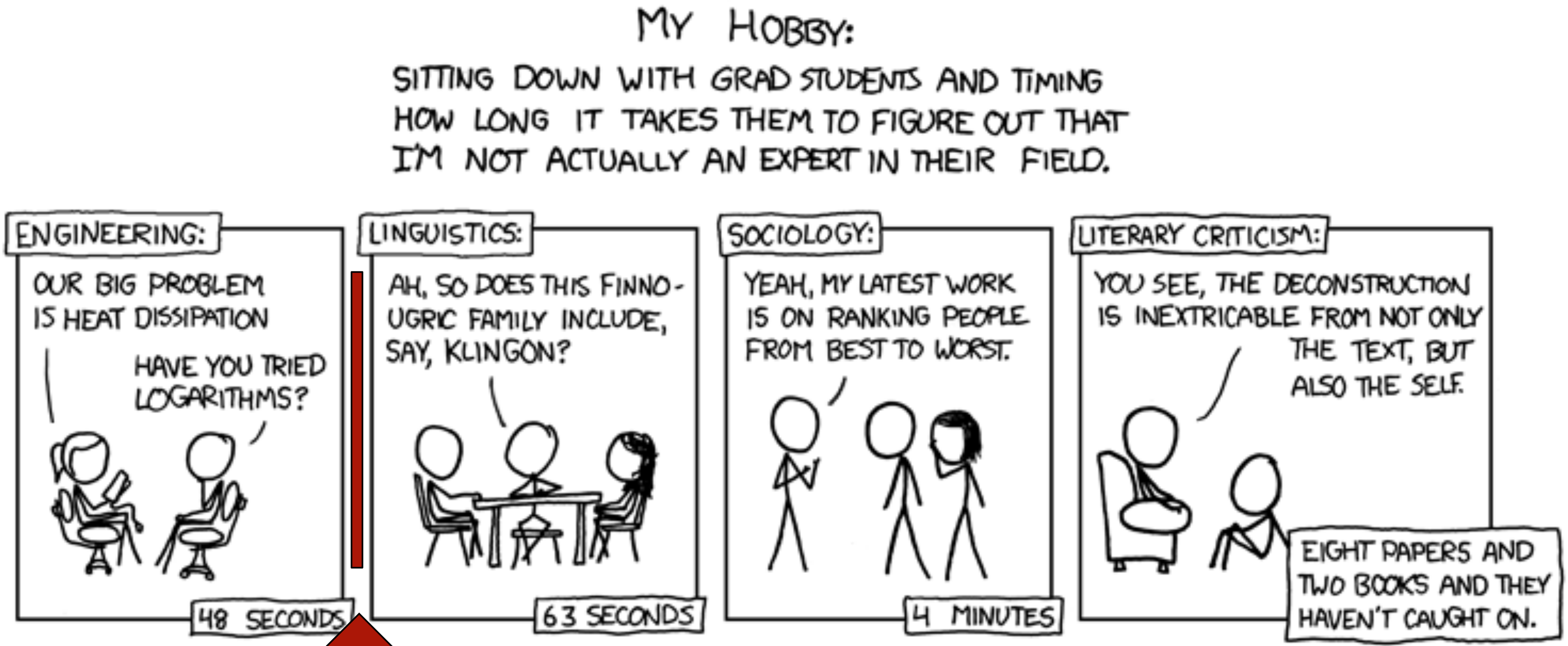
Computational Linguistics


MY HOBBY:
SITTING DOWN WITH GRAD STUDENTS AND TIMING HOW LONG IT TAKES THEM TO FIGURE OUT THAT I'M NOT ACTUALLY AN EXPERT IN THEIR FIELD.
ENGINEERING:
OUR BIG PROBLEM IS HEAT DISSIPATION
HAVE YOU TRIED LOGARITHMS?
48 SECONDS
LINGUISTICS:
AH, SO DOES THIS FINNO-UGRIC FAMILY INCLUDE, SAY, KLINGON?
63 SECONDS
SOCIOLOGY:
YEAH, MY LATEST WORK IS ON RANKING PEOPLE FROM BEST TO WORST.
4 MINUTES
LITERARY CRITICISM:
YOU SEE, THE DECONSTRUCTION IS INEXTRICABLE FROM NOT ONLY THE TEXT, BUT ALSO THE SELF.
EIGHT PAPERS AND TWO BOOKS AND THEY HAVEN'T CAUGHT ON.

Today, we explore this interstice

cartoon from xkcd.com

Computational Linguistics
(aka Natural Language Processing)

Christopher Manning

Ling 1

November 4, 2011

What is Computational Linguistics?

- Getting computers to perform useful tasks involving human languages whether for:
  - Enabling human-machine communication
  - Improving human-human communication
  - Doing stuff with language data … email, blogs, etc.

- Examples:
  - Machine Translation
  - Automatic Question Answering
  - Speech Recognition
  - Text-to-Speech Synthesis
  - Text Understanding

CL vs. NLP

- Why say “Computational Linguistics (CL)” versus “Natural Language Processing” (NLP)?

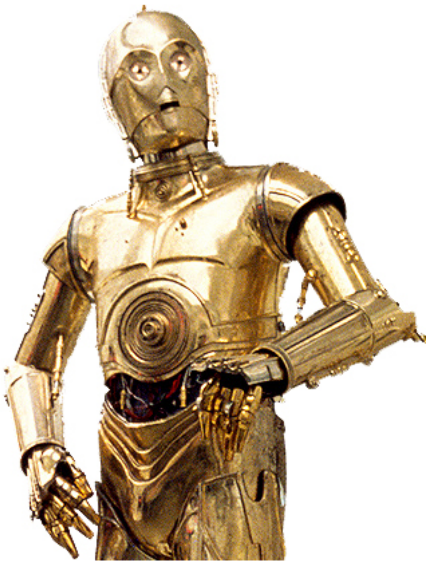
- Either choose either freely or …

- Computational Linguistics
  - The science of computers dealing with language
  - Some interest in modeling what people do

- Natural Language Processing
  - Developing computer systems for processing and understanding human language text

The Vision

I’m sorry, Dave.
I can’t do that.



Oh, dear!

That is correct,
captain.

Language: the ultimate UI

Where is A Bug's Life playing in Mountain View?

A Bug's Life is playing at the Century 16 Theater.

When is it playing there?

It's playing at 2pm, 5pm, and 8pm.

OK. I'd like 1 adult and 2 children for the first show.
How much would that cost?

But we need domain knowledge, discourse knowledge, world knowledge
(Not to mention linguistic knowledge!)

NLP: Goals of the field

- From the lofty …
  - full-on natural language understanding
  - participation in spoken dialogues
  - open-domain question answering
  - real-time bi-directional translation
- … to the mundane

  Predominant in recent years

  - identifying spam
  - categorizing news stories
  - finding & comparing product information on the web
  - assessing sentiment toward products, brands, stocks, …

NLP in the commercial world

the problem session for your course, CS224n in Gates B03 from 1:15-2:05 Skilling Aud

Create New iCal Event...
Show This Date in iCal...

ski resort

[Sugar Bowl **Ski** Lodging]

Escape to our Snowbound Village.
Fresh tracks steps from your room.
www.sugarbowl.com

Their are many approaches, out

cymfony
harnessing influ
PEARSON
Knowledge Technologies
Google
Powerset
YAHOO!
Microsoft
BETA
hakia
search for meaning
collective intellect
J.D.POWER
AND ASSOCIATES
Nielsen
BuzzMetrics

Current motivations for NLP

What's driving NLP? Three trends:

- The explosion of machine-readable natural language text
  - Exabytes (10^{18} bytes) of text, doubling every year or two
  - Web pages, emails, IMs, SMSs, tweets, docs, PDFs, …
  - Opportunity — and increasing necessity — to extract meaning
- Mediation of human interactions by computers
  - Opportunity for the computer in the loop to do much more
- Growing role of language in human-computer interaction

Further motivation for CL

One reason for studying language — and for me personally the most compelling reason — is that it is tempting to regard language, in the traditional phrase, as a "mirror of mind".
Chomsky, 1975

For the same reason, computational linguistics is a compelling way to study human language acquisition and processing.

Sometimes, the best way to understand something is to build a model of it.

What I cannot create, I do not understand. Feynman, 1988

Subfields and tasks

mostly solved

Spam detection

OK, let's meet by the big … ✓

D1ck too small? Buy V1AGRA … ✗

Text categorization

Phillies shut down Rangers 2-0 SPORTS

Jobless rate hits two-year low BUSINESS

Part-of-speech (POS) tagging

ADJ	ADJ	NOUN	VERB	ADV
Colorless	green	ideas	sleep	furiously.

Named entity recognition (NER)

PERSON	ORG	LOC
Obama	met with UAW leaders	in Detroit …

Information extraction (IE)

You're invited to our bunga bunga party, Friday May 27 at 8:30pm in Cordura Hall

Party
May 27
add

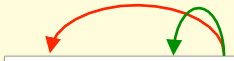
making good progress

Sentiment analysis

The pho was authentic and yummy. 👍

Waiter ignored us for 20 minutes. 👎

Coreference resolution

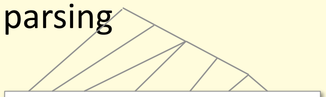


Obama told Mubarak he shouldn't run again.

Word sense disambiguation (WSD)

I need new batteries for my *mouse*.

Syntactic parsing



I can see Russia from my house!

Machine translation (MT)

Our specialty is panda fried rice. ⇨

我们的专长是熊猫炒饭

still really hard

Semantic search

people protesting globalization Search

⇨ …demonstrators stormed IMF offices…

Question answering (QA)

Q. What currency is used in China?

A. The yuan

Textual inference & paraphrase

T. Thirteen soldiers lost their lives …

H. Several troops were killed in the … YES

Summarization

Sheen continues rant against … ⇨ Sheen is nuts

Discourse & dialog

Where is Thor playing in SF?

Metreon at 4:30 and 7:30

Why is computational linguistics hard?

Human languages:

- are highly ambiguous at all levels
- are complex, with recursive structures and coreference
- subtly exploit context to convey meaning
- are fuzzy and vague
- require reasoning about the world for understanding
- are part of a social system: persuading, insulting, amusing, …

(Nevertheless, simple features often do half the job!)

OK, why *else* is NLP hard?

Oh so many reasons!

non-standard English

Great job @justinbieber! Were SOO PROUD of what youve accomplished! U taught us 2 #neversaynever & you yourself should never give up either♥

segmentation issues

the New York-New Haven Railroad

the New York-New Haven Railroad

idioms

dark horse
get cold feet
lose face
throw in the towel

neologisms

unfriend
retweet
bromance
teabagger

garden path sentences

The man who hunts ducks out on weekends.

The cotton shirts are made from grows here.

tricky entity names

… a mutation on the *for* gene …

Where is *A Bug's Life* playing …

Most of *Let It Be* was recorded …

world knowledge

Mary and Sue are sisters.

Mary and Sue are mothers.

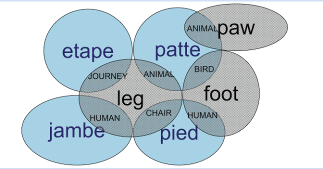
prosody

I never said *she* stole my money.

I never said she *stole* my money.

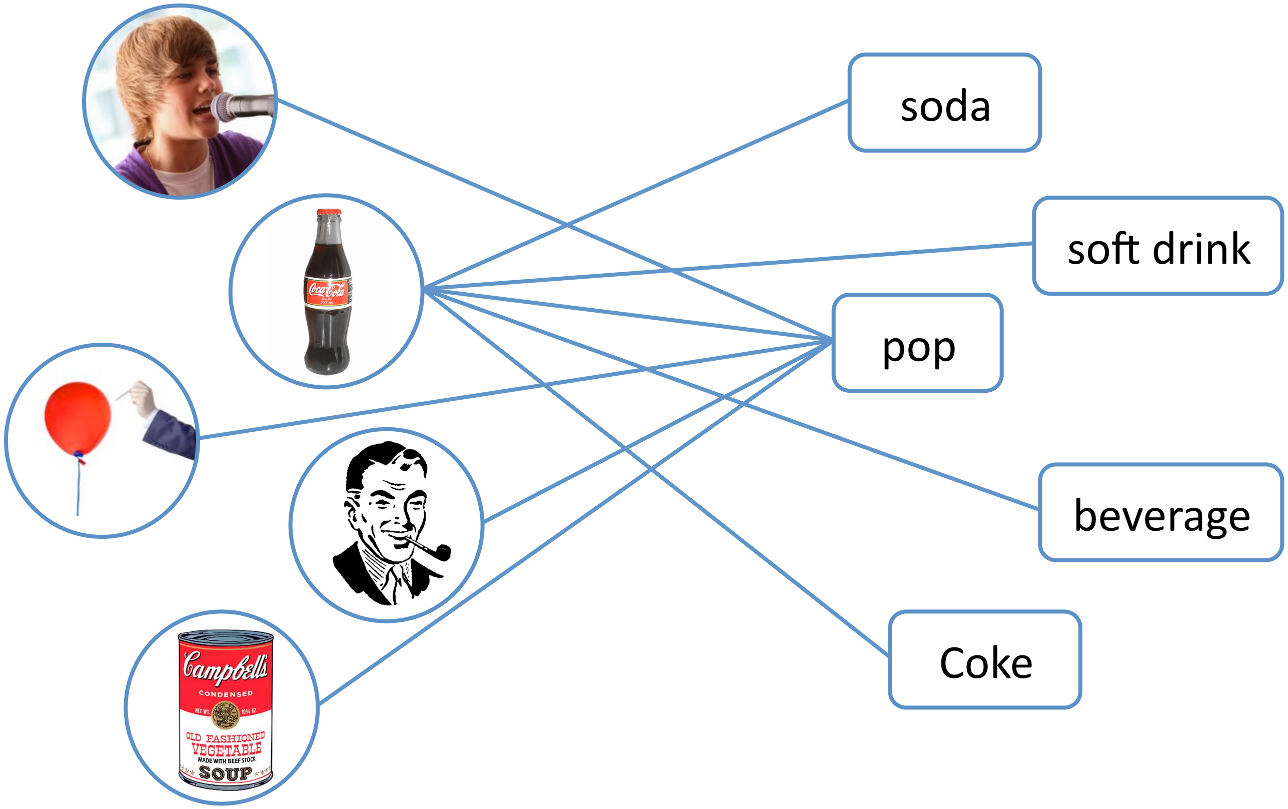
I never said she stole *my* money.

lexical specificity



But that's what makes it fun!

Meanings and expressions



soda

soft drink

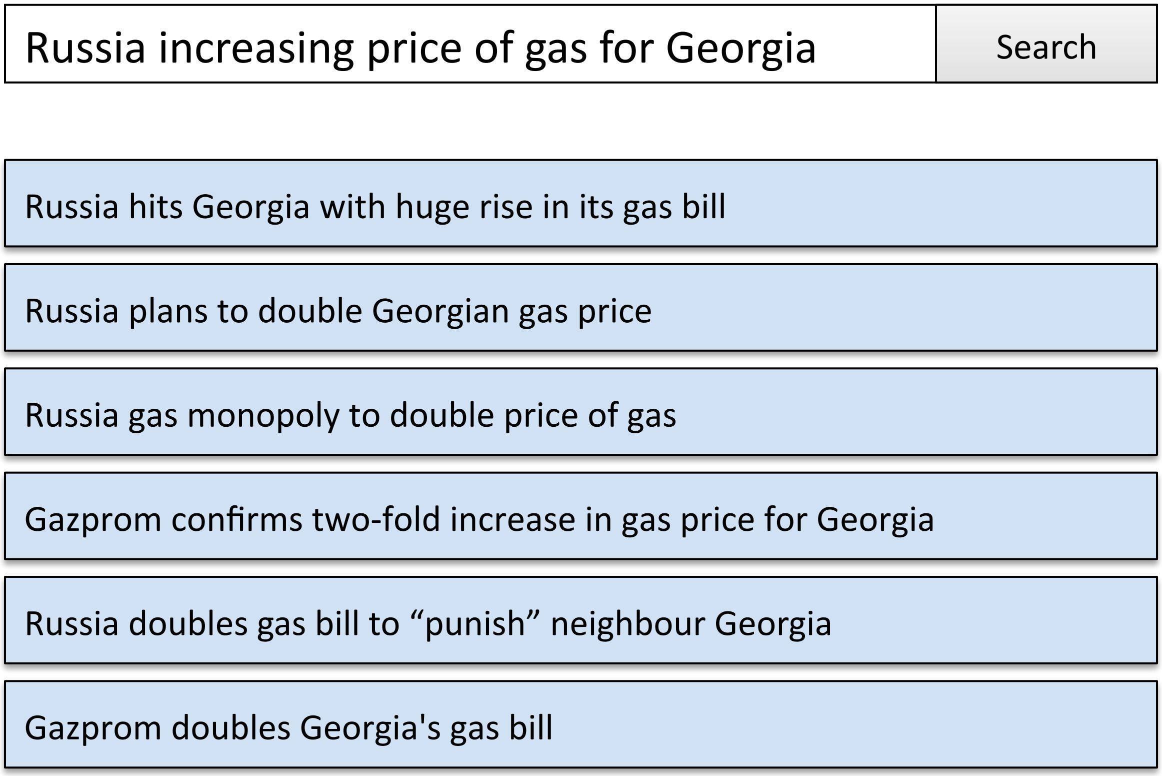
pop

beverage

Coke

One meaning, many expressions

Consider a semantic search application:



Russia increasing price of gas for Georgia

Russia hits Georgia with huge rise in its gas bill

Russia plans to double Georgian gas price

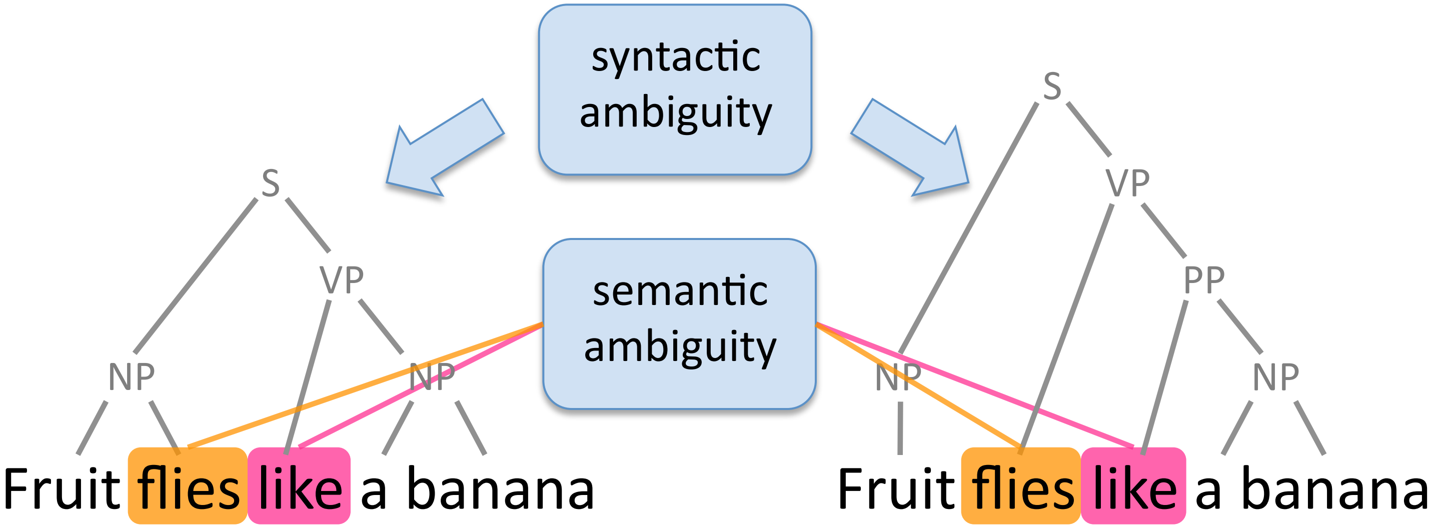
Russia gas monopoly to double price of gas

Gazprom confirms two-fold increase in gas price for Georgia

Russia doubles gas bill to “punish” neighbour Georgia

Gazprom doubles Georgia's gas bill

One expression, many meanings
Syntactic & semantic ambiguity

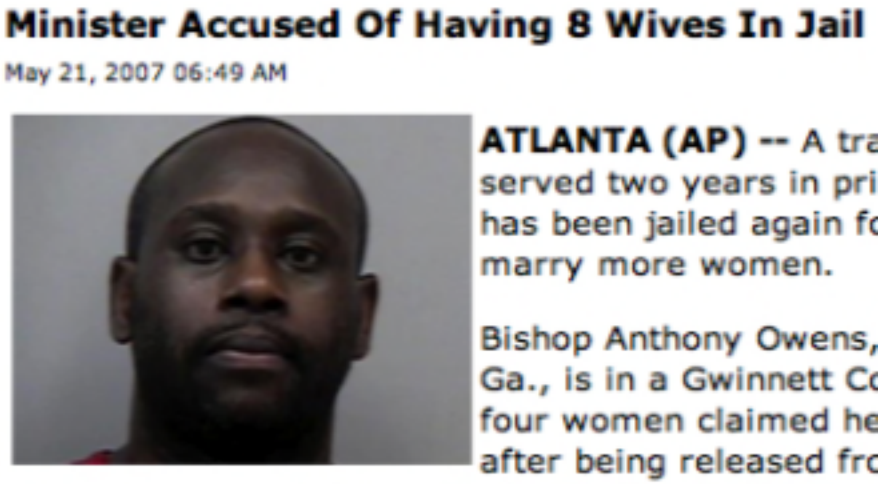


syntactic ambiguity

semantic ambiguity

photos from worth1000.com

Ambiguous headlines



Minister Accused Of Having 8 Wives In Jail

May 21, 2007 06:49 AM

ATLANTA (AP) -- A tra
served two years in pri
has been jailed again fo
marry more women.

Bishop Anthony Owens,
Ga., is in a Gwinnett Co
four women claimed he
after being released fro

100%
REAL

Teacher Strikes Idle Kids

China to Orbit Human on Oct. 15

Juvenile Court to Try Shooting Defendant

Clinton Wins on Budget, but More Lies Ahead

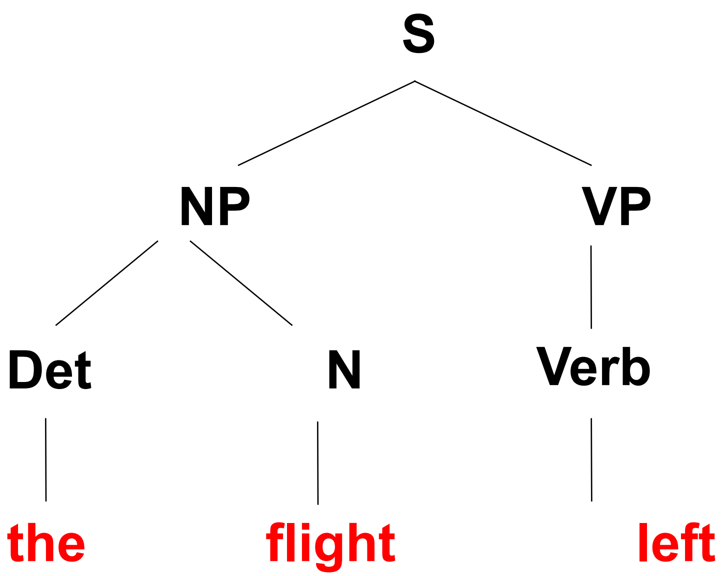
Local High School Dropouts Cut in Half

Police: Crack Found in Man’s Buttocks

Parsing

- Parsing is the process of taking a string and a grammar and returning a parse tree or trees for that string

the flight left



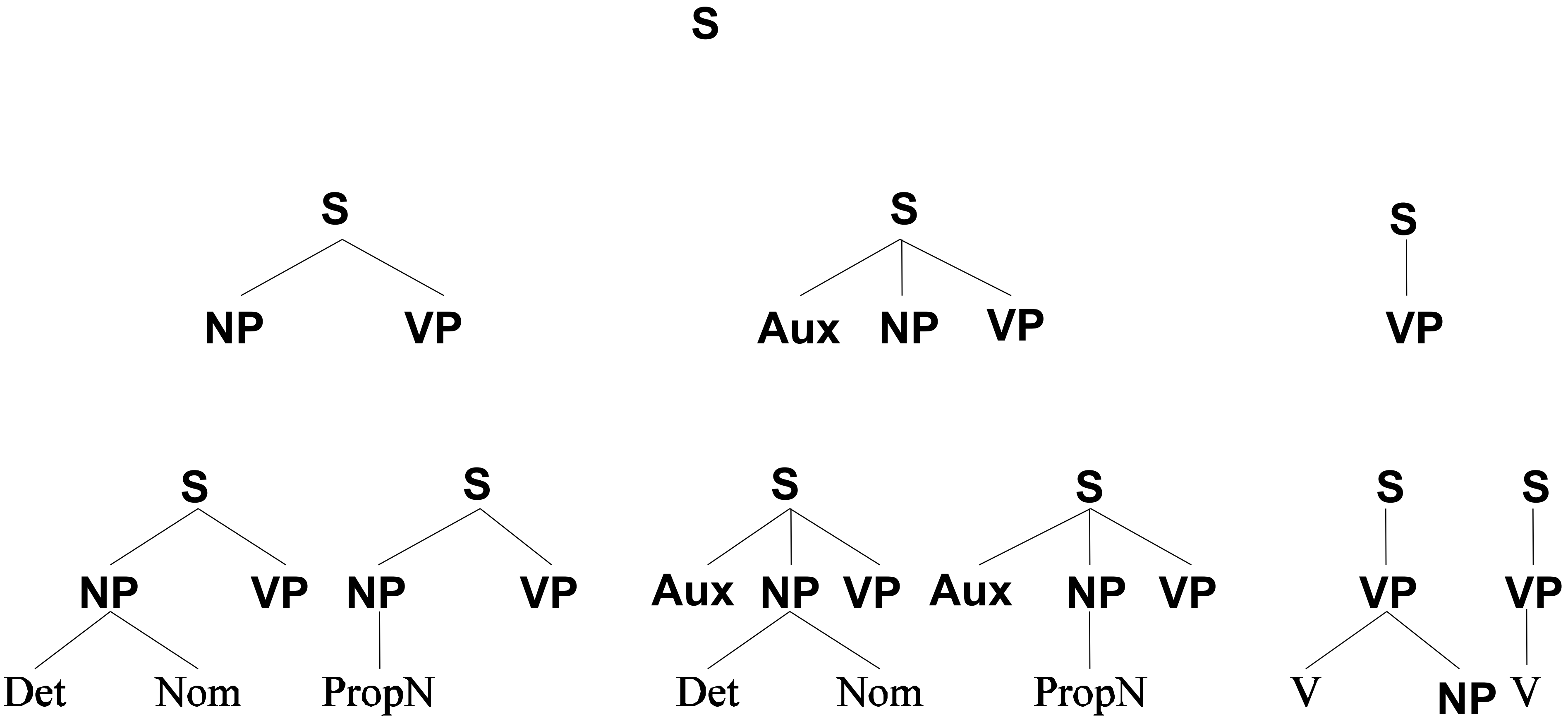
Parsing involves search

- As with most everything of interest, parsing involves a search which involves the making of choices
- We’ll look at some basic methods to give you an idea of the problem

Top-Down Parsing

- Since we’re trying to find trees rooted with an S (Sentence) start with the rules that give us an S.
- Then work your way down from there to the words.

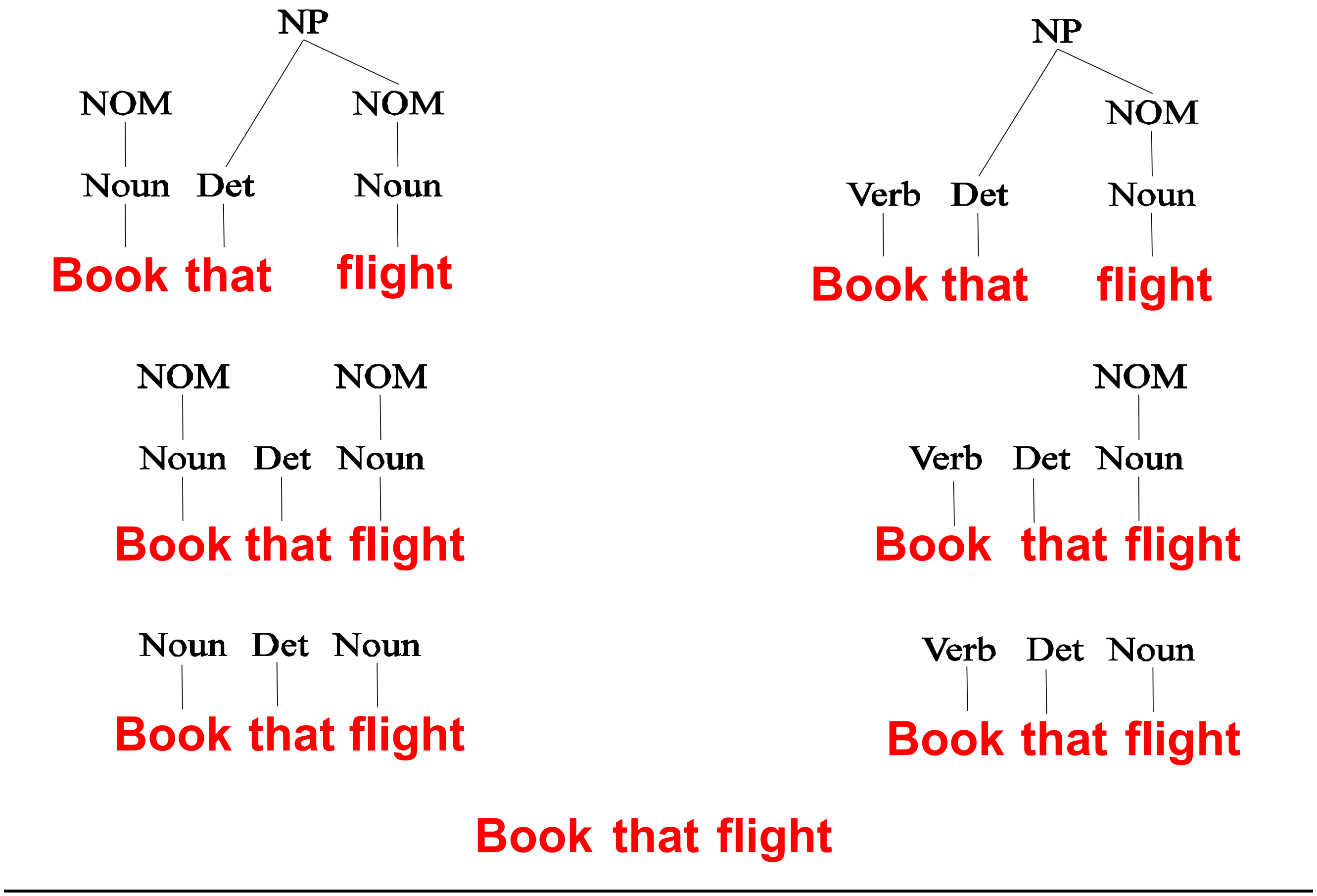
Top-Down Space



Bottom-Up Parsing

- Of course, we also want trees that cover the input words. So start with trees that link up with the words in the right way.
- Then work your way up from there.

Bottom-Up Space



NP
NOM NOM
Noun Det Noun
Book that flight

NP
NOM
Verb Det Noun
Book that flight

NOM NOM
Noun Det Noun
Book that flight

NOM
Verb Det Noun
Book that flight

Noun Det Noun
Book that flight

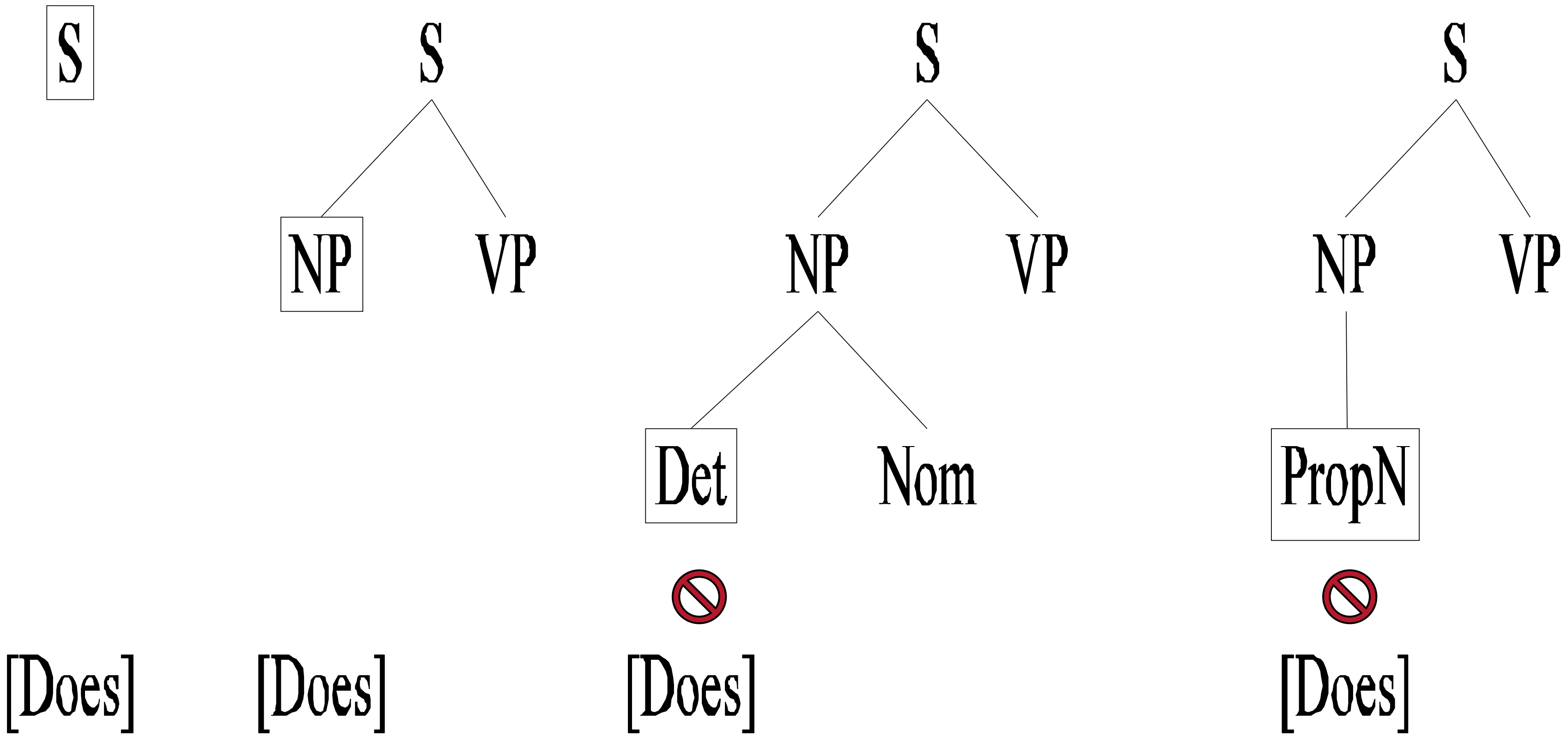
Verb Det Noun
Book that flight

Book that flight

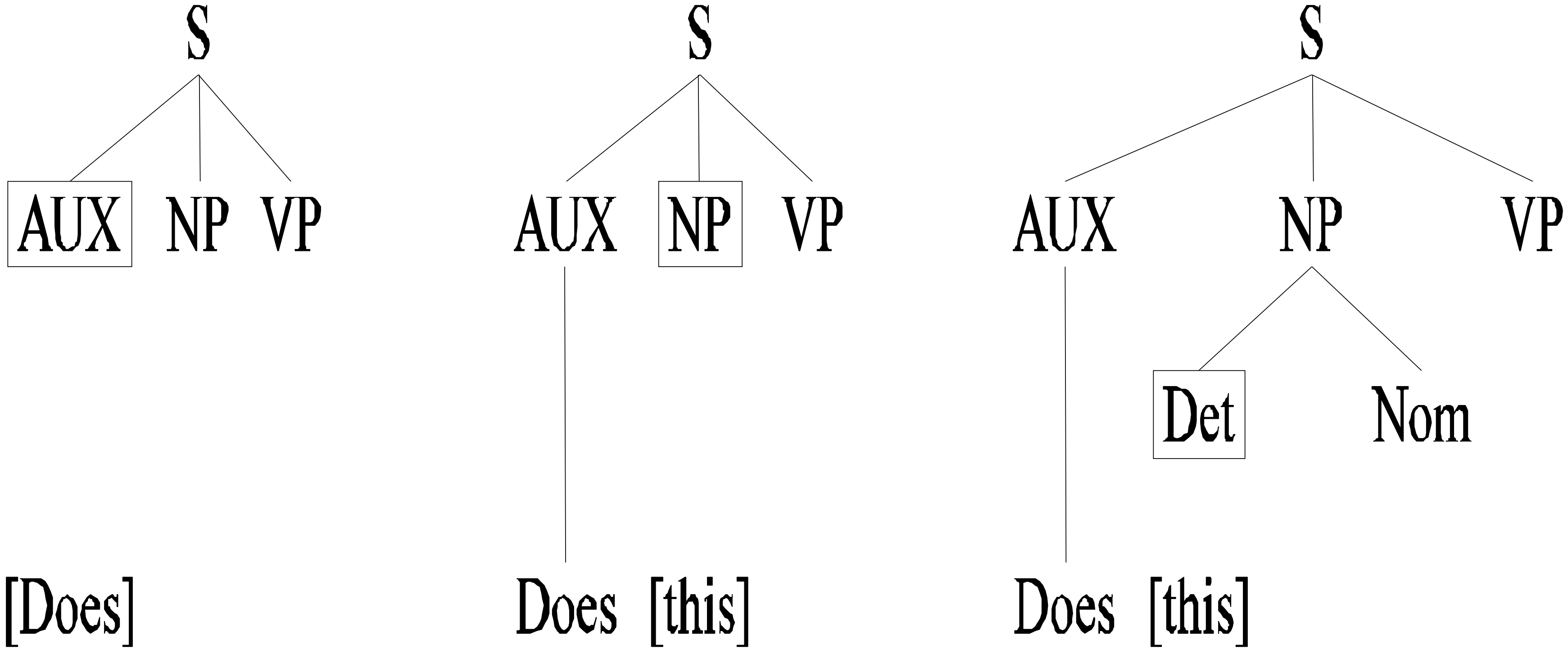
Control

- We need to keep track of the search space and have a strategy to make choices
    - We need to systematically explore everything to make sure we find the right parse for a sentence
    - Which node to try to expand next?
    - Which grammar rule to use to expand a node?

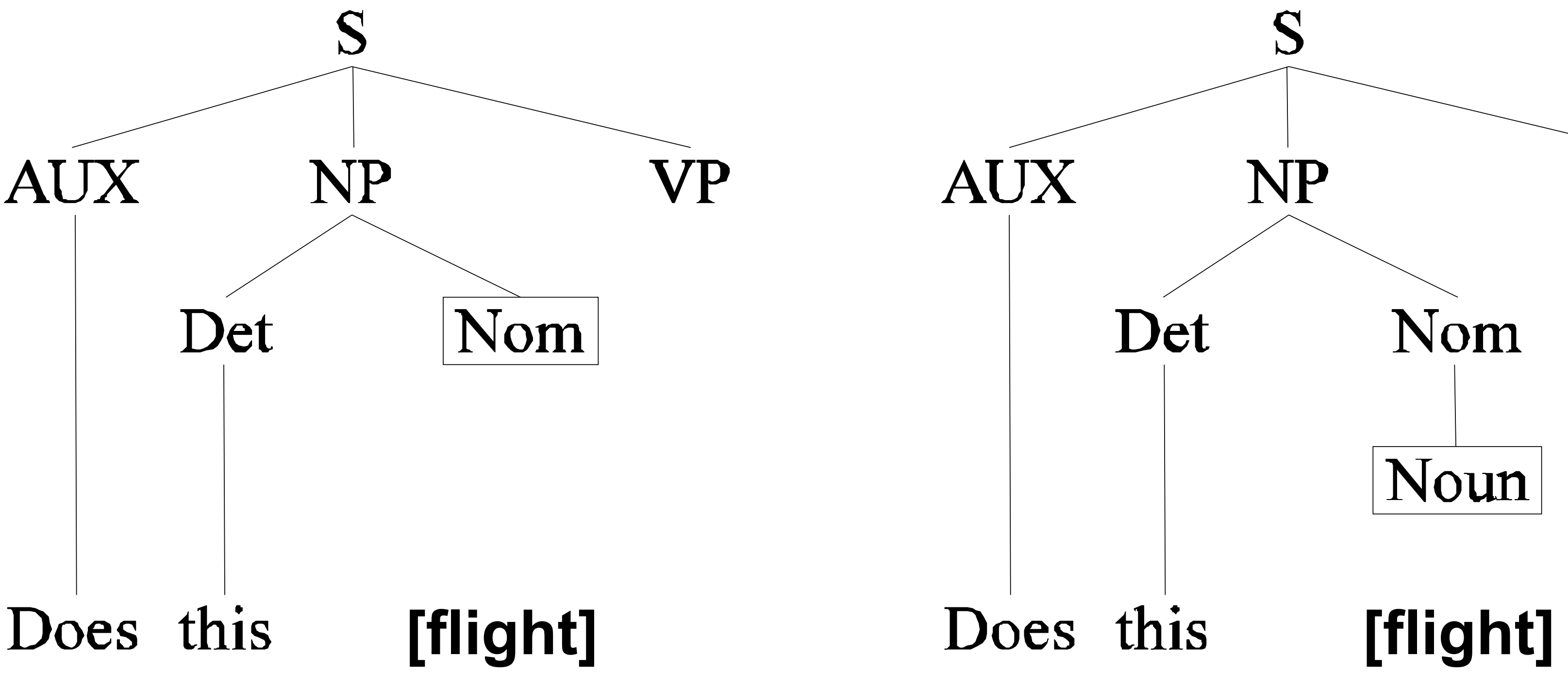
Top-Down, Depth-First, Left-to-Right Search



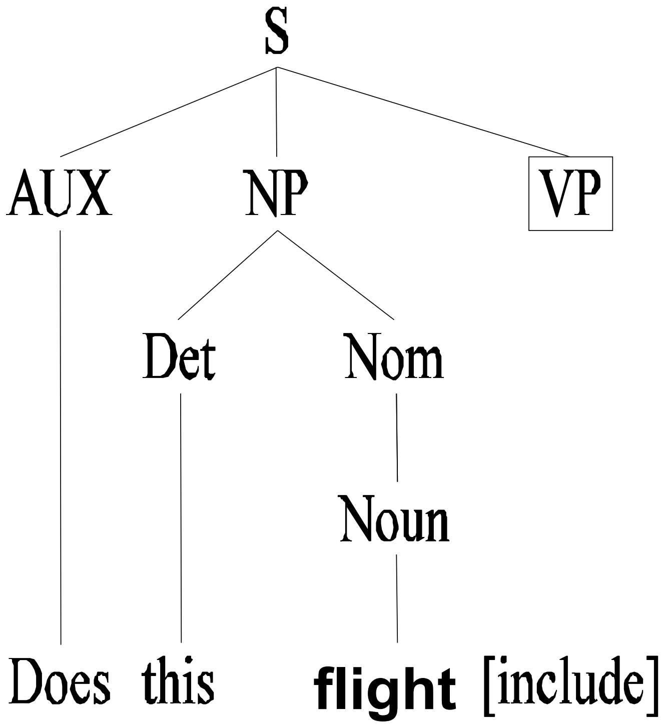
Example

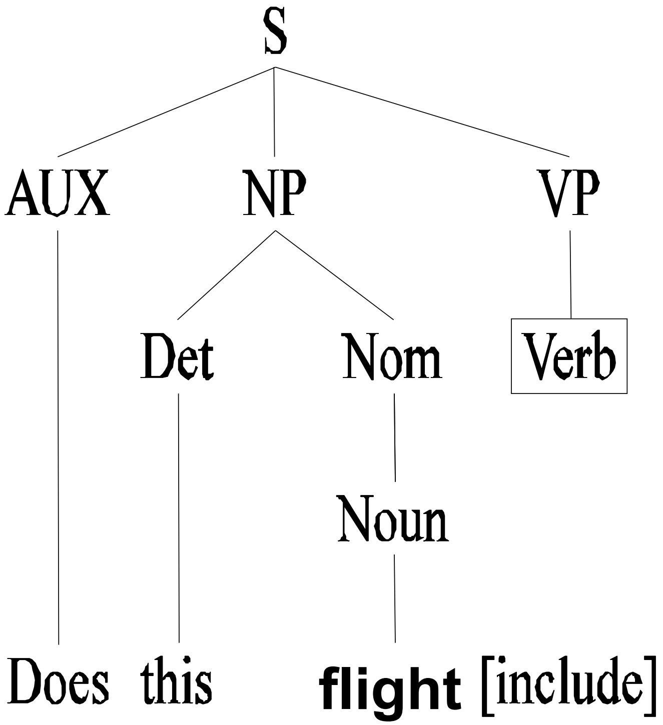

S
AUX
NP
VP
[Does]
S
AUX
NP
VP
Does
[this]
S
AUX
NP
VP
Det
Nom
Does
[this]

Example


S
AUX
NP
VP
Det
Nom
Does
this
[flight]
S
AUX
NP
VP
Det
Nom
Noun
Does
this
[flight]

Example


S
AUX
NP
VP
Det
Nom
Noun
Does
this
flight
[include]


S
AUX
NP
VP
Det
Nom
Verb
Noun
Does
this
flight
[include]

Efficient parsing

- That should give you the general idea of how a parser can work by exploring hypotheses systematically
- But really we need to do much more to make parsing efficient … this leads into dynamic programming, memoization, and other tricky stuff that I won’t mention further here.

How to choose between parses?

- Probabilistic methods!
- Augment the grammar rules with probabilities
- Modify the parser to keep only most probable parses
- At the end, return the most probable parse

A statistical scientific revolution

- Computational Linguistics before 1990:
  - Hand-built parsers, hand-built dialogue systems
  - High precision, low coverage methods

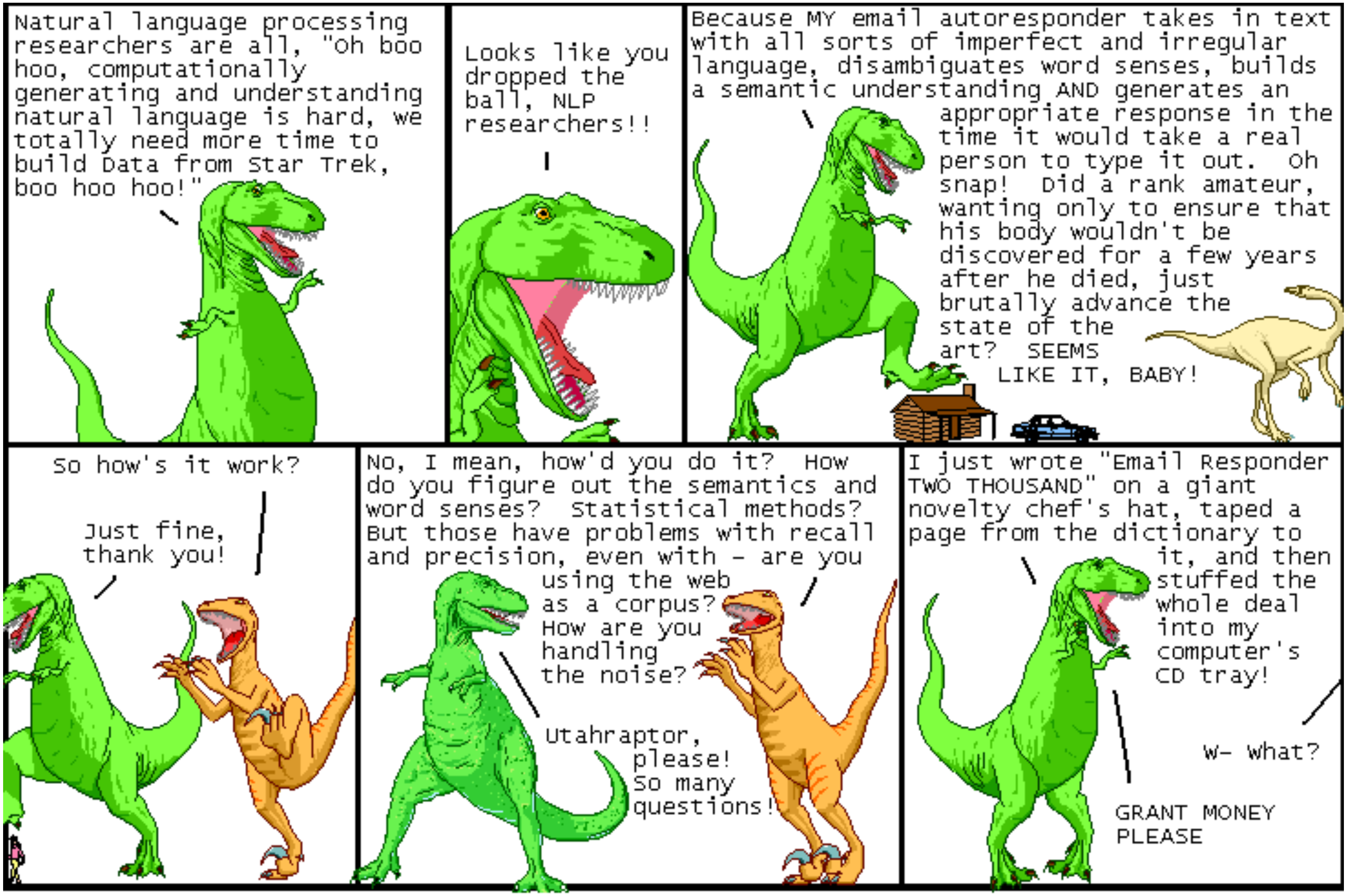
- Computational Linguistics after 1995:
  - Automatically trained parsers, unsupervised clustering, statistical machine translation
  - High coverage, low precision methods
  - Build models exploiting **data**

Demos!

If you might like NLP / CompLing …

- learn Java or Python (and play with JavaNLP or NLTK)
- get some exposure to linguistics (LING1, …)
- and to logic, probability, statistics, linear algebra
- study AI and machine learning (CS121, CS221, CS229)
- read Jurafsky & Martin or Manning & Schütze
- Take
  - Ling 180/CS124: From Languages to Information
  - Ling 284/CS224N: Natural Language Processing
  - Ling 281/CS224S: Speech Recognition & Synthesis
  - Ling /CS224U: Natural Language Processing

One more for the road


Natural language processing researchers are all, "oh boo hoo, computationally generating and understanding natural language is hard, we totally need more time to build Data from Star Trek, boo hoo hoo!"
Looks like you dropped the ball, NLP researchers!!
Because MY email autoresponder takes in text with all sorts of imperfect and irregular language, disambiguates word senses, builds a semantic understanding AND generates an appropriate response in the time it would take a real person to type it out. Oh snap! Did a rank amateur, wanting only to ensure that his body wouldn't be discovered for a few years after he died, just brutally advance the state of the art? SEEMS LIKE IT, BABY!
So how's it work?
Just fine, thank you!
No, I mean, how'd you do it? How do you figure out the semantics and word senses? Statistical methods? But those have problems with recall and precision, even with - are you using the web as a corpus? How are you handling the noise?
Utahraptor, please! So many questions!
I just wrote "Email Responder TWO THOUSAND" on a giant novelty chef's hat, taped a page from the dictionary to it, and then stuffed the whole deal into my computer's CD tray!
W- What?
GRANT MONEY PLEASE

cartoon from gwantz.com