

# Language Technology

<http://cs.lth.se/edan20/>  
Chapter 7: Part-of-Speech Tagging Using Rules

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# The Parts of Speech

The parts of speech (POS) are classes that correspond to the lexical – or word – categories

Plato made a distinction between the verb and the noun.

After him, the word categories further evolved and grew in number until Dionysus Thrax formulated and fixed them.

Aelius Donatus popularized the list of the eight parts of speech: noun, pronoun, verb, participle, conjunction, adverb, preposition, and interjection.

Grammarians have adopted these POS for most European languages although they are somewhat arbitrary



# Part-of-speech Annotation

Sentence:

*That round table might collapse*

Annotation:

| Words           | Parts of speech | POS tags |
|-----------------|-----------------|----------|
| <b>that</b>     | Determiner      | DT       |
| <b>round</b>    | Adjective       | JJ       |
| <b>table</b>    | Noun            | NN       |
| <b>might</b>    | Modal verb      | MD       |
| <b>collapse</b> | Verb            | VB       |

The automatic annotation uses predefined POS tagsets such as the Penn Treebank tagset for English



# Word Ambiguity

|                | English              | French               | German             |
|----------------|----------------------|----------------------|--------------------|
| Part of speech | <i>can</i> modal     | <i>le</i> article    | <i>der</i> article |
|                | <i>can</i> noun      | <i>le</i> pronoun    | <i>der</i> pronoun |
| Semantic       | <i>great</i> big     | <i>grand</i> big     | <i>groß</i>        |
|                | <i>great</i> notable | <i>grand</i> notable | <i>groß</i>        |



# POS Tagging

| Words           | Possible tags  | Example of use  |
|-----------------|--|---|
| <b>that</b>     | Subordinating conjunction<br>Determiner<br>Adverb<br>Pronoun<br>Relative pronoun | <i>That he can swim is good</i><br><i>That white table</i><br><i>It is not that easy</i><br><i>That is the table</i><br><i>The table that collapsed</i> |
| <b>round</b>    | Verb<br>Preposition<br>Noun<br>Adjective<br>Adverb                               | <i>Round up the usual suspects</i><br><i>Turn round the corner</i><br><i>A big round</i><br><i>A round box</i><br><i>He went round</i>                  |
| <b>table</b>    | Noun<br>Verb   | <i>That white table</i><br><i>I table that</i>  |
| <b>might</b>    | Noun<br>Modal verb   | <i>The might of the wind</i><br><i>She might come</i>   |
| <b>collapse</b> | Noun<br>Verb   | <i>The collapse of the empire</i><br><i>The empire can collapse</i>   |



# Part-of-Speech Ambiguity in Swedish

The word *som* in the *Norstedts svenska ordbok*, 1999, has three entries:

- ① *Om jag vore lika vacker som du, skulle jag vara lycklig.* (konjunktion)
- ② *Bilen som jag köpte i fjol.* (pronomen)
- ③ *Som jag har saknat dig.* (adverb)

The part-of-speech difference can be significant:

Swedish. Compare the pronunciation of *vaken*, adjective, as in *Han är aldrig vaken innan klockan sju* and *vaken*, noun, as in *Vi fiskade i vaken i sjön*

English. Compare *object* in *I object to violence*, verb, or *I could see an object*, noun.



# Simple Grammatical Constraints are not Satisfying

Although, it makes no sense,

*I see a bird*

can be tagged as:

*I/**noun** see/**noun** a/**noun** bird/**noun***

Because sequences of four nouns are possible in English as in:

*city school committee meeting.*

The disambiguation methods are based on

- Handcrafted rules
- Automatically learned rules
- Statistical methods

Currently disambiguation accuracy is greater than 95% for many languages



# POS Annotation with Rules

The phrase *The can rusted* has two readings

Let's suppose that *can/modal* is more frequent than *can/noun* in our corpus

First step: Assign the most likely POS

*The/art can/modal rusted/verb*

Second step: Apply rules

Change the tag from modal to noun if one of the two previous words is an article

*The/art can/noun rusted/verb*

This is the idea of Brill's tagger.





# Rule Templates

| Rules  | Explanation   |
|--|---|
| <code>alter(A, B, prevtag(C))</code>           | Change A to B if preceding tag is C                 |
| <code>alter(A, B, nexttag(C))</code>           | Change A to B if the following tag is C             |
| <code>alter(A, B, prev2tag(C))</code>          | Change A to B if tag two before is C                |
| <code>alter(A, B, next2tag(C))</code>          | Change A to B if tag two after is C                 |
| <code>alter(A, B, prev1or2tag(C))</code>       | Change A to B if one of the two preceding tags is C |
| <code>alter(A, B, next1or2tag(C))</code>       | Change A to B if one of the two following tags is C |
| <code>alter(A, B, surroundingtag(C, D))</code> | Change A to B if surrounding tags are C and D       |
| <code>alter(A, B, nextbigram(C, D))</code>     | Change A to B if next bigram tag is C D             |
| <code>alter(A, B, prevbigram(C, D))</code>     | Change A to B if previous bigram tag is C D         |



# Learning Rules Automatically

Compare the hand-annotation of the reference corpus with the automatic one

Automatic tagging

*The/art can/modal rusted/verb*

Hand annotation: gold standard

*The/art can/noun rusted/verb*

For each error instantiate the templates

Rules correcting the error

```
alter(modal, noun, prevtag(art)).  
alter(modal, noun, prev1or2tag(art)).  
alter(modal, noun, nexttag(verb))  
alter(modal, noun, surroundingtag(art, verb))
```

Rules introduce good and bad transformations

Select the rule that has the greatest error reduction and apply it



# Part-of-Speech Ambiguity in Swedish

The Swedish word *den* can be a determiner or a pronoun.  
It corresponds to two entries in the *Nordstedts svenska ordbok* (1999, page 187):

- **den** artikel ... som här antas vara känd ...: **den** nya bilen
- **den** pron. personen eller företeelsen som är omtalad i sammanhanget ...: *Var har du köpt kameran? Jag har fått **den** i present.*

Frequency information:

```
egrep -i "den dt" talbanken.txt | wc -l  
820  
egrep -i "den pn" talbanken.txt | wc -l  
256
```



# Ambiguity Resolution in Swedish: The Baseline

Let us suppose that *den* is the only word to tag in the corpus and that it has two possible parts of speech: dt and pn.

Using the most frequent part of speech produces the annotations:

|     |     |            |         |       |     |
|-----|-----|------------|---------|-------|-----|
| Den | nya | läroplanen | innebär | också | ... |
| dt  | jj  | nn         | vb_fin  | ab    |     |

|     |        |      |     |    |         |
|-----|--------|------|-----|----|---------|
| Jag | har    | fått | den | i  | present |
| pn  | vb_fin | vb   | dt  | pp | nn      |

If the POS tagger is restricted to *den*, out of  $820 + 256 = 1076$  POS assignments,

$$\frac{820}{1076} = 76\%$$

are correct.



# Ambiguity Resolution in Swedish: The Rule Templates

Let us use two rules templates `alter(A, B, prev(C))` and `alter(A, B, next(C))` and instantiate them with the error on *Jag har fått den i present*.

|     |        |           |           |           |         |
|-----|--------|-----------|-----------|-----------|---------|
| Jag | har    | fått      | den       | i         | present |
| pn  | vb_fin | <b>vb</b> | (dt → pn) | <b>pp</b> | nn      |

It yields:

- 1 Change dt to pn if previous POS tag is vb:  
`alter(dt, pn, prev(vb))`
- 2 Change dt to pn if next POS tag is pp: `alter(dt, pn, next(pp))`

Both rules produce a correct annotation on the training example



# Ambiguity Resolution in Swedish: Selecting the Rules

Let us apply the two rules to all the occurrences of *den* in the corpus and ignore all the other words:

- The first rule corrects 15 wrong annotations of *den* and introduces 59 mistakes:  $15 - 59 = -44$
- The second rule corrects 20 wrong annotations and introduces 5 mistakes:  $20 - 5 = +15$

The training step of Brill's tagger selects the most efficient rule, here `alter(dt, pn, next(pp))`.

Of course, this step is applied to all the ambiguous words and not only *den*.

We iterate the procedure until the error rate is below a certain threshold.



# Brill's Learning Algorithm

| St. | Operation   | Input  | Output                                      |
|-----|---|--|---|
| 1.  | Annotate each word of the corpus with its most likely part of speech  | <i>Corpus</i>                                | <i>AnnotatedCorpus(1)</i>                   |
| 2.  | Compare pairwise the part of speech of each word of the <i>AnnotationReference</i> and <i>AnnotatedCorpus(i)</i>  | <i>AnnotationReference</i>                   | List of errors<br><i>AnnotatedCorpus(i)</i> |
| 3.  | For each error, instantiate the rule templates to correct the error   | List of errors                               | List of tentative rules                     |
| 4.  | For each instantiated rule, compute on <i>AnnotatedCorpus(i)</i> the number of good transformations minus the number of bad transformations the rule yields | <i>AnnotatedCorpus(i)</i><br>Tentative rules | Scored tentative rules                      |



# Brill's Learning Algorithm

| St. | Operation  | Input                             | Output                 |
|-----|--|-----------------------------------|------------------------|
| 5.  | Select the rule that has the greatest error reduction and append it to the ordered list of transformations | Tentative rules                   | $Rule(i)$              |
| 6.  | Apply $Rule(i)$ to $AnnotatedCorpus(i)$  | $AnnotatedCorpus(i)$<br>$Rule(i)$ | $AnnotatedCorpus(i+1)$ |
| 7.  | If number of errors is under predefined threshold, end the algorithm else go to step 2.                    | –                                 | List of rules          |





# First Brill's Rules

| Change |      |     |                                       |
|--------|------|-----|---------------------------------------|
| #      | From | To  | Condition                             |
| 1      | NN   | VB  | Previous tag is TO                    |
| 2      | VBP  | VB  | One of the previous three tags is MD  |
| 3      | NN   | VB  | One of the previous two tags is MD    |
| 4      | VB   | NN  | One of the previous two tags is DT    |
| 5      | VBD  | VBN | One of the previous three tags is VBZ |

In the table, rules consider parts of speech only. This is the normal case and they are called unlexicalized.

Rules can also consider word values and they are called lexicalized.

| Change |      |    |   |
|--------|------|----|---|
|        | From | To | Condition                                 |
|        | IN   | RB | The word two positions to the right is as |



# Standard POS Tagsets: The Penn Treebank

|     |       |                              |     |      |                                   |
|-----|-------|------------------------------|-----|------|-----------------------------------|
| 1.  | CC    | Coordinating conjunction     | 25. | TO   | to                                |
| 2.  | CD    | Cardinal number              | 26. | UH   | Interjection                      |
| 3.  | DT    | Determiner                   | 27. | VB   | Verb, base form                   |
| 4.  | EX    | Existential <i>there</i>     | 28. | VBD  | Verb, past tense                  |
| 5.  | FW    | Foreign word                 | 29. | VBG  | Verb, gerund/present participle   |
| 6.  | IN    | Preposition/sub. conjunction | 30. | VBN  | Verb, past participle             |
| 7.  | JJ    | Adjective                    | 31. | VBP  | Verb, non-third pers. sing. pres. |
| 8.  | JJR   | Adjective, comparative       | 32. | VBZ  | Verb, third-pers. sing. present   |
| 9.  | JJS   | Adjective, superlative       | 33. | WDT  | <i>wh</i> -determiner             |
| 10. | LS    | List item marker             | 34. | WP   | <i>wh</i> -pronoun                |
| 11. | MD    | Modal                        | 35. | WP\$ | Possessive <i>wh</i> -pronoun     |
| 12. | NN    | Noun, singular or mass       | 36. | WRB  | <i>wh</i> -adverb                 |
| 13. | NNS   | Noun, plural                 | 37. | #    | Pound sign                        |
| 14. | NNP   | Proper noun, singular        | 38. | \$   | Dollar sign                       |
| 15. | NNPS  | Proper noun, plural          | 39. | .    | Sentence final punctuation        |
| 16. | PDT   | Predeterminer                | 40. | ,    | Comma                             |
| 17. | POS   | Possessive ending            | 41. | :    | Colon, semicolon                  |
| 18. | PRP   | Personal pronoun             | 42. | (    | Left bracket character            |
| 19. | PRP\$ | Possessive pronoun           | 43. | )    | Right bracket character           |
| 20. | RB    | Adverb                       | 44. | "    | Straight double quote             |
| 21. | RBR   | Adverb, comparative          | 45. | '    | Left open single quote            |
| 22. | RBS   | Adverb, superlative          | 46. | "    | Left open double quote            |
| 23. | RP    | Particle                     | 47. | '    | Right close single quote          |



# An Example of Tagged Text from the Penn Treebank

Battle-tested/JJ Japanese/JJ industrial/JJ managers/NNS here/RB  
always/RB buck/VBP up/RP nervous/JJ newcomers/NNS with/IN  
the/DT tale/ NN of/IN the/DT first/JJ of/IN their/PP\$  
countrymen/NNS to/TO visit/VB Mexico/NNP ,/, a/DT boatload/NN  
of/IN samurai/FW warriors/NNS blown/VBN ashore/RB 375/CD  
years/NNS ago/RB ./.

“/” From/IN the/DT beginning/NN ,/, it/PRP took/VBD a/DT  
man/NN with/IN extraordinary/JJ qualities/NNS to/TO succeed/VB  
in/IN Mexico/NNP ”/” says/VBZ Kimihide/NNP Takimura/NNP ,/,  
president/NN of/IN the/DT Mitsui/NNP group/NN ’s/POS  
Kensetsu/NNP Engineering/NNP Inc./NNP unit/NN ./.



# Measuring Quality: The Confusion Matrix

From Franz (1996, p. 124)

| ↓ <b>Correct</b> | <b>Tagger</b> → |      |      |      |      |      |      |      |      |      |
|------------------|-----------------|------|------|------|------|------|------|------|------|------|
|                  | DT              | IN   | JJ   | NN   | RB   | RP   | VB   | VBD  | VBG  | VB   |
| DT               | 99.4            | 0.3  | –    | –    | 0.3  | –    | –    | –    | –    | –    |
| IN               | 0.4             | 97.5 | –    | –    | 1.5  | 0.5  | –    | –    | –    | –    |
| JJ               | –               | 0.1  | 93.9 | 1.8  | 0.9  | –    | 0.1  | 0.1  | 0.4  | 1.5  |
| NN               | –               | –    | 2.2  | 95.5 | –    | –    | 0.2  | –    | 0.4  | –    |
| RB               | 0.2             | 2.4  | 2.2  | 0.6  | 93.2 | 1.2  | –    | –    | –    | –    |
| RP               | –               | 24.7 | –    | 1.1  | 12.6 | 61.5 | –    | –    | –    | –    |
| VB               | –               | –    | 0.3  | 1.4  | –    | –    | 96.0 | –    | –    | 0.2  |
| VBD              | –               | –    | 0.3  | –    | –    | –    | –    | 94.6 | –    | 4.8  |
| VBG              | –               | –    | 2.5  | 4.4  | –    | –    | –    | –    | 93.0 | –    |
| VBN              | –               | –    | 4.6  | –    | –    | –    | –    | 4.3  | –    | 90.1 |



# Recognizing Parts of Speech

Parts of speech denomination is comparable in Western European languages and roughly corresponds

They follow Donatus' teaching

(<https://www.thelatinlibrary.com/don.html>)

If you are not sure, look up in a dictionary

Two common mistakes in the labs:

- Confusion between noun and the Swedish word *namn*.
  - A common noun, or more simply a noun, corresponds to *substantiv*
  - Proper noun, or name, (or proper name) corresponds to *namn* or *egennamn*.
- Possessive pronouns like *my*, *your*, *his*, *her*, ... are not real pronouns. They should be called possessive adjectives or determiners.



# Multext and Google's Universal POS tagset

| Part of speech                  | Multext | Universal POS, new version |
|---------------------------------|---------|----------------------------|
| <b>Noun</b>                     | N       | NOUN, PROPN                |
| <b>Verb</b>                     | V       | VERB, AUX                  |
| <b>Adjective</b>                | A       | ADJ                        |
| <b>Pronoun</b>                  | P       | PRON                       |
| <b>Determiner</b>               | D       | DET                        |
| <b>Adverb</b>                   | R       | ADV                        |
| <b>Adposition (Preposition)</b> | S       | ADP                        |
| <b>Conjunction</b>              | C       | CCONJ, SCONJ               |
| <b>Numeral</b>                  | M       | NUM                        |
| <b>Interjection</b>             | I       | INTJ                       |
| <b>Residual</b>                 | X       | X                          |
| <b>Particle</b>                 | -       | PART                       |
| <b>Punctuation mark</b>         | -       | PUNCT                      |
| <b>Symbol</b>                   | -       | SYM                        |

See also: <https://universaldependencies.org/u/pos/index.html>



# Attributes for Nouns (Multext)

| Position | Attribute | Value      | Code |
|----------|-----------|------------|------|
| 1        | Type      | Common     | c    |
|          |           | Proper     | p    |
| 2        | Gender    | Masculine  | m    |
|          |           | Feminine   | f    |
|          |           | Neuter     | n    |
| 3        | Number    | Singular   | s    |
|          |           | Plural     | p    |
| 4        | Case      | Nominative | n    |
|          |           | Genitive   | g    |
|          |           | Dative     | d    |
|          |           | Accusative | a    |

See also: <https://universaldependencies.org/u/feat/index.html>

