

T-(538|725)-MALV, Natural Language Processing Part-of-speech and morphology

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Outline

- 1 Part-of-speech
- 2 The lexicon
- 3 Morphology
- 4 Two-level morphology

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Part-of-speech (POS) (í. Orðflokkar)

Definition

- Word classes, whose words share common grammatical properties.
 - Morphological properties (e.g. inflection vs. no inflection)
 - Syntactic properties (e.g. adjectives often modify nouns)
 - Semantic properties (e.g. nouns “name” things, adjectives describe attributes)
 - <http://is.wikibooks.org/wiki/Orðflokkagreining>
- Also called *lexical categories*.

Two main classes

- Closed class (í. Lokaður flokkur)
- Open class (í. Opinn flokkur)

Part-of-speech (POS) (í. Orðflokkar)

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Two main classes

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Closed class

- Relatively stable over time, new words are not added to this class.
- Function words:
 - Articles/Determiners (í. ákvæðisorð): **the, several** (English), **der** (German)
 - Prepositions (í. forsetningar): **to, of** (English), **í, á** (Icelandic))
 - Conjunctions (í. samtengingar): **and, or** (English), **og, eða** (Icelandic)
 - Auxiliaries/modals (í. hjálparsagnir): **be, have** (English), **vera, hafa** (Icelandic)
 - Adverbs (í. atviksorð), but not all of them.

Open class

- Forms the bulk of a vocabulary.
- Words get constantly added to this class.
- Nouns (í. nafnorð), adjectives (í. lýsingarorð), verbs (í. sagnir) (except auxiliaries/modals), adverbs (í. atviksorð; eingöngu háttaratviksorð í íslensku).

11 word classes in Icelandic

Fallorð	Sagnorð	Smáorð
Words which inflect	Verbs	Function words

Nafnorð (e. nouns)	Sagnorð (e. verbs)	Forsetningar (e. prepositions)
Lýsingarorð (e. adjectives)		Atviksorð (e. adverbs)
Fornöfn (e. pronouns)		Samtengingar (e. conjunctions)
Töluorð (e. numerals)		Upphrópanir (e. interjections)
Greinir (e. article)		Nafnháttarmerki (e. infinitive marker)

Words which inflect (í. fallorð)

Features (í. beygingarleg einkenni)
(the bold font refers to the letters in the Icelandic POS tagset)

- Kyn (e. gender)
 - **k**arlkyn (e. masculine)
 - **k**venkyn (e. feminine)
 - **h**vorugkyn (e. neuter)
- Tala (e. number)
 - **e**intala (e. singular)
 - **f**leirtala (e. plural)
- Fall (e. case)
 - **n**efnifall (e. nominative)
 - **þ**olfall (e. accusative)
 - **þ**águfall (e. dative)
 - **e**ignarfall (e. genitive)

Features

■ Háttur (e. mood)

http://is.wikipedia.org/wiki/Hættir_sagna

- framsöguháttur (e. indicative mood)
- viðtengingarháttur (e. subjunctive mood)
- boðháttur (e. imperative mood)
- nafnháttur (e. infinitive mood)
- lýsingarháttur nútíðar (e. present participle)
- lýsingarháttur þátíðar (e. past participle)

■ Mynd (e. voice)

<http://is.wikipedia.org/wiki/Sagnmyndir>

- germynd (e. active)
- miðmynd (e. middle)
- þolmynd (e. passive) - generated using past participle (í lýsingarháttur þátíðar).

Features

- Persóna (e. person): 1., 2., 3.
- Tala (e. number): eintala, fleirtala
- Tíð (e. tense)
 - nútíð (e. present)
 - þátíð (e. past)

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A lexicon (í. orðasafn)

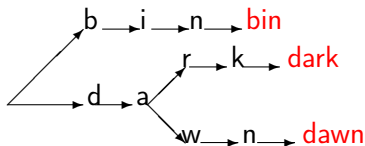
Contains what?

- A list of words, lexical entries (lexemes), with or without **annotations**.
 - Pronunciation
 - Morphology
 - POS tags
 - Syntactic and semantic labels.
- A lexicon with annotation is sometimes called a *dictionary*.
- Often generated to cover a particular domain, e.g. technology, science, finance.
- Generally the first unit needed for a Language Technology System.

A lexicon/dictionary

Data structure

- Hash-table (key–value): each word is a key and further information about the word is stored in the value.
 - Memory intensive for large lexicons.
- *Letter trees* (tries) <http://en.wikipedia.org/wiki/Trie>
 - Words are stored as trees of characters and they share branches as far as the letters of two words are identical.



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Morphology (í. Orðhlutafræði)

Morpheme (í. Myndan/morfem)

- The smallest meaningful unit of a word
- Divide into **stems** (í. stofn) and **affixes** (í. aðskeyti)
- The stem is the common part shared by all word forms.
- Example: The English word form “churches” consists of two morphemes:
 - The stem “church”
 - The plural suffix/ending “es”
- Example: The Icelandic word form “orði” consists of two morphemes:
 - The stem “orð”.
 - The inflectional ending “i” (denoting the dative case (í. þágufall)).

Affixes

- Prefix (í. forskeyti)
 - Appears before the stem.
 - Example: rewrite, örfínn
- Suffix (í. viðskeyti)
 - Appears after the stem.
 - Example: teacherer, kennarari
- Infix (í. innskeyti)
 - Squeezed into the stem.
 - Example: humingi in tagalog; hingi: to lend, humingi: the person who gets the loan
- Circumfix (í. umskeyti)
 - Appears both before and after the stem.
 - Example: gesagtt in German past participle

- [http://en.wikipedia.org/wiki/Morphology_\(linguistics\)](http://en.wikipedia.org/wiki/Morphology_(linguistics))
- The theory of how words are built from morphemes
- Two kinds of systems:
 - Concatenative morphology
 - For example, Germanic languages
 - http://en.wikipedia.org/wiki/Germanic_languages
 - Prefix + Stem + Suffix
 - Non-concatenative (templatic) morphology
 - http://en.wikipedia.org/wiki/Nonconcatenative_morphology
 - For example, Arabic or Hebrew

Icelandic morphology

Words are generated from morphemes in two ways:

Using inflection (í. beyging)

- Prefix + Stem + inflectional ending
- The new word belongs to the same word class as the stem.
- Example: hestur (e. a horse), kona (e. a woman)

Using derivation (í. afleiðsla)

- Prefix + Stem + Suffix
- The new word can belong to a different word class
- Example: misjafn (e. unequal), klofningur (e. a split), kennari (e. a teacher)

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Morphological analysis/parsing

- í. Orðhlutafræðileg greining/þáttun
- The task of breaking a word into morphemes.
- A necessary unit in many LT systems:
 - **Lemmatization** (í. lemmun). The task of finding the lemma of a word – the dictionary form (í. uppflettimynd).
 - An Icelandic lemmatiser: <http://www.springerlink.com/content/h530q7157285563u/>
 - **Stemming**. The task of finding the stem of a word. For example, important in Information Retrieval.
 - Words not found in a lexicon (unknown words) need analysis, for example in POS tagging

Morphological generation = Generating words given morphemes.

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Lemmatisation vs. Stemming

- Example: “hesti”. Lemma = “hestur”. Stem = “hest”

Ambiguity in lemmatisation.

- 1 A **run** in the forest. Lemma: **run**, a singular noun.
- 2 The sportsmen **ran** everyday. Lemma: **run**, a verb in past tense, third person, plural.
- 3 **Rétturinn** var fullskipaður. Lemma: **réttur**, a noun in masculine, singular, nominative, suffixed definite article.
- 4 Dæmið var **rétt**. Lemma: **réttur**, an adjective in neuter, singular, nominative, strong declension, positive

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What should be in the lexicon?

- Why don't we list all word forms in the lexicon? For example, all inflectional endings?
- Many processes are predictable.
 - It is therefore inefficient to list all word forms.
- Many processes are productive
 - It is there not possible to list all word forms.
- Thus, we may need to separate the lexicon from the rules for generating words.

The slide is taken from the course: Inngangur að tungutækni,
Eiríkur Rögnvaldsson, HÍ, 2002.

Two-level morphology (í. tveggja laga orðhlutagreining)

Purpose

- Kimmo Koskeniemi, 1983.
 - <http://www.ling.helsinki.fi/~koskenni/doc/Two-LevelMorphology.pdf>
- Links the *surface form* of a word – the word as it is actually in a text – to its *lexical form* (underlying form) – its sequence of morphemes.
- The mapping between the surface form and the lexical form (in both directions) is implemented using a *finite-state transducer* (í. stöðuferjald).

Two-level morphology (í. tveggja laga orðhlutagreining)

Examples of surface and lexical forms in English

dis+en+tangle+ed disentangled
happy+er happier
move+ed moved

Correspondence between lexical and surface forms

- Example for Icelandic (0 denotes the empty string)

Lexical form: hest+ur (a morpheme used)

Surface form: hest0ur

Lexical form: hest +n +k +e +n (morphological features used)

Surface form: hest 0 0 u r

A finite-state transducer

- A finite-state automaton recognising or generating a **pair of strings**.
- Arcs are labeled with two symbols: the first is the input, the second is the output
- The machine transduces the input symbol into the output symbol as a transition occurs on the arc.
- See Fig. 5.6. page 132 in the textbook.

A finite-state transducer (FST)

A mathematical definition

A FST consists of five components $(Q, \Sigma, q_0, F, \delta)$:

- 1 Q is a finite set of states, $q_0, q_1 \dots q_n$.
- 2 Σ is a finite set of symbol pairs $i : o$, i is from the input alphabet, o is from the output alphabet.
- 3 q_0 is the start state, $q_0 \in Q$.
- 4 F is a set of final states, $F \subseteq Q$.
- 5 δ is the transition function $Q \times \Sigma \rightarrow Q$, $\delta(q, i, o)$ returns the state where the automaton moves when it is in state q and consumes the input symbol pair $i : o$.

A finite-state transducer: Example

hestur

Singular

Lexical: hest +n +k +e +n

Surface: hest 0 0 u r

Lexical: hest +n +k +e +o

Surface: hest 0 0 0 0

Lexical: hest +n +k +e +þ

Surface: hest 0 0 0 i

Lexical: hest +n +k +e +e

Surface: hest 0 0 0 s

Plural

hest +n +k +f +n

hest 0 0 a r

hest +n +k +f +o

hest 0 0 0 a

hest +n +k +f +þ

hest 0 0 u m

hest +n +k +f +e

hest 0 0 0 a

Prolog implementation

- Prolog: See Appendix A in the textbook.
- SWI-Prolog: <http://www.swi-prolog.org/>
- The implementation of the finite-state transducer (Prolog-code): See “Other material” in MySchool.
- Read the code into the Prolog interpreter:
`consult('transduce.pro')`.
- Test the FST: `transduce(1, Final, Lexical, [h,e,s,t,u,r])`.
- Test the FST: `transduce(1, Final, [h,e,s,t,+n,+k,+e,+n], Surface)`.