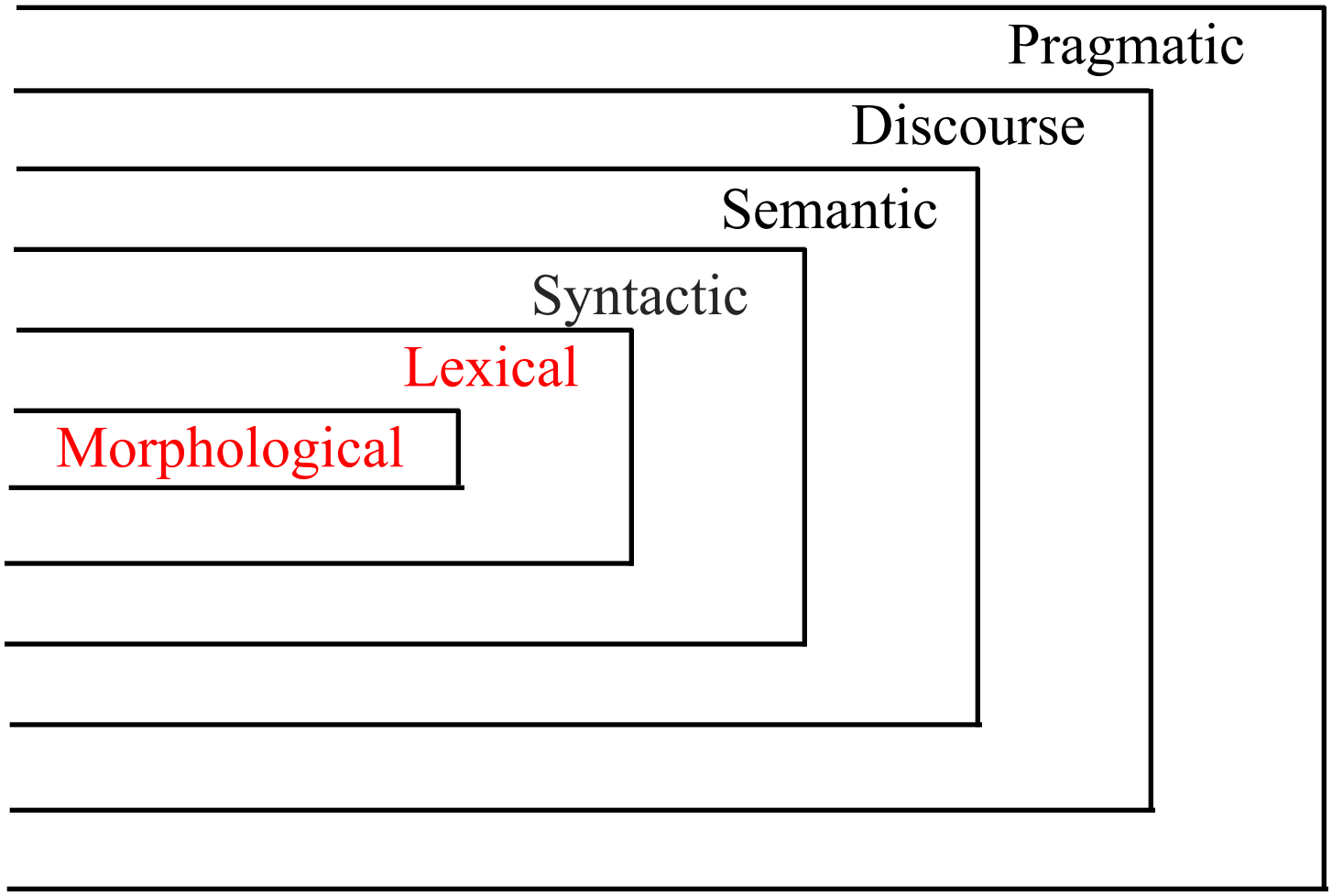
Basic Text Processing:
Morphology
Word Stemming

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
- 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 of *fusional* languages, like English
  - 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 (2nd ed.) – on Blackboard under Resources

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 not required
- 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

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
- 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 *parti* → *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'