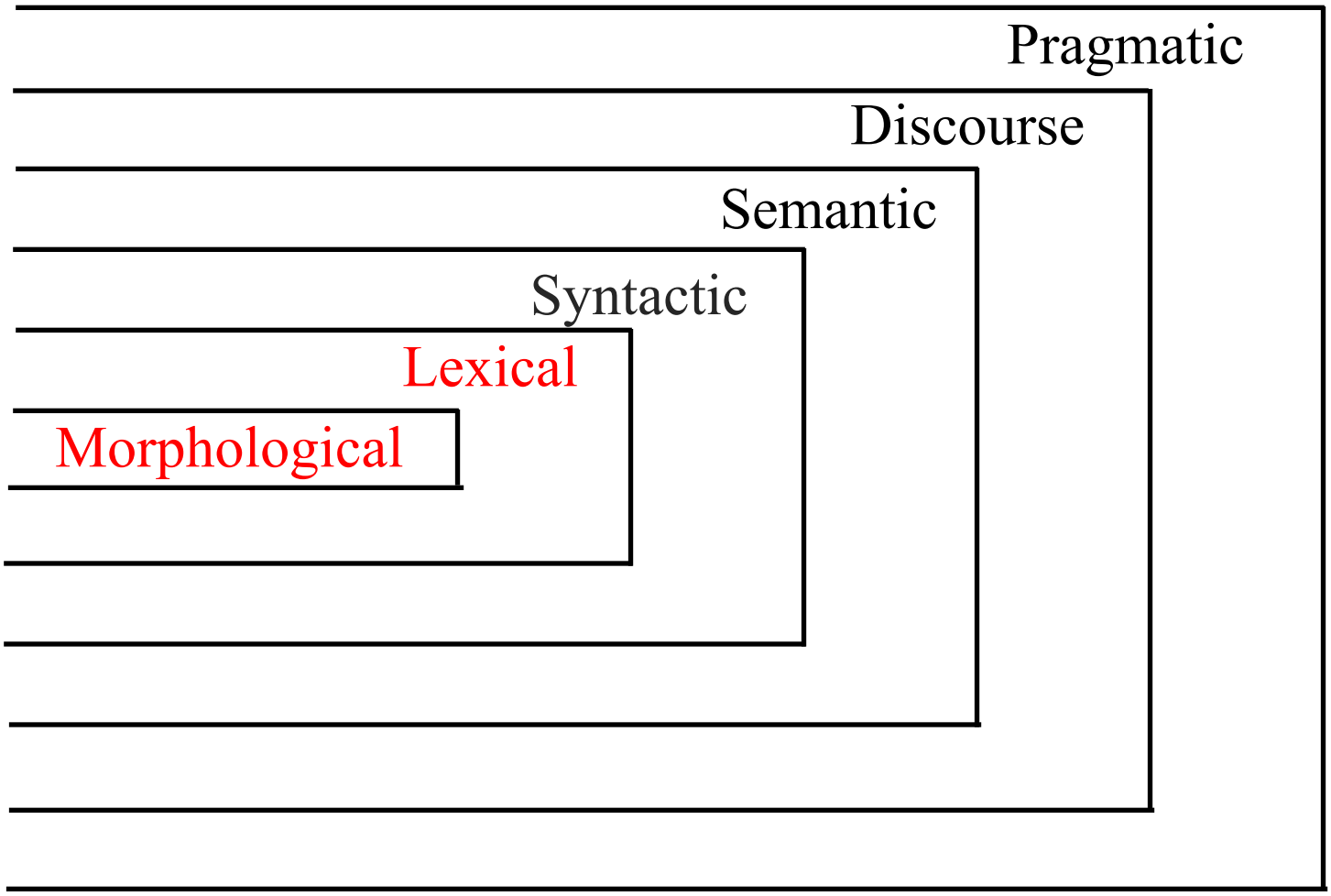
Basic Text Processing:
Morphology
Sentence Segmentation

Basic Text Processing

- Every NLP task needs to do text normalization to determine what are the words of the document:
  - Segmenting/tokenizing words in running text
    - Special characters like hyphen “-” and apostrophe ‘
  - Normalizing word formats
    - (Non) capitalization of words
    - Reducing words to stems or lemmas
  - Segmenting sentences in running text
- To do these tasks, we need to use morphology

Synchronic Model of Language



Morphology

- Morphology is the level of language that deals with the internal structure of words
- General morphological theory applies to all languages as all natural human languages have systematic ways of structuring words (even sign language)
- Must be distinguished from morphology of a specific language
  - English words are structured differently from German words, although both languages are historically related
  - Both are vastly different from Arabic

Minimal Units of Meaning

- **Morpheme** = the minimal unit of meaning in a word
  - *walk*
  - *-ed*

- **Simple words** cannot be broken down into smaller units of meaning
  - Monomorphemes
  - Called base words, roots or stems

- **Affixes** are attached to free or bound forms
  - prefixes, infixes, suffixes, circumfixes

Affixes

- **Prefixes** appear in front of the stem to which they attach
  - **un-** + happy = *unhappy*
- **Infixes** appear inside the stem to which they attach
  - **-blooming-** + absolutely = *absobloominglutely*
- **Suffixes** appear at the end of the stem to which they attach
  - *emot**ion*** = emote + -ion
  - English may stack up to 4 or 5 suffixes to a word
  - Agglutinative languages like Turkish may have up to 10
- **Circumfixes** appear at both the beginning and end of stem
  - German past participle of *sagen* is *gesagt*: ge- + sag + -t
- Spelling and sound changes often occur at the boundary
  - Very important for NLP

Inflection

- Inflection modifies a word's form in order to mark the grammatical subclass to which it belongs
  - *apple* (singular) > *apples* (plural)
- Inflection does not change the grammatical category (part of speech)
  - *apple* – noun; *apples* – still a noun
- Inflection does not change the overall meaning
  - both *apple* and *apples* refer to the fruit

Derivation

- Derivation creates a new word by changing the category and/or meaning of the base to which it applies
- Derivation can change the grammatical category (part of speech)
  - sing (verb) > singer (noun)
- Derivation can change the meaning
  - act of singing > one who sings
- Derivation is often limited to a certain group of words
  - You can **Clintonize** the government, but you can't **Bushize** the government
  - This restriction is partially phonological

Inflection & Derivation: Order

- **Order is important** when it comes to inflections and derivations
  - **Derivational suffixes must precede inflectional suffixes**
    - sing + -er + -s is ok
    - sing + -s + -er is not
  - This order may be used as a clue when working with natural language text

Inflection & Derivation in English

- English has few inflections
  - Many other languages use inflections to indicate the role of a word in the sentence
  - Use of case endings allows fairly free word order
  - English instead has a fixed word order
    - Position in the sentence indicates the role of a word, so case endings are not necessary
  - This was not always true; Old English had many inflections

- English has many derivational affixes, and they are regularly used to form new words
  - Part of this is cultural -- English speakers readily accept newly introduced terms

- For more details, see examples from J&M, sections 3.1 – 3.3 (2^{nd} ed.)

Classes of Words

- **Closed** classes are fixed – new words cannot be added
  - Pronouns, prepositions, comparatives, conjunctions, determiners (articles and demonstratives)
  - Function words

- **Open** classes are not fixed – new words can be added
  - Nouns, Verbs, Adjectives, Adverbs
  - Content words
  - New content words are a constant issue for NLP

Creation of New Words

- **Derivation** - adding prefixes or suffixes to form a new word
  - Clinton → Clintonize
- **Compounding** - combining two existing words
  - home + page → homepage
- **Clipping** - shortening a polysyllabic word
  - Internet → net
- **Acronyms** - take initial sounds or letters to form new word
  - Scuba → Self Contained Underwater Breathing Apparatus
- **Blending** - combine parts of two words
  - motor + hotel → motel
  - smoke + fog → smog
- **Backformation**
  - resurrection → resurrect

Word Formation Rules: Agreement

- Plurals
  - In English, the morpheme s is often used to indicate plurals in nouns
  - Nouns and verbs must agree in plurality
- Gender – nouns, adjectives and sometimes verbs in many languages are marked for gender
  - 2 genders (masculine and feminine) in Romance languages like French, Spanish, Italian
  - 3 genders (masc, fem, and neuter) in Germanic and Slavic languages
  - More are called noun classes – Bantu has up to 20 genders
  - Gender is sometimes explicitly marked on the word as a morpheme, but sometimes is just a property of the word

How does NLP make use of morphology?

- Stemming
  - Strip prefixes and / or suffixes to find the base root, which may or may not be an actual word
    - Spelling corrections are not made
- Lemmatization
  - Strip prefixes and / or suffixes to find the base root, which will always be an actual word
    - Spelling corrections are crucial
    - Often based on a word list, such as that available at WordNet
- Part of speech guessing
  - Knowledge of morphemes for a particular language can be a powerful aid in guessing the part of speech for an unknown term

Stemming

- Removal of affixes (usually suffixes) to arrive at a base form that may or may not necessarily constitute an actual word
- Continuum from very conservative to very liberal modes of stemming
  - Very Conservative
    - Remove only plural –*s*
  - Very Liberal
    - Remove all recognized prefixes and suffixes
- Good resource:
  - http://www.comp.lancs.ac.uk/computing/research/stemming/

for example compressed and compression are both accepted as equivalent to compress.

for exampl compress and compress ar both accept as equival to compress

Porter Stemmer

- Popular stemmer based on work done by Martin Porter
  - M.F. Porter. An algorithm for suffix stripping. 1980, Program 14(3), pp. 130-137.
- Very liberal step stemmer with five steps applied in sequence
  - See example rules on next slide
- Probably the most widely used stemmer
  - Has been incorporated into a number of Information Retrieval systems
- Does not require a lexicon.
- Open source software available for almost all programming languages.

Examples of Porter Stemmer Rules

Step 1a

sses → ss	caresses → caress		
ies → i	ponies → poni		
ss → ss	caress → caress		
s → ø	cats → cat		

Step 1b

(*v*)ing → ø	walking → walk		
	sing → sing		
(*v*)ed → ø	plastered → plaster		
…			

Where *v* is the occurrence of any verb.

From Dan Jurafsky

Step 2 (for long stems)

ational→ ate	relational→ relate		
izer→ ize	digitizer → digitize		
ator→ ate	operator → operate		
…			

Step 3 (for longer stems)

al → ø	revival → reviv		
able → ø	adjustable → adjust		
ate → ø	activate → activ		
…			

Some other Stemmers for English

- Paice-Husk Stemmer
  - Simple iterative stemmer; rather heavy when used with standard rule set
- Krovetz Stemmer
  - Light stemmer; removes inflections only; removal of inflections is very accurate (actually a lemmatizer)
  - Often used as a first step before using another stemmer for increased compression
- Lovins Stemmer
  - Single-pass, context-sensitive, longest match stemmer; not widely used
- Dawson Stemmer
  - Complex linguistically targeted stemmer based on Lovins; not widely used

Lemmatization

- Removal of affixes (typically suffixes),
- But the goal is to find a base form that does constitute an actual word

- Example:
  - *parties* → remove *-es*, correct spelling of remaining form → *party*

- Spelling corrections are often rule-based

- May use a lexicon to find actual words

Guessing the Part of Speech

- English is continuously gaining new words on a daily basis
- And new words are a problem for many NLP systems
  - New words won't be found in the MRD or lexicon, if one is used
- How might morphology be used to help solve this problem?
- What part of speech are:
  - clemness
  - foramtion
  - depickleated
  - outtakeable

Ambiguous Affixes

- Some affixes are ambiguous:
  - -er
    - Derivational: Agentive –er Verb + -er > Noun
    - Inflectional: Comparative –er Adjective + -er > Adjective
  - -s or –es
    - Inflectional: Plural Noun + -(e)s > Noun
    - Inflectional: 3rd person sing. Verb + -(e)s > Verb
  - -ing
    - Inflectional Progressive Verb + -ing > Verb
    - Derivational "act of" Verb + -ing > Noun
    - Derivational "in process of" Verb + -ing > Adjective
- As with all other ambiguity in language, this morphological ambiguity creates a problem for NLP

Complex Morphology

- Some languages requires complex morpheme segmentation
  - Turkish
  - Uygarlastiramadiklarimizdanmissinizcasina
  - `(behaving) as if you are among those whom we could not civilize'
  - Uygar `civilized' + las `become'
    + tir `cause' + ama `not able'
    + dik `past' + lar 'plural'
    + imiz 'p1pl' + dan 'abl'
    + mis 'past' + siniz '2pl' + casina 'as if'

Importance of Punctuation

- So far we have discussed what words to keep and possible alternate forms of words through stemming and lemmatization
- Note that for further steps of language processing, we need to keep all the punctuation as tokens.
- Punctuation determines the clauses of a sentence and can profoundly affect the meaning
  - From the book "Eats, Shoots and Leaves: The Zero Tolerance Approach to Punctuation" by Lynne Truss, a collection of quotes: http://www.goodreads.com/work/quotes/854886-eats-shoots-leaves-the-zero-tolerance-approach-to-punctuation
  - Another example seen on a t-shirt:

    Let's eat Grandma!
    Let's eat, Grandma!
    Commas save lives!

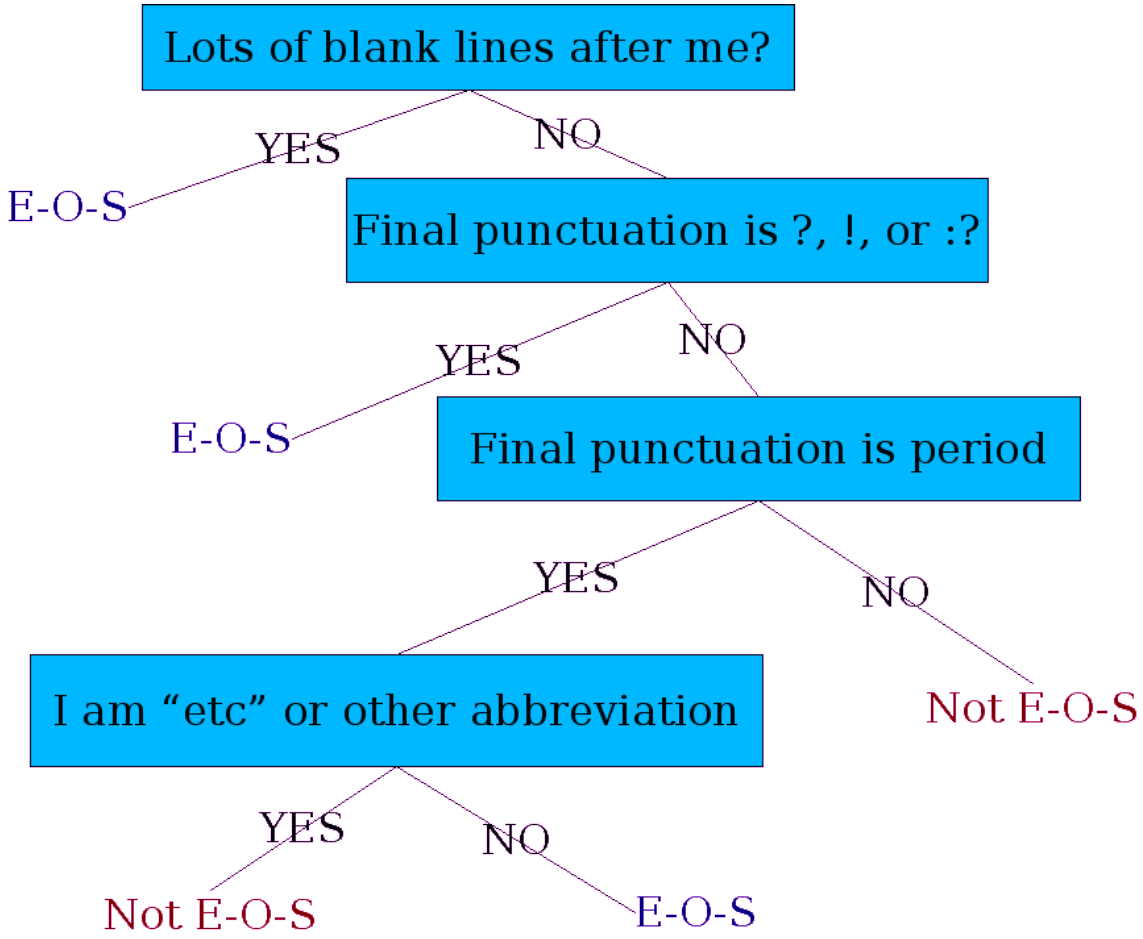
Sentence Segmentation

- Punctuation not only shows internal structure of sentences, but is crucial in determining the end of sentences.
- !, ? are relatively unambiguous
- Period "." is quite ambiguous
  - Sentence boundary
  - Abbreviations like Inc. or Dr.
  - Numbers like .02% or 4.3
- Treat this as a classification problem
  - Looks at a "." (or the word preceding the ".")
  - Decides EndOfSentence/NotEndOfSentence
  - Classifiers: hand-written rules, regular expressions, or machine-learning

Slides in this section are from Dan Jurafsky

Classify whether a word is End-of-Sentence

- An example of one way to classify is a Decision Tree:



Classification Problem Features

- Each property used in the decision tree to decide which branch to take is usually called a feature of the word
- More sophisticated features for end-of-sentence decision
  - Word shape features
    - Case of word with ".": Upper, Lower, Cap, Number
    - Look at word after "." to see if it begins a new sentence:
      - Case of word after ".": Upper, Lower, Cap, Number
  - Numeric features
    - Length of word with "."
    - Probability(word with "." occurs at end-of-s)
    - Probability(word after "." occurs at beginning-of-s)