T-(538|725)-MALV, Natural Language Processing
PoS tagging – with rules

Hrafn Loftsson¹  Hannes Högni Vilhjálmsson¹

¹School of Computer Science, Reykjavik University

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Outline

1. PoS tagging
2. Accuracy in PoS tagging
3. Type of taggers
4. Linguistic rule-based taggers
5. A tagger which learns rules
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What is PoS tagging (í. mörkun)?

A definition

- To label (í. marka) each word in a text with the appropriate word class (í. orðflokkur) and morphological features (í. beygingarleg einkenni).
- The string used as a label is called a tag (í. mark)

Why is this difficult?

- Some words are ambiguous (í. margræð).
  - A tagger is sometimes called a disambiguator, since it performs ambiguity resolution (í. einræðing).
- When looking up a word in a dictionary or performing morphological analysis ⇒ more than one tag (analysis) for the word is possible.
PoS tagging

Significance

- The tag for a word gives important information about the word and its neighbors.
  - “You shall know a word by the company it keeps” (Firth, 1957)
  - For example, the gender, number and case of an adjective signify comparable features for the following noun.
- Helps with speech synthesis.
  - OBject (noun) vs. obJECT (verb)
- The base for grammar checking, machine translation, parsing.
- Used in the construction of annotated corpora.
PoS tagging

Tagset

- A tagset (í. markamengi) is the set of all possible tags (labels).
- Different languages have different tagsets.
- The same language can have more than one tagset.
- Icelandic: *The Icelandic Frequency Dictionary (Íslensk orðtíðnibók)* – 700 tags.
- Swedish: *Parole*: 139 tags.
### Full disambiguation (í. full einræðing)

- A single tag is assigned to each word (token).
- The most common method, but ... 
- ...sometimes a tagger cannot perform full disambiguation.
- In that case, the tagger returns a set of possible tags for a given word.
Example: English PoS tagging

Penn Treebank tagset: http://www.ling.upenn.edu/courses/Fall_2003/ling001/penn_treebank_pos.html

- The back door = JJ
- On my back = NN
- Win the voters back = RB
- Promised to back the bill = VB
Example: Icelandic PoS tagging

“Gamli maðurinn borðar kalda súpu með mjög góðri lyst” (Old man-the eats cold soup with very good appetite)

<table>
<thead>
<tr>
<th>Icelandic</th>
<th>PoS Tagging</th>
</tr>
</thead>
<tbody>
<tr>
<td>gamli</td>
<td>lkenvf</td>
</tr>
<tr>
<td>maðurinn</td>
<td>nkeng</td>
</tr>
<tr>
<td>borðar</td>
<td>sfg3en_sfg2en</td>
</tr>
<tr>
<td>kalda</td>
<td>lveosf_lkfosf_lkeovf_lkeþvf_lkeevf_lvenvf_lhenvf_lheovf_lheþvf_lheevf</td>
</tr>
<tr>
<td>súpu</td>
<td>nveo_nveþ_nvee</td>
</tr>
<tr>
<td>með</td>
<td>aþ_aa</td>
</tr>
<tr>
<td>mjög</td>
<td>aa</td>
</tr>
<tr>
<td>góðri</td>
<td>lveþsf</td>
</tr>
<tr>
<td>lyst</td>
<td>nven_nveo_nveþ</td>
</tr>
</tbody>
</table>
“Gamli maðurinn borðar kalda súpu með mjög góðri lyst”

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<td>sfg3en</td>
</tr>
<tr>
<td>kalda</td>
<td>lveosf</td>
</tr>
<tr>
<td>súpu</td>
<td>nveo</td>
</tr>
<tr>
<td>með</td>
<td>ap</td>
</tr>
<tr>
<td>mjög</td>
<td>aa</td>
</tr>
<tr>
<td>góðri</td>
<td>lvepsf</td>
</tr>
<tr>
<td>lyst</td>
<td>nvep</td>
</tr>
</tbody>
</table>
PoS tagging

In a research for English and French: 50-60% of tokens have only one possible tag, 15-25% have only two possible tags.

Assigning the most frequent tag for a word yields more than 75% accuracy.

This is called base tagging (í. grunnmörkun)

Charniak (1993) has obtained more than 90% accuracy by applying base tagging for English.

Note that the underlying tagset plays an important role here.
Baseline tagging

In the Icelandic Frequency Dictionary (IFD):

- Unambiguous word forms: 84.16%
- Ambiguous word forms: 15.84%
- Ambiguous word forms with 2 tags: 11.07%
- Ambiguous word forms with 3 tags: 2.96%
- Ambiguous word forms with 4 tags: 0.97%

Which words are ambiguous?

- Usually the most common words, the function words.
### Baseline tagging

#### Common words and their tags in the IFD

<table>
<thead>
<tr>
<th>Word Count</th>
<th>Word</th>
<th>Tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>33181</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22176</td>
<td>og</td>
<td>c</td>
</tr>
<tr>
<td>22083</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21011</td>
<td>að</td>
<td>cn_c_aþ_aa</td>
</tr>
<tr>
<td>15319</td>
<td>í</td>
<td>aþ_ao_aa</td>
</tr>
<tr>
<td>12450</td>
<td>á</td>
<td>aþ_ao_sfg1en_sfg3en_aa_nven_nveo_nveþ_au</td>
</tr>
<tr>
<td>8040</td>
<td>hann</td>
<td>fpken_fpkeo</td>
</tr>
<tr>
<td>7905</td>
<td>var</td>
<td>sfg3ep_sfg1ep_lkensf</td>
</tr>
<tr>
<td>7676</td>
<td>sem</td>
<td>ct_c_aa_sfg1en</td>
</tr>
<tr>
<td>6357</td>
<td>er</td>
<td>sfg3en_sfg1en_ct_c</td>
</tr>
</tbody>
</table>
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Measuring the accuracy

### Full disambiguation

Accuracy (í. hittni) = \[
\frac{\text{# correctly tagged tokens}}{\text{total number of tokens}}
\] (1)

### Not full disambiguation

Precision = \[
\frac{\text{# correct tags generated by the tagger}}{\text{total number of tags generated by the tagger}}
\] (2)

Recall = \[
\frac{\text{# correct tags generated by the tagger}}{\text{total number of correct tags}}
\] (3)

Ambiguity rate = \[
\frac{\text{# tags generated by tagger}}{\text{total number of tokens}}
\] (4)
Measuring the accuracy

Example: 100 tokens

- A tagger performs full disambiguation and correctly tags 95 tokens. ⇒ **accuracy** = 95/100 = 95%

- A tagger doesn’t perform full disambiguation and returns 105 tags, of which 95 are correct.
  - ⇒ **precision** = 95/105 = 90.5%
  - ⇒ **recall** = 95/100 = 95.0%
  - ⇒ **ambiguity rate** = 105/100 = 1.05

Note that when full disambiguation is applied then **accuracy**=**precision**=**recall** and **ambiguity rate**=1.0.

- Icelandic terms: precision=nákvæmni, recall=griphlutfall, ambiguity rate=margræðníhlutfall
Accuracy in PoS tagging

What can affect the accuracy?

- The type of tagger – the quality of the language model.
- The size of the tagset.
- The ratio of unknown words.
  - The possible tags for unknown words are not known!
  - An *unknown word guesser* is needed.
- The size of the training corpus.
- The type of the test corpus.
Accuracy in PoS tagging

- **English:**
  - 96.7% (Brants, 2000)
  - Ratio of unknown words: 2.9%
  - Training corpus: 1,000,000 words.
  - Tagset: 45 tags (Penn TreeBank).

- **Swedish:**
  - 93.6% (Megyesi, 2002)
  - Ratio of unknown words: 15.0%
  - Training corpus: 100,000 words.
  - Tagset: 139 tags.

- **Icelandic:**
  - 92.5% (Loftsson et al., 2009)
  - Ratio of unknown words: 6.8%
  - Development corpus: 59,000 words.
  - Tagset: 700 tags.
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Type of taggers

Rules vs. statistics

- Rules use the context of a word to eliminate or change a particular tag.
- Rules can be hand-written or learned in a data-driven manner from a tagged corpus.
- Statistical methods are used to assign words in a sentence the most likely tag sequence.
- Statistical methods use frequency information (e.g. n-grams) which are derived from a tagged corpus.
## Type of taggers

### Linguistic rule-based taggers (í. Málfræðilegir reglumarkarar)
- Are based on hand-written linguistic rules.
- Only used to tag a particular language using a specific tagset.

### Data-driven taggers (í. Gagnamarkarar)
- Language and tagset independent.
- Use PoS tagged corpora to automatically collect information which is later used for disambiguation of new texts.
- This information can, for example, be in the form of statistics or rules.
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Linguistic rule-based taggers

Typical functionality

1. Each word is assigned its *tag profile*, the set of possible tags for that word
   - Using a dictionary, or a morphological analyser, and/or an unknown word guesser.

2. Disambiguation using rules
   - Inappropriate tags eliminated with regard to context (reductionist approach)
Typical functionality

Use rules about the nature of sentences and phrases to tags the words.

- A preposition does (usually) not appear before a verb
  - The word *fórum* is a noun in the context *í fórum mínum*.

- A possessive pronoun agrees with the following noun in gender, number and case.
  - In the context *hesta þinna* (horses yours), the word *þinna* is unambiguously genitive case and therefore the word *hesta* is also genitive, but not accusative.
Linguistic rule-based taggers

Constraint Grammar Framework (Fred Karlsson 1990)

- A morphological analyser (based on two-level morphology) returns all possible analysis for each word.
- Rules (constraints) are written to eliminate tags with regard to context.
- Often thousands of rules, e.g. EngCG-2 with 3,600 rules.
- Time-consuming but recall is high. Does not perform full disambiguation for all words.
- Samuelsson and Voutilainen (1997):
  - Recall: 99.6%
  - Ambiguity rate: 1.02%.
Linguistic rule-based taggers

*IceTagger* - Hrafn Loftsson

- Unknown word guesser: *IceMorphy*
- Local rules
  - About 175 rules.
  - Eliminate a specific tag in a particular context.
  - The local context is 5 words.
- Global rules
  - Heuristics (í. leitaraðferðir)
  - Guess the syntactic functions of words (subject, verb, object).
  - Mark preposition phrases.
  - Use the above to force feature agreement.
**IceTagger**

**Full disambiguation**

- The most frequent tag for a word is selected if a word is still ambiguous after the application of local and global rules.
- *IceTagger* is thus a combination of a linguistic rule-based tagger and a base tagger.

**Test**

- [http://nlp.ru.is](http://nlp.ru.is) and select *IceNLP*. 
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A tagger which learns rules

Brill’s tagger (Eric Brill 1992)

- A data-driven tagger.
- Learns rules in training which change one tag to another.
  - ⇒ “Transformation-based learning”
- A dictionary is derived from the training corpus.
  - Keeps track of the most frequent tag for a word.
Brill’s tagger

**Functionality**

- Initially, assigns the most frequent tag to each word (base tagging).
- Applies a list of rules (transformations) to change the initial tagging.
- The rules are applied in a specific order and each transformation is applied on the text from left to right.
- An example for English:
  - “The can rusted”
  - With the most likely tag: **The/art can/modal rusted/verb**.
  - Rule: *Change the tag from modal to noun if the previous word is an article.*
  - Result: **The/art can/noun rusted/verb**.
Brill’s tagger

How are the rules derived?

- Rules are based on templates.
- The templates restrict the type of rules that can be generated.
- Example template:
  - `alter(A, B, prevtag(C))` Change A to B if preceding tag is C.
  - `alter(A, B, nextbigram(C,D))` Change A to B if next bigram tag is C D.
- Brill used 11 templates for English, which resulted in about 500 rules, sufficient for achieving about 97% accuracy.
Brill’s tagger – The training algorithm

<table>
<thead>
<tr>
<th>St.</th>
<th>Operation</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Base tagging</td>
<td>Corpus</td>
<td>Corpus(1)</td>
</tr>
<tr>
<td>2.</td>
<td>Compare PoS of each word in Gold standard and Corpus(i)</td>
<td>Gold standard</td>
<td>List of errors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Corpus(i)</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>For each error, instantiate the rule templates to correct the error</td>
<td>List of errors</td>
<td>List of tentative rules</td>
</tr>
<tr>
<td>4.</td>
<td>For each rule, compute on Corpus(i) # of good transf. - # of bad transf.</td>
<td>Corpus(i)</td>
<td>Scored tentative rules</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tentative rules</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Select the rule that has the greatest error reduction and append it to the</td>
<td>Tentative rules</td>
<td>Rule(i)</td>
</tr>
<tr>
<td></td>
<td>ordered list of tranformations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Apply Rule(i) to Corpus(i)</td>
<td>Corpus(i)</td>
<td>Corpus(i+1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rule(i)</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>If number of errors &lt; δ exit else go to step 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Brill’s tagger – Example of rules for known words

Training on the Icelandic Frequency Dictionary

- GOOD:1505 BAD:9 SCORE:1496 RULE: pos_0=sfg3eþ  
  pos:[-2,-1]=fp1en ⇒ pos=sfg1eþ
  - Change tag sfg3eþ to sfg1eþ if one of the two previous tags is fp1en.
  - This rule corrected 1505 errors in the initial tagging.

- GOOD:836 BAD:38 SCORE:798 RULE: pos_0=aþ  
  pos:[1,2]=nkeog ⇒ pos=ao

- GOOD:563 BAD:20 SCORE:543 RULE: pos_0=aþ  
  pos:[1,2]=nveog ⇒ pos=ao
Brill’s tagger

Unknown words

- Labels unknown words as proper nouns if they start with a capital letter.
- Labels all other unknown words as common nouns.
- Then applies special templates (see page 155) for generating rules which change the tag of an unknown word from $X$ to $Y$. 
Brill’s tagger – Example of rules for unknown words

Training on the Icelandic Frequency Dictionary

- **GOOD:558 BAD:3 SCORE:555 RULE:** pos=nken
  word::〜〜1〜〜a ⇒ pos=sng
  - Change tag nken to sng if the last letter of the word is “a”.
  - This rule corrected 558 errors in the initial tagging but only added 3 errors.

- **GOOD:438 BAD:6 SCORE:432 RULE:** pos=nken
  word::〜〜3〜〜nni ⇒ pos=nveþg

- **GOOD:275 BAD:4 SCORE:271 RULE:** pos=nheþ
  word::〜〜3〜〜aði ⇒ pos=sfg3eþ