** problem (term from computer science).

Should we give up? No --- there are still ways to make things computable.

The Chomsky Hierarchy



Decidability

The more you know about the formal properties of an underlying syntactic theory, the better.

Montonicity: this basically means you do not overwrite information once you've got it as part of your analysis.

Mathematical Proofs: based on the properties of one's formal theory**,** one can prove whether it is *decidable* or not.

Decidability

The more you know about the formal properties of an underlying syntactic theory, the better.

GB/Minimalism: couched in a very formal way, but includes unconstrained movements, which makes it *non-monotonic* and puts it into the space of a Turing Machine.

HPSG: formal properties still under debate and an active area of research (e.g., Lexical Rules).

LFG: formal properties well understood and has been proven to be decidable (Kaplan and Bresnan 1982, Backofen 1993).

Decidability

"First, an explanatory linguistic theory undoubtedly will impose a variety of substantive constraints on how our formal devices may be employed in grammars of human languages. ... It is quite possible that the worst case computational complexity for the subset of lexical-functional grammars that conform to such constraints will be plausibly sub-exponential." [Kaplan and Bresnan 1982]

In practice, one can (and does) also come up with smart computational techniques that avoide the worst-case scenario.