Corpus transformations

Praktikum Verarbeitung natürlicher Sprache

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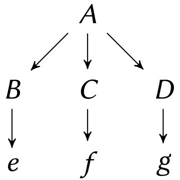
Praktical problems in parsing

Our basic CFG parser has some issues:

- Only binary and unary rules can be processed, but the training corpus is n-ary

$$A \to BC$$
$$A \to a$$

vs.



- Training corpus does not contain all English words

  `He is a brilliant deipnosophist .` $\rightsquigarrow$ No parse!

- Sparse data problem: rare words in the training corpus may get atypical probabilities

Outline

Straight-forward binarization

Binarizing the training corpus vs. binarizing the grammar

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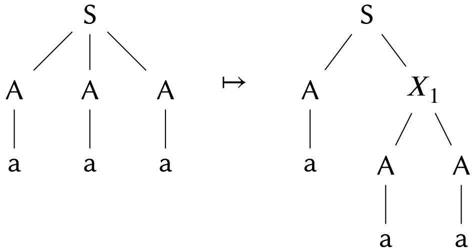

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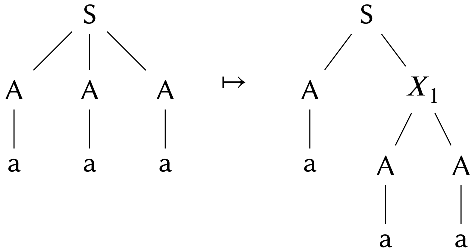

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- Each occurence of two consecutive nonterminals leads to a new nonterminal X_i

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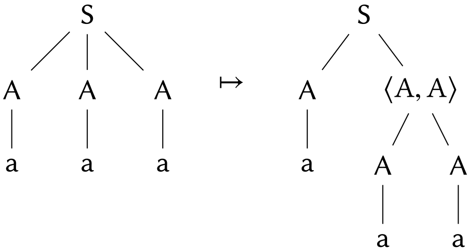

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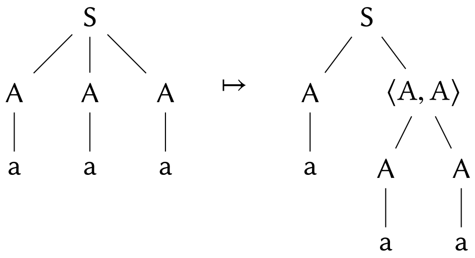

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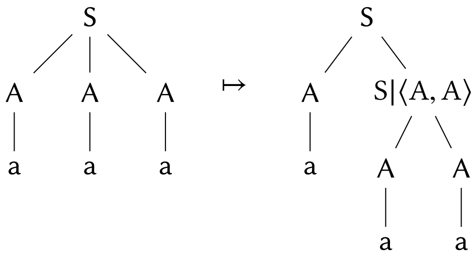

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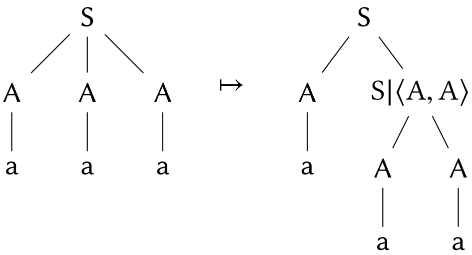

Problems:

- Each occurence of two consecutive nonterminals leads to a new nonterminal X_i
- No information about context is preserved
- Number of right-hand side nonterminals is fixed

Vertical and horizontal Markovization [KM03]

Previous slide Markovization with $v = 1$ and „$h = \infty$“

In general store $v \in \mathbb{N}_+$ nonterminals towards the root and $h \in \mathbb{N}_+$ nonterminals to the left

function $\textsc{markovize}(t = \sigma(t_1, \ldots, t_k))$
    if t is preterminal ***then***
        return t
    else if $k \leq 2$ ***then***
        return $\textsc{annotate}(\sigma)\big(\textsc{markovize}(t_1), \ldots, \textsc{markovize}(t_k)\big)$
    else
        $\sigma' \leftarrow \textsc{originalLabel}(\sigma)|\langle$label of t_2, ..., label of $t_{h+1}\rangle$
        return $\textsc{annotate}(\sigma)\big(\textsc{markovize}(t_1), \textsc{markovize}(\sigma'(t_2, \ldots, t_k))\big)$

Note:

- $\textsc{annotate}(\sigma) = \sigma^\wedge\langle l_1, \ldots, l_{v-1}\rangle$, where the l_i are the labels of the ancestors of σ which occur in the original tree
- If $v = 1$ or there are no parents, leave out $^\wedge\langle\rangle$

After parsing: debinarization

Why?

- Debinarized parse trees are linguistically relevant
- Comparison with (debinarized) gold corpus

function DEBINARIZE($t = \sigma(t_1, \ldots, t_k)$)
    if ROOT(t_k) is Markovization node with children t'_1, t'_2 ***then***
        return DEBINARIZE($\sigma(t_1, \ldots, t_{k-1}, t'_1, t'_2)$)
    else
        return $\sigma\big($DEBINARIZE(t_1), …, DEBINARIZE(t_k)$\big)$

Also: remove ancestor annotation from each node (not shown)!

In material: both binarized and (debinarized) gold corpus

Outline

Basic unking

Idea:

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2. Assign some probability mass to rules that generate `UNK`

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Implementation:

1. Reflection in the parser: before parsing w (requires words of grammar Σ)

$wmap \leftarrow (w_i \mid i \in \{1, \ldots, |w|\})$
for $i = 1, \ldots, |w|$ ***do***
    if $w_i \notin \Sigma$ ***then***
        $w_i \leftarrow \texttt{UNK}$

and after parsing w as t, restore original words

for $i = 1, \ldots, |w|$ ***do***
    $\textsc{leaves}(t)[i] \leftarrow wmap[i]$

Basic unking (2)

2. Reflection in the grammar: replace rare words in the training corpus by `UNK`

Require: tree corpus *corpus* with terminal alphabet Σ, $\mathit{threshold} \in \mathbb{N}_+$
Ensure: every word occuring $\leq$ *threshold* times in *corpus* is replaced by `UNK`

$\mathit{wordcount} \leftarrow (0 \mid i \in \Sigma)$
for $t \in \mathit{corpus}$ **do**
  for $i = 1, \ldots, |\textsc{leaves}(t)|$ **do**
    $\mathit{wordcount}[\textsc{leaves}(t)[i]] \leftarrow \mathit{wordcount}[\textsc{leaves}(t)[i]] + 1$
for $t \in$ corpus **do**
  for $i = 1, \ldots, |\textsc{leaves}(t)|$ **do**
    if $\mathit{wordcount}[\textsc{leaves}(t)[i]] \leq \mathit{threshold}$ **then**
      $\textsc{leaves}(t)[i] \leftarrow \mathtt{UNK}$

The grammar is induced from the modified corpus!

Refinement

Observation: each unknown word is assigned the same probability

- bad language model: certain words are more likely to occur
- may worsen the parsing of sentences with rare words

Solution: categorize unknown words based on their *signature* [KM03]

$$w_i \leftarrow \texttt{UNK} \quad \rightsquigarrow \quad w_i \leftarrow \textsc{getSignature}(w_i, i)$$
$$\textsc{leaves}(t)[i] \leftarrow \texttt{UNK} \quad \rightsquigarrow \quad \textsc{leaves}(t)[i] \leftarrow \textsc{getSignature}(w_i, i)$$

- Some signatures can be found in the source code of the Berkely parser
- Here: „unknownLevel = 4“
- Heuristics, prone to overfitting

```
function getSignature(word, i)
    if |word| = 0 then return UNK
    letterSuffix ←  isUpper(word_0) ∧ none(isLower, word)   ⇒  -AC
                    isUpper(word_0) ∧ i = 1                 ⇒  -SC
                    isUpper(word_0)                         ⇒  -C
                    any(isLower, word)                      ⇒  -L
                    any(isLetter, word)                     ⇒  -U
                    otherwise                               ⇒  -S
    numberSuffix ←  all(isDigit, word)   ⇒  -N
                    any(isDigit, word)   ⇒  -n
                    otherwise            ⇒  ε
    dashSuffix ←    any((= '-'), word)   ⇒  -H
                    otherwise            ⇒  ε
    periodSuffix ←  any((= '.'), word)   ⇒  -P
                    otherwise            ⇒  ε
    commaSuffix ←   any((= ','), word)   ⇒  -C
                    otherwise            ⇒  ε
    wordSuffix ←    |word| > 3   ⇒  toLower(word_|word|)
                    otherwise    ⇒  ε
    return UNK · letterSuffix · numberSuffix · dashSuffix · periodSuffix · commaSuffix · wordSuffix
```

What to do?

Until 03.07.2019, 23:59,

- implement debinarization (3a)
- implement trivial unking for corpus and adapt parser (3b)
- implement 3 of
  - Markovization
  - smoothing
  - pruning
  - *n*-best parsing
  - heuristic search

  } next week (pruning, *n*-best parsing, heuristic search)

All tasks' solutions are one submission!
You may send in your solutions earlier for feedback.

References I

[KM03] D. Klein und C. D. Manning. „Accurate unlexicalized parsing“. Association for Computational Linguistics. 2003.