Advanced NLP Processing

Beyond tokens…

Dan Jurafsky

NLP Text Processing Pipeline

nltk covers POS tagging, phrase chunking

Stanford NLP toolkit provides parsing, coreference, NER

- Document → Sections and Paragraphs
- Paragraphs → Sentences (sentence segmentation / extraction)
- Sentences → Tokens
- Tokens → Lemmas or Morphological Variants / Stems
- **Tokens → Part-of-speech (POS) Tags**
- **Tokens, POS Tags → Phrase Chunks (Named entities and Keyphrases)**
- **Tokens, POS Tags → Parse Trees**
  - **Augment above with coreference, entailment, sentiment, …**

Part-of-speech tagging

A simple but useful form of linguistic analysis

Christopher Manning

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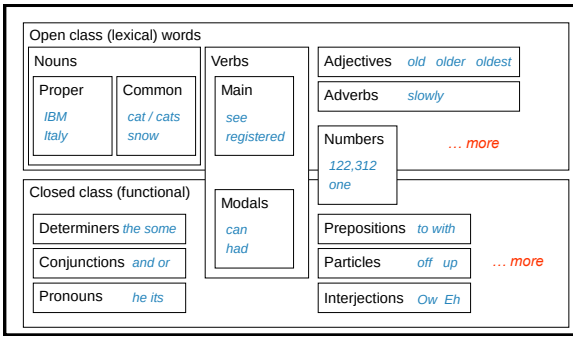
Parts of Speech

- Perhaps starting with Aristotle in the West (384–322 BCE), there was the idea of having parts of speech
  - a.k.a lexical categories, word classes, "tags", POS
- It comes from Dionysius Thrax of Alexandria (c. 100 BCE) the idea that is still with us that there are 8 parts of speech
  - But actually his 8 aren't exactly the ones we are taught today
    - Thrax: noun, verb, article, adverb, preposition, conjunction, participle, pronoun
    - School grammar: noun, verb, adjective, adverb, preposition, conjunction, pronoun, interjection



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Open vs. Closed classes

- Open vs. Closed classes
  - Closed:
    - determiners: ***a, an, the***
    - pronouns: ***she, he, I***
    - prepositions: ***on, under, over, near, by, …***
    - Why "closed"?
  - Open:
    - Nouns, Verbs, Adjectives, Adverbs.

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POS Tagging

- Words often have more than one POS: *back*
  - The *back* door = JJ
  - On my *back* = NN
  - Win the voters *back* = RB
  - Promised to *back* the bill = VB
- The POS tagging problem is to determine the POS tag for a particular instance of a word.

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POS Tagging

- Input: Plays well with others
- Ambiguity: NNS/VBZ UH/JJ/NN/RB IN NNS
- Output: Plays/VBZ well/RB with/IN others/NNS
- Uses:
  - Text-to-speech (how do we pronounce "lead"?)
  - Can write regexps like (Det) Adj* N+ over the output for phrases, etc.
  - As input to or to speed up a full parser
  - If you know the tag, you can back off to it in other tasks

Penn Treebank POS tags

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POS tagging performance

- How many tags are correct? (Tag accuracy)
  - About 97% currently
  - But baseline is already 90%
    - Baseline is performance of stupidest possible method
      - Tag every word with its most frequent tag
      - Tag unknown words as nouns
  - Partly easy because
    - Many words are unambiguous
    - You get points for them (*the*, *a*, etc.) and for punctuation marks!

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Deciding on the correct part of speech can be difficult even for people

- Mrs/NNP Shaefer/NNP never/RB got/VBD around/RP to/TO joining/VBG
- All/DT we/PRP gotta/VBN do/VB is/VBZ go/VB around/IN the/DT corner/NN
- Chateau/NNP Petrus/NNP costs/VBZ around/RB 250/CD

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How difficult is POS tagging?

- About 11% of the word types in the Brown corpus are ambiguous with regard to part of speech
- But they tend to be very common words. E.g., *that*
  - I know *that* he is honest = IN
  - Yes, *that* play was nice = DT
  - You can't go *that* far = RB
- 40% of the word tokens are ambiguous

Phrase Chunking and Special Noun Phrases

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Phrase Chunking

- Find all non-recursive noun phrases (NPs) and verb phrases (VPs) in a sentence.
  - [NP I] [VP ate] [NP the spaghetti] [PP with] [NP meatballs].
  - [NP He] [VP reckons] [NP the current account deficit] [VP will narrow] [PP to] [NP only # 1.8 billion] [PP in] [NP September]

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Phrase Chunking as Sequence Labeling

- Tag individual words with one of 3 tags
  - B (Begin) word starts new target phrase
  - I (Inside) word is part of target phrase but not the first word
  - O (Other) word is not part of target phrase
- Sample for NP chunking
  - He reckons the current account deficit will narrow to only # 1.8 billion in September.

Begin **Inside** **Other**

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Named Entity Recognition (NER)

- A special class of **Proper Noun Phrases**
- **People:** Scott Sanner, President Obama, Madonna
- **Places:** New York, Madison Square Garden, Millenium Park
- **Organizations:** New York Times, University of Toronto

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Keyphrases

- Useful noun phrases, but not necessarily Proper Nouns, e.g.,
  - "machine learning"
  - "support vector machines"
  - "genetically modified organisms"
- A subset of frequent noun phrases (harder to extract than NEs)
  - This paper has the best method I've found so far:
    "Automatic Recognition of Multi-Word Terms: the C-value/NC-value Method
    Katerina Frantziy, Sophia Ananiadouy, Hideki Mima" IJODL 2000.
    http://personalpages.manchester.ac.uk/staff/sophia.ananiadou/ijodl2000.pdf

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Statistical Natural Language Parsing

Parsing: Two views of syntactic structure

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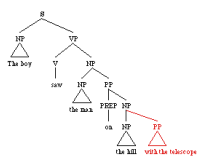
Why parsing?



- "The boy saw the man on the hill with the telescope."
  - Who had the telescope?
- Depends on whether you attach "with the telescope" to "I" or "man on the hill"
- How do you determine attachments? Parsing.
  - Some sentences are inherently ambiguous: attachment ambiguity.

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For fun

- Who polices the police?
- Police police police police.
- Who polices the police police? ☺
- Point: we need more than word order / POS to interpret sentences… we need structure.

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Two views of linguistic structure: 1. Constituency (phrase structure)

- Phrase structure organizes words into nested constituents.
- What is a constituent?
- Constituent behaves as unit that can appear in different places:
  - John talked [to the children] [about drugs].
  - John talked [about drugs] [to the children].
  - Substitution/expansion/pro-forms:
    - I sat [on the box/right on top of the box/there].
  - Coordination, regular internal structure, no intrusion, fragments, semantics, …

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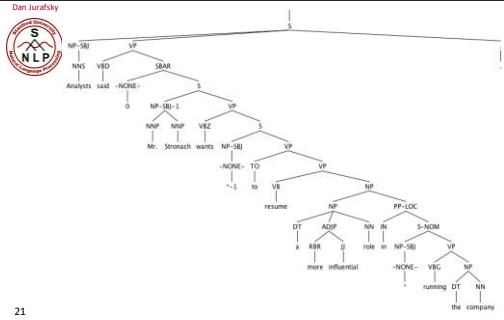

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Grammars for Parse Tree Production

- Parent → Child1 Child2 | Child3 Child4 … | …
- S → NP VP | …
- NP → … NN* …
- VP → … VB* …
- ADJP → … JJ* …
- ADVP → … RB* …
- …

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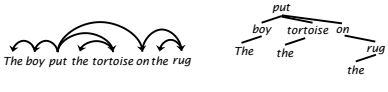
Two views of linguistic structure: 2. Dependency structure

- Dependency structure shows which words depend on (modify or are arguments of) which other words.

The boy put the tortoise on the rug



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Two views of linguistic structure: 2. Dependency structure

- Dependency structure shows which words depend on (modify or are arguments of) which other words.
- Can derive dependency tree from parse tree
- What about reverse?

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Semantic Language Analysis

Coreference and entailment

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Coreference

- Discourse (multiple sentences) use coreferring phrases.
- Example:
  "John saw a beautiful Acura Integra in the dealership.
  He showed it to Bob.
  He bought it."
- What do "He" and "it" refer to in the 2nd sentence?

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Coreference Resolution

- "John saw a beautiful Acura Integra in the dealership.
  He1 showed it1 to Bob.
  He2 bought it2."

Referent	Phrases
John	{John, He1, He2}
Integra	{a beautiful Acura Integra, it1, it2}
Bob	{Bob}
dealership	{the dealership}

- Important in processing reviews: "I liked it!"

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Entailment

- **Question:** When did the Berlin wall open?
- **Text contains:** The Berlin wall fell on November 9, 1989.
- Simple entailment? Does "fall" → "open"?
  - A wall falling is a wall opening
  - A person falling is not a person opening
- Entailment can be highly contextual. But WordNet (in nltk) contains basic entailments, e.g., "snoring" → "sleeping".