

# **Introduction to Computational Linguistics**

**Frank Richter**

**fr@sfs.uni-tuebingen.de.**

**Seminar für Sprachwissenschaft  
Eberhard Karls Universität Tübingen  
Germany**

# A Quick Guide to Morphology (1)

- Morphology studies the internal structure of words.
- The building blocks are called morphemes. One distinguishes between free and bound morphemes.
  - Free morphemes are those which can stand alone as words.
  - Bound morphemes are those that always have to attach to other morphemes.

# A Simple Morphological Typology

- Isolating languages: no bound morphemes

# A Simple Morphological Typology

- Isolating languages: no bound morphemes
- Agglutinative languages: all bound forms are affixes

# A Simple Morphological Typology

- Isolating languages: no bound morphemes
- Agglutinative languages: all bound forms are affixes
- Inflectional languages: distinct features merged into single bound form; same underlying feature expressed differently, depending on paradigm

# A Simple Morphological Typology

- Isolating languages: no bound morphemes
- Agglutinative languages: all bound forms are affixes
- Inflectional languages: distinct features merged into single bound form; same underlying feature expressed differently, depending on paradigm
- Polysynthetic languages: more structural information expressed morphologically

# A Quick Guide to Morphology (2)

Linguists commonly distinguish three types of morphological processes:

- Inflectional morphology: refers to the class of bound morphemes that do not change word class.
- Derivational morphology: refers to the class of bound morphemes that do change word class.
- Compounding: a morphologically complex word can be constructed out of two or more free morphemes.

# Inflectional Morphemes

- Bound morphemes which do not change part of speech, e.g. *big* and *bigger* are both adjectives.
- Typically indicate syntactic or semantic relations between different words in a sentence, e.g. the English present tense morpheme -s in *waits* shows agreement with the subject of the verb.
- Typically occur with all members of some large class of morphemes, e.g. the plural morpheme -s occurs with most nouns.
- Typically occur at the margins of words as affixes (prefix, suffix, circumfix)



# Derivational Morphemes

- Bound morphemes which change part of speech, e.g. *-ment* forms nouns, such as *judgment*, from verbs such as *judge*.
- Typically indicate semantic relations within the word, e.g. the morpheme *-ful* in *painful* has no particular connection with any other morpheme beyond the word *painful*.
- Typically occur with only some members of a class of morphemes, e.g. the suffix *-hood* occurs with just a few nouns such as *brother*, *neighbor*, and *knight*, but not with many others, e.g. *friend*, *daughter*, *candle*, etc.
- Typically occur before inflectional suffixes, e.g. in *interpretierbar* (*Antwort*) the derivational suffix *bar* before the inflectional suffix *-e*.

# Compounding

- A compound is a word formed by the combination of two independent words.
- The parts of the compound can be free morphemes, derived words, or other compounds in nearly any combination:
  - *girlfriend* (two independent morphemes),
  - *looking glass* (derived word + free morpheme),
  - *life insurance salesman* (compound + free morpheme).

# Morphology: The Naive Solution

The simplest, but for most cases naive solution:

- Compile a full-form lexicon which lists all possible word forms together with their morphological analyses.
- If a given word has only one morphological analysis, the full-form lexicon stores exactly one reading.
- If a given word has more than one morphological analysis, the full-form lexicon stores all possible readings separately.

# Morphological Analysis: Lemmatization

- Lemmatization refers to the process of relating individual word forms to their citation form (lemma) by means of morphological analysis.
- Lemmatization provides a means to distinguish between the total number of word tokens and distinct lemmata that occur in a corpus.
- Lemmatization is indispensable for highly inflectional languages which have a large number of distinct word forms for a given lemma.

# Examples from English (1)

Input: *spies*

Analysis:

spies spy+Noun+Pl

spies spy+Verb+Pres+3sg

Input: *travelling*

Analysis:

travelling travel+Verb+Prog

travelling travelling+Adj

travelling travelling+Noun+Sg

# Examples from English (2)

Input: *foxes*

Analysis:

foxes fox+Noun+Pl

foxes fox+Verb+Pres+3s

Input: *moved*

Analysis:

moved move+Verb+PastBoth+123SP

moved moved+Adj

# Examples from German (1)

Input: *Staubecken*

Analysis:

1. Stau+Noun+Common+Masc+Sg#  
Becken+Noun+Common+Neut+Sg+NomAccDat
2. Stau+Noun+Common+Masc+Sg#  
Becken+Noun+Common+Neut+Pl+NomAccDatGen
3. Staub+Noun+Common+Masc+Sg#  
Ecke+Noun+Common+Fem+Pl+NomAccDatGen

# Examples from German (2)

<form>hat</form> <ENGLISH>has</ENGLISH>

<lemma wkl=VER typ=AUX pers=3 num=SIN modtemp=PRÄ>haben</lemma>

<lemma wkl=VER pers=3 num=SIN modtemp=PRÄ konj=NON>haben</lemma>

<form>man</form> <ENGLISH>one</ENGLISH>

<lemma wkl=PRO typ=IND kas=NOM num=SIN gen=ALG stellung=STV>man</lemma>

<form>mir</form> <ENGLISH>me</ENGLISH>

<lemma wkl=PRO typ=REF kas=DAT num=SIN gen=ALG pers=1>sich</lemma>

<lemma wkl=PRO typ=PER kas=DAT num=SIN gen=ALG pers=1>ich</lemma>

<form>gesagt</form> <ENGLISH>told</ENGLISH>

<lemma wkl=VER form=PA2 konj=SFT>sagen</lemma>

<lemma wkl=PA2 gebrauch=PRD komp=GRU>gesagt</lemma>

<form>,</form>

<lemma wkl=SZK>,</lemma>

<form>ja</form> <ENGLISH>right</ENGLISH>

<lemma wkl=ADV typ=MOD>ja</lemma>



# Stemmers

- Stemmers are the simplest type of morphological analyzer.
- One of the main advantages of stemmers is that they do not require a lexicon.
- The function of a stemmer is to remove the most common morphological and inflectional endings from words.
- Its main use is as part of a term normalisation process that is usually done when setting up Information Retrieval systems.

# Finite-State Morphology

- Basic Idea: Encode morphological analysis and generation as composition of finite-state transducers.
- Resources needed:
  - Morpho-syntactic lexicon that specifies which combinations of free and bound morphemes are grammatical.
  - Context-sensitive replacement rules for spelling alternations.

# 2-level Rules: Restriction Operators

Two-level morphology employs a set of particular restriction operators:

- => the correspondence only occurs in the environment
- <= the correspondence always occurs in the environment
- <=> the correspondence always and only occurs in the environment
- /<= the correspondence never occurs in the environment

# 2-level Rules: Restriction Operators

Two-level morphology employs a set of particular restriction operators:

=> the correspondence only occurs in the environment

<= the correspondence always occurs in the environment

<=> the correspondence always and only occurs in the environment

/<= the correspondence never occurs in the environment

**Idea:** Rules with restriction operators function as constraints on the mapping between lexical and surface form of morphs.

# Toy Rules for English (1)

## i:y-spelling

die+ing tie+ing  
dy00ing ty00ing

Rule: i:y <= \_ e:? +:0 i

## Elision

agree+ed dye+ed hoe+ed hoe+ing  
agre00ed dy00ed ho00ed hoe0ing

Rule: e:0 <= C { V, y } \_ +:? e:e

with V = { a e i o u } and

C = { b c d f g h j k l m n p q r s t v w x y z sh ch }

# Toy Rules for English (2)

**Epenthesis** (simplified!; c.f. Trost, p. 41, (2.32))

fox+s kiss+s church+s spy+s  
foxes kisses churches spies

Rule:  $+ :e \Leftrightarrow \{ C_{\text{sib}}, y:i, o:o \} \_ s$

with  $C_{\text{sib}} = \{ s \ x \ z \ sh \ ch \}$