Algorithms for Natural Language Processing

Lecture 8: Parts of Speech

- My cat who lives dangerously no longer has nine lives.

- My cat who lives dangerously no longer has nine lives.

- My cat who lives dangerously no longer has nine lives.

- lives: noun /lajvz/
- lives: verb /lɪvz/

- Mr. Black used to have a black beard but it is less black now than it used to be. He might black out if he realizes this fact.

- Mr. Black used to have a black beard but it is less black now than it used to be. He might black out if he realizes this fact.

Part-of-Speech Tagging Task

- Input: a sequence of word tokens **w**
- Output: a sequence of part-of-speech tags **t**, one per word

The linguistic facts are considerably more complicated than the state of affairs presupposed by the structure of this task, but there are good reasons for keeping it simple.

Example

Charlie	Brown	received	a	valentine	.

Example

Charlie	Brown	received	a	valentine	.
proper noun	proper noun	verb	determiner	noun	punctuation

Example

Charlie	Brown	received	a	valentine	.
proper noun	proper noun	verb	determiner	noun	punctuation
name, first name, person name, ...	name, last name, person name,	past tense, transitive	indefinite, singular	singular, count	end-of-sentence, period

Kaplan's Question

"So you work on POS tagging. What's a part of speech?"

What are Parts of Speech?

- The lexicon (collection of words of a language) is not some amorphous soup
- To the extent that it is soup-like, it is very chunky
  - A small, finite number of categories
  - Structured subcategories within these categories
  - Though sometimes these categories are soft, like potatoes in stew or curry.
- If you miss the structured nature of the lexicon, you are making life hard for yourself!

Q: What Do English Teachers Do?

A: Tell well-intentioned lies.

What are Parts of Speech?

- A limited number of tags for word “class”
- **Distributional**
  - Has the same contexts
  - Has the same syntactic functions (subject, object, modifier of nouns)
  - Occurs in the same positions in syntactic structure
- **Morphological**
  - Allows the same suffixes, prefixes
- **Not about meaning**
  - We are suggesting that your English teacher lied to you
  - Get used to it

Some Open-Class Parts of Speech

English Nouns

- Can be subjects and objects of verbs
  - *This **book** is about geography.*
  - *I read a good **book**.*
- Can be objects of prepositions
  - *I'm mad about **books**.*
- Can be plural or singular (***books***, ***book***)
- Can have determiners (*the **book***)
- Can be modified by adjectives (*blue **book***)
- Can have possessors (*my **book**, John's **book***)

English Verbs

- Takes nouns phrases as arguments
  - At least a subject
    - *Dr. Mortensen **parsed** aggressively.*
  - Sometimes one or two objects
    - *Dr. Mortensen **parsed** the data.*
    - *Prof. Black **passed** [the function] [an argument].*
- Can take tense morphology (past/non-past)
- Can be modified by adverbs

English Adjectives

- Modify nouns (restrict their reference)
  - his **pitiful** code (attributively)
  - His code is **pitiful**. (predicatively)
- Can take comparative/superlative (-er/-est) suffixes when allowed by prosody
  - *big*, *bigger*, *biggest*
  - But *pitiful*, *more pitiful*, *most pitiful*
- Not all languages have adjectives—some languages (like Korean, Hmong, and Vietnamese) use verbs to modify nouns in this way

English Adverbs

- Modify verbs, adjectives and other adverbs
  - He **erroneously** concluded that PHP is a real programming language **simply** because it is Turing complete.
  - He concluded **erroneously** that PHP is a real programming language.
  - The design of PHP is **exceptionally** poor.
  - My code runs **very slowly.**

Some Closed-Class Parts of Speech

English Prepositions

- Occur before noun phrases
- Relate noun phrase to some higher-level constituent
  - I scattered the data **from** hell **to** breakfast.
  - He lingered **in** the depths **of** despair.
- It is actually not difficult to characterize pronouns **formally**, but they are very difficult to characterize **semantically** (a good argument not to introduce semantic considerations into PoS categories)
- Also, they are often identical in spelling and pronunciation to **particles**

NLP Barbie Says…

English Determiners

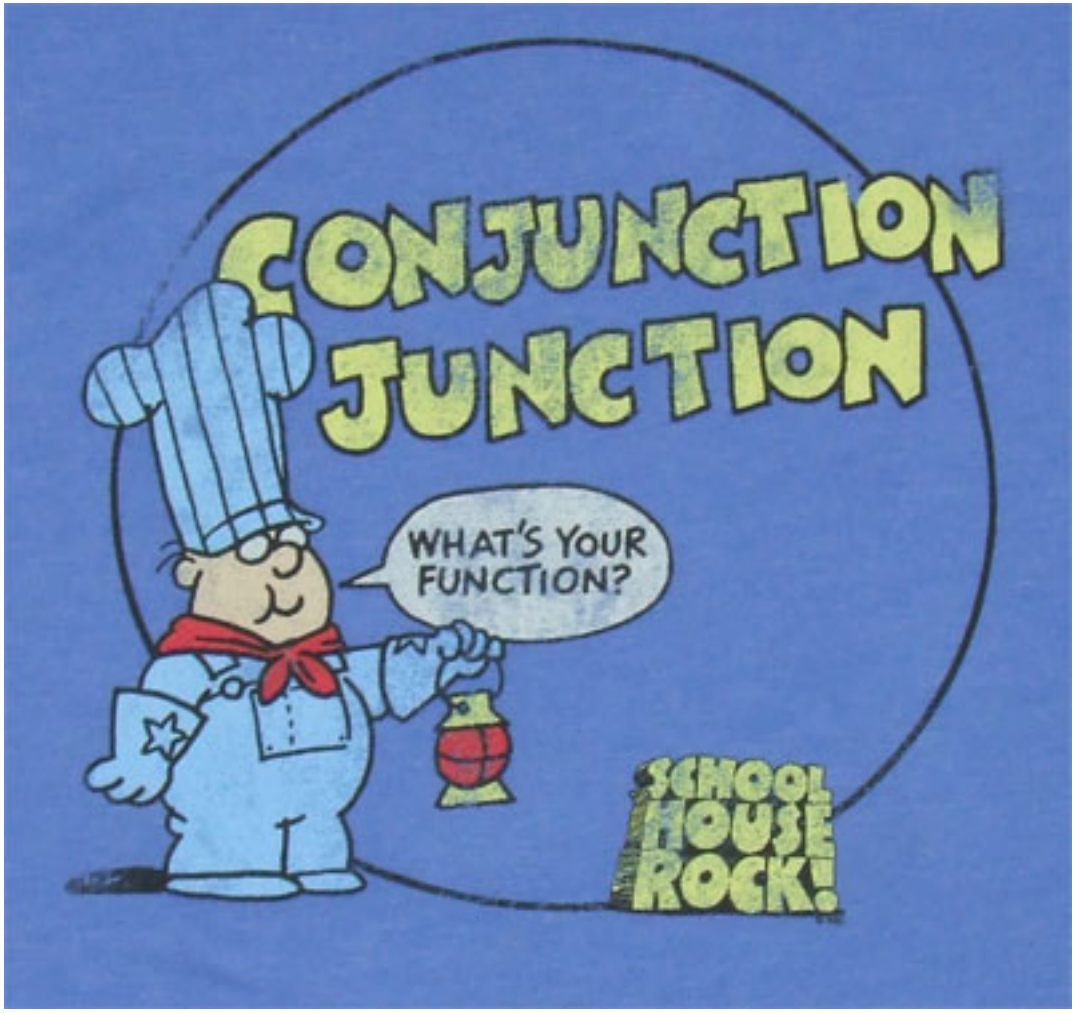
- Determiners are words that come at the beginning of noun phrases in English
- The most recognizable determiners are probably **articles** like *the*, *a*, and *an*
  - **The** interpreter choked on **an** unknown identifier.
- Other determiners include some demonstratives like *this* and *that*.
  - **That** version of Python really chaps my hide.

English Pronouns

- Pronouns replace noun phrases, acting as a sort of shorthand for them
  - **You** code like a boy.
  - **Your** type system is not well-founded.
  - **Who** knows Haskell, really?

English Conjunctions

- Conjunctions join phrases, clauses, or sentences.
- Typically, the conjuncts joined by a conjunction are of the same time
- Coordinating conjunctions
  - *and*, *or*, *but*…
- Subordinating conjunctions
  - *if*, *because*, *though*, *while…*


CONJUNCTION JUNCTION
WHAT'S YOUR FUNCTION?
SCHOOL HOUSE ROCK!

English Auxiliary Verbs

- "Helping verbs" that occur before main verbs
- Some occur as main verbs as well
  - *Be*
    - I **am** the type system. (main verb)
    - I **am** working on my project, you insensitive clod. (aux. verb)
  - *Have*
    - I **have** no qualms about criticizing your choice of languages. (main verb)
    - I **have** written a brilliant function that **will** accomplish just that! (aux. verb)
- Others (e.g. modals) occur only as auxiliary verbs
  - *would, will, could, can, might, must…*

English Particles

- *Particle* is sometimes used as a grab-bag category for closed-class items that do not fit in another category
- Most often, in English, these resemble prepositions or adverbs and are used in combination with a verb
  - He tore **off** his shirt.
  - He tore his shirt **off**.

Numerals

- Numerals have properties of both nouns and adjectives
  - They can be the subject and object of verbs:
    - Two will enter but only one will leave.
    - I bought twenty.
  - They can function both attributively and predicatively:
    - Two variables were undeclared.
    - We are three.
  - When then are used attributively, they come before any adjectives:
    - The two undeclared variables were the cause of much consternation.
    - *The undeclared two variables were the cause of much consternation.

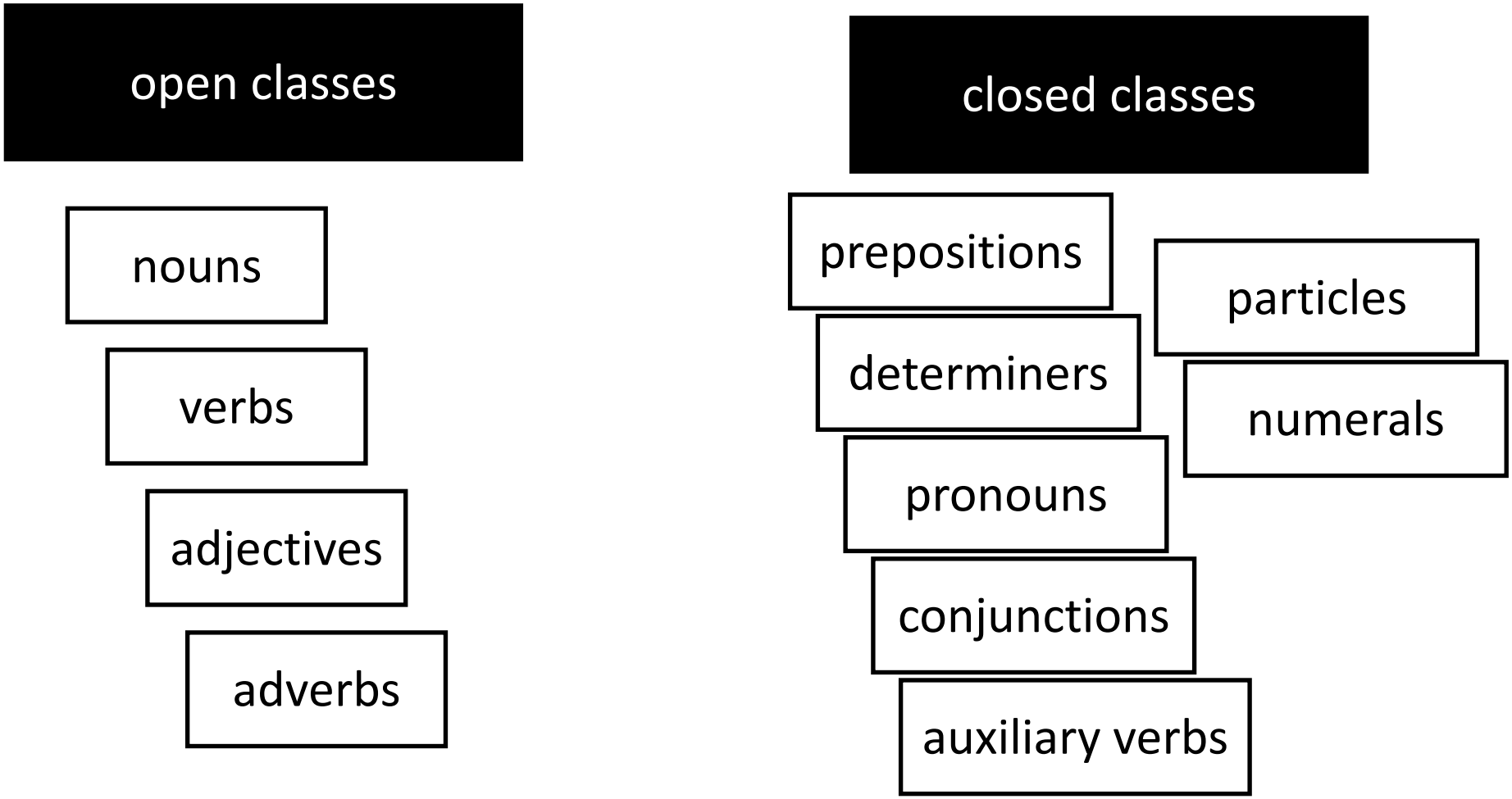
Why have Parts of Speech

- There are too many words
  - You'd need a lot of data to train rules
  - Rules would be very specific
- PoS tags allow generalization of models
- Give useful reduction in model sizes
- There are many different tag sets
  - You want the right one for your task

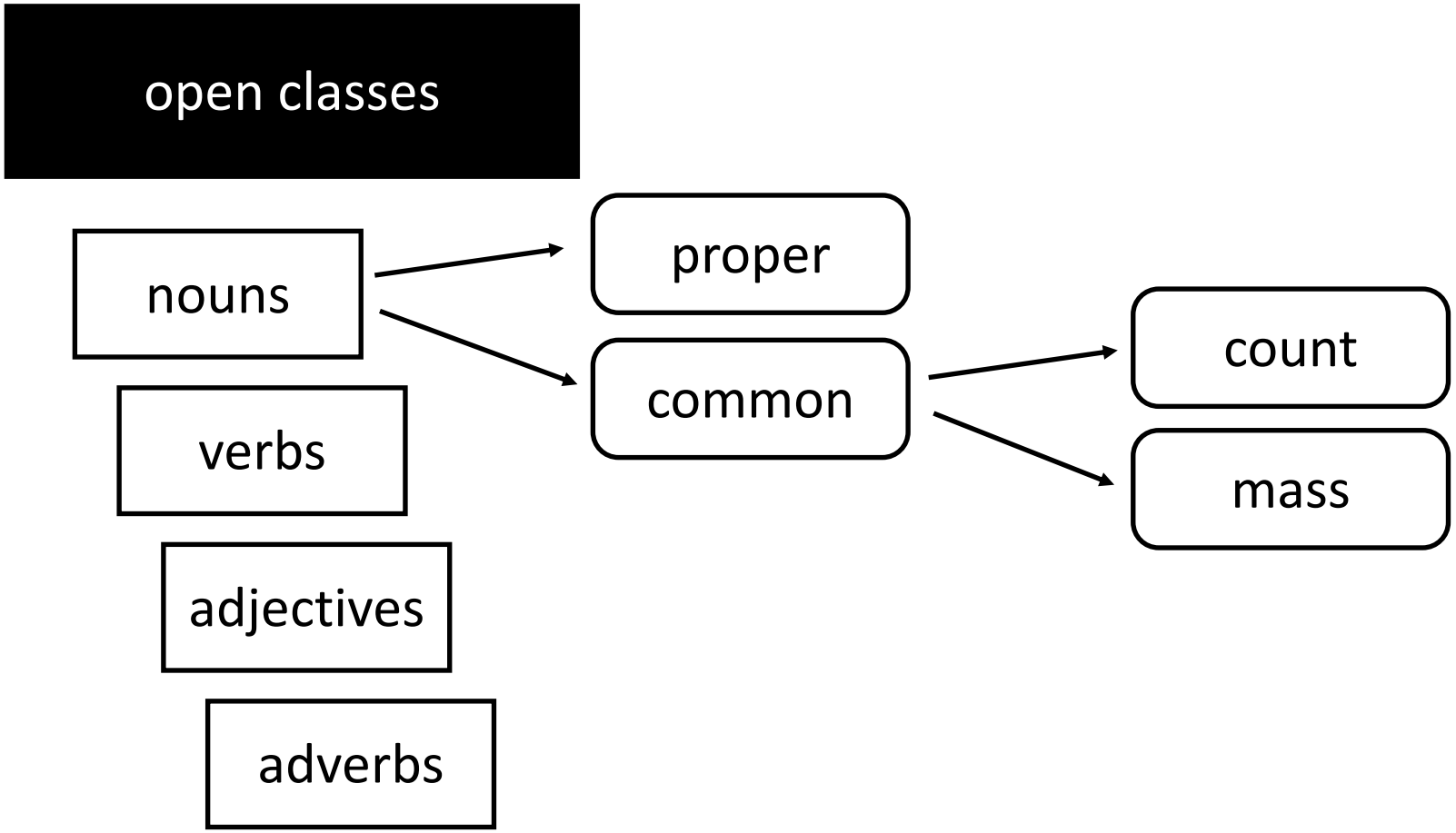
How do we know the class?

- Substitution test
  - The ADJ cat sat on the mat
  - The blue NOUN sits on the NOUN
  - The blue cat VERB on the mat
  - The blue cat sat P the mat

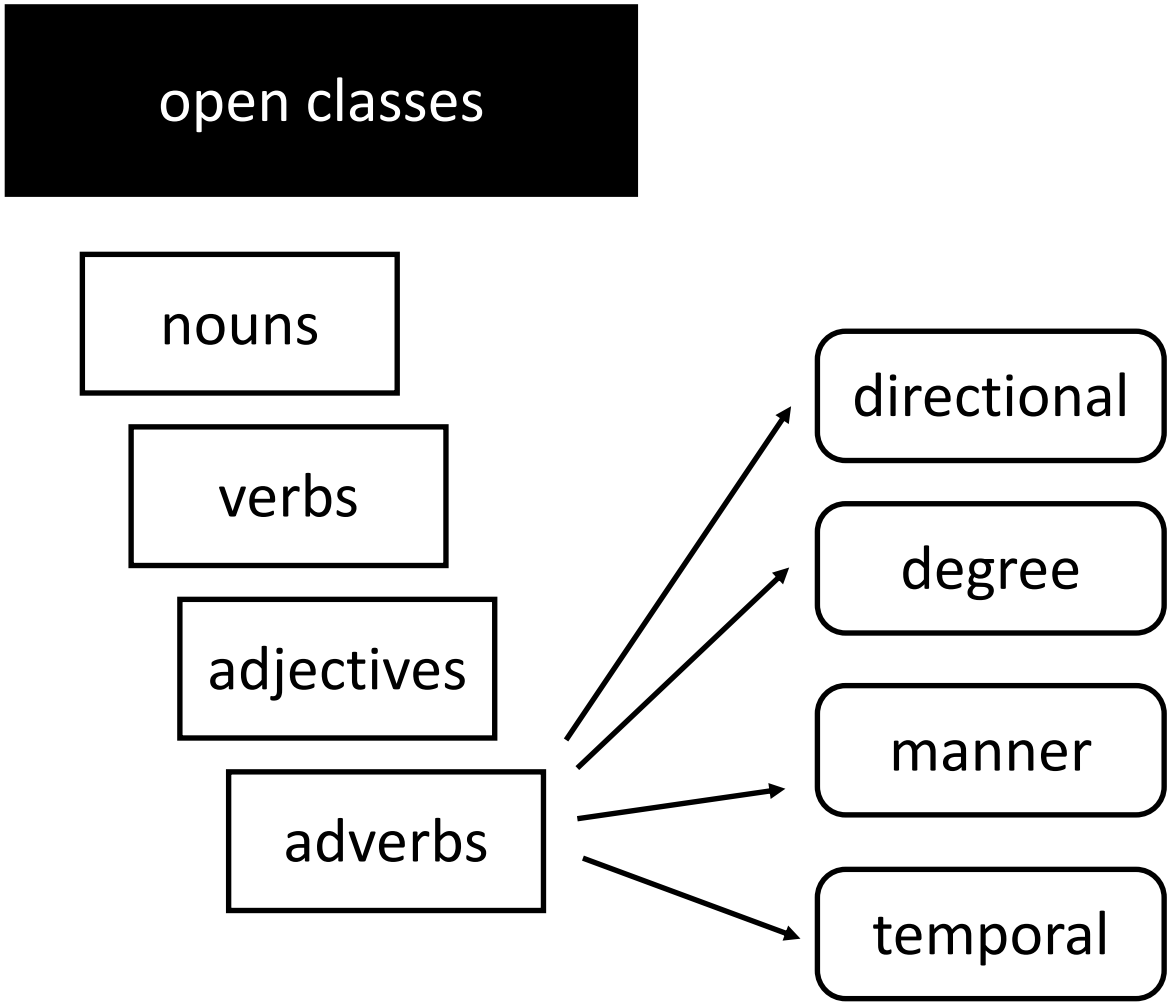
Broad POS categories



More Fine-Grained Classes



More Fine-Grained Classes



Hard Cases

- I will call up my friend
- I will call my friend up
- I will call my friend up in the treehouse
- Gerunds
  - I like walking.
  - I like apples.
  - His walking kept him fit.
  - His apples kept him fit.
  - His walking slowly kept him fit.
  - His apples slowly kept him fit.

But what do you want these for?

Maybe?

- Interjections
- Negatives
- Politeness markers
- Greetings
- Existential *there*
- Numbers, Symbols, Money, …
- Emoticon
- URL
- Hashtag

Google Universal POS Tags

ADJ: adjective

ADP: adposition (preposition or postposition)

ADV: adverb

AUX: auxiliary

CCONJ: coordinating conjunction

DET: determiner

INTJ: interjection

NOUN: noun

NUM: numeral

PART: particle

PRON: pronoun

PROPN: proper noun

PUNCT: punctuation

SCONJ: subordinating conjunction

SYM: symbol

VERB: verb

X: other

Some PTB Data (POS Tags)

IN In DT an NNP Oct. CD 19 NN review IN of `` `` DT The NN Misanthrope '' '' IN at NNP Chicago POS 's NNP Goodman NNP Theatre -LRB- -LRB- `` `` VBN Revitalized NNS Classics

VBP Take DT the NN Stage IN in NNP Windy NNP City , , '' '' NN Leisure CC & NNS Arts -RRB- -RRB- , , DT the NN role IN of NNP Celimene , , VBN played IN by NNP Kim NNP Cattrall , , VBD was RB mistakenly VBN attributed TO to NNP Christina NNP Haag . .

NNP Ms. NNP Haag VBZ plays NNP Elianti . .

NNP Rolls-Royce NNP Motor NNPS Cars NNP Inc. VBD said PRP it VBZ expects PRP$ its NNP U.S. NNS sales TO to VB remain JJ steady IN at IN about CD 1,200 NNS cars IN in CD 1990 . .

DT The NN luxury NN auto NN maker JJ last NN year VBD sold CD 1,214 NNS cars IN in DT the NNP U.S.

Why Tagging is Hard

- If every word by spelling (orthography) was a candidate for just one tag, PoS tagging would be trivial
  - How would you do it?
  - What problems do you foresee?
- As we've already seen, this won't always work
  - *lives* can be a noun or a verb
  - *black* can be a adjective, verb, proper noun, common noun, etc.
- But how bad is this problem, really?

How bad is the ambiguity?

PoS tags per orthographic word in PTB (Penn Treebank)

7 down
6 that
6 set
6 put
6 open
6 hurt
6 cut
6 bet
6 back
5 vs.
5 the
5 spread
5 split
5 say
5 's
5 run
5 repurchase
5 read
5 present

5 out
5 many
5 less
5 left
5 Japanese
5 in
5 hit
5 half
5 further
5 forecast
5 fit
5 first
5 East
5 counter
5 cost
5 close
5 bid
5 beat
5 a

317 down RB
200 down RP
138 down IN
10 down JJ
1 down VBP
1 down RBR
1 down NN

“Down”

CD One CD hundred CC and CD ninety CD two JJ former NNS greats , , JJ near NNS greats , , RB hardly NNS knowns CC and NNS unknowns VBP begin DT a JJ 72-game , , JJ three-month NN season IN in NN spring-training NNS stadiums RB up CC and RB down NNP Florida
PRP He MD will VB keep DT the NN ball RP down , , VB move PRP it RB around IN As DT the NN judge VBD marched IN down DT the JJ center NN aisle IN in PRP$ his VBG flowing JJ black NN robe , , PRP he VBD was VBN heralded IN by DT a NN trumpet NN fanfare
JJ Other NNP Senators VBP want TO to VB lower DT the JJ down NNS payments VBN required IN on JJ FHA-insured NNS loans
NNP Texas NNP Instruments , , WDT which VBD had VBN reported NNP Friday IN that JJ third-quarter NNS earnings VBD fell RBR more IN than CD 30 NN % IN from DT the JJ year-ago NN level , , VBD went RBR down CD 2 CD 1\/8 TO to CD 33 IN on CD 1.1 CD million NNS shares
IN Because NNS hurricanes MD can VB change NN course RB rapidly , , DT the NN company VBZ sends NNS employees NN home CC and NNS shuts VBP down NNS operations IN in NNS stages : -- DT the RBR closer DT a NN storm VBZ gets , , DT the RBR more JJ complete DT the NN shutdown
NNP Jaguar POS 's JJ American NN depositary NNS receipts VBD were IN up CD 3\/8 NN yesterday IN in DT a NN down NN market , , VBG closing IN at CD 10 CD 3\/8

“Japanese”

RB Meanwhile , , JJ Japanese NNS bankers VBD said PRP they VBD were RB still JJ hesitant IN about VBG accepting NNP Citicorp POS 's JJS latest NN proposal
CC And DT the NNPS Japanese VBP are JJ likely TO to VB keep RB close IN on NNP Conner POS 's NNS heels
DT The NN issue VBZ is RB further VBN complicated IN because IN although DT the NNS organizations VBP represent JJ Korean NNS residents , , DT those NNS residents VBD were RB largely VBN born CC and VBN raised IN in NNP Japan CC and JJ many VBP speak RB only NNP Japanese
CC And DT the NNP Japanese VBP make RB far JJR more NNS suggestions : -- CD 2,472 IN per CD 100 JJ eligible NNS employees CC vs. RB only CD 13 IN per CD 100 NNS employees IN in DT the (...)
DT The NNS Japanese VBP are IN in DT the JJ early NN stage RB right RB now , , VBD said NNP Thomas NNP Kenney , , DT a JJ onetime NN media NN adviser IN for NNP First NNP Boston NNP Corp. WP who VBD was RB recently VBN appointed NN president IN of NNP Reader POS 's NNP Digest NNP Association POS 's JJ new NNP Magazine NNP Publishing NNP Group
IN In CD 1991 , , DT the NNS Soviets MD will VB take DT a JJ Japanese NN journalist IN into NN space , , DT the JJ first NN Japanese TO to VB go IN into NN orbit

How do we do this

- Pick the most frequent tag
  - Gives about 90% accuracy
- Look at the context
  - Preceeding (and succeeding) words
  - Preceeding (and succeeding) tags
  - The …
  - To …
  - John's blue …
- We'll understand how we might look at local context better after we talk about **HMMs**

The Out-of-Vocabulary Problem

- How do you handle cases where your dictionary does not include all of the words?
  - Proper names?
  - Borrowed words?
  - Neologisms?
- These are not generally a problem for you, as a language user
- How would you give a POS-tagger the same superpower?
- Stay tuned!

Summary

- Here are a few important points:
  - Parts of speech are defined in terms of distribution and structure, not meaning (semantics)
  - Parts of speech may be open class or closed class
  - Parts of speech may differ across languages
  - PoS tags allow models to be more general
  - PoS tagging is non-trivial
    - Ambiguity–more than on PoS per orthographic word
    - Hard cases—more than one tag appropriate for a single sense of a word
    - Out of vocabulary (OOV) problem—your tagger will come across (open class) words it has never seen before