# Improving UD processing via satellite resources for morphology

Kaja Dobrovoljc Tomaž Erjavec Nikola Ljubešić

Jozef Stefan Institute
Ljubljana, Slovenia

cjvt Centre for Language Resources and Technologies

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# Motivation

- many treebanks and tools available for UD-based NLP tasks
  - state-of-the-art results for dependency parsing and lower layers
- UD treebanks require both morphological and syntactic annotation (costly)
- UD tools could benefit from other existing language resources, as well
  - esp. for lemmatization, POS tagging, feature prediction of languages with complex morphology
- e.g. language resources available for Croatian and Slovenian morphology

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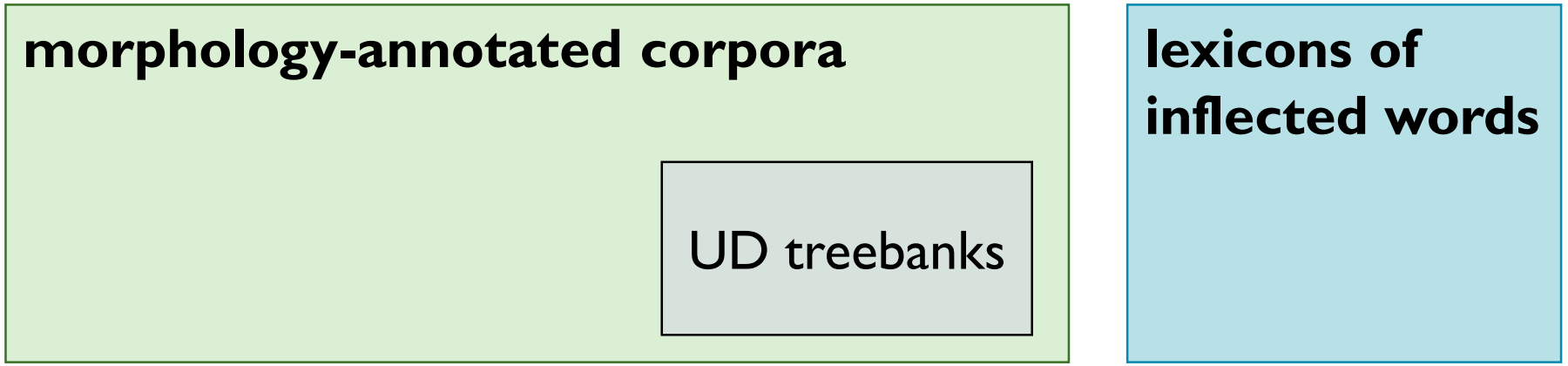
  - esp. for lemmatization, POS tagging, feature prediction of languages with complex morphology
- e.g. language resources available for Croatian and Slovenian morphology



# Our goal

- present the conversion of existing morphology resources to UD scheme
- explore their contribution to UD processing on different linguistic levels

**Talk outline**

1. Conversion of the resources
2. Experiments
3. Results
4. Conclusions

# CONVERSION OF THE RESOURCES

# Language resources for morphology

- two reference training corpora with morphology annotations
  - ssj500k (Krek et al. 2013-) for Slovenian
  - hr500k (Ljubešić et al. 2018-) for Croatian

- two reference lexicons of inflected forms
  - Sloleks morphological lexicon (Dobrovoljc et al. 2013-) for Slovenian
  - hrLex inflection lexicon (Ljubešić 2016-) for Croatian

- similar, but developed within different projects
  - including the conversion to UD

# Morphology-annotated corpora

| ssj500k | hr500k |
| --- | --- |
| • The largest manually annotated corpus of Slovenian (~580,000 tokens)<br>• Fully annotated for segmentation, lemmatization, morphosyntax (JOS/MULTEXT-East).<br>• Partially annotated for named entities, JOS dependency syntax, semantic roles, multi-word expressions, Universal Dependencies.<br>• Rule-based conversion to UD (Dobrovoljc et al. 2015) → **25% of the corpus** | • The largest manually annotated corpus of Croatian (~500,000 tokens).<br>• Fully annotated for segmentation, lemmatization, morphosyntax (MULTEXT-East), named entities.<br>• Partially annotated for semantic roles, Universal Dependencies.<br>• Rule-based conversion to UD morphology, manual annotation of UD syntax (Agić and Ljubešić 2015) → **40% of the corpus** |

# Morphology-annotated corpora

## ssj500k

- Context-independent JOS-to-UD conversion rules for morphology.
- Exception 1: list of DET (lexicon-based)
- Exception 2: *biti* as AUX/VERB (syntax-based)
- Released as part of ssj500k 2.2, in CONLL-U and TEI XML

CLARIN.SI



## hr500k

- Context-independent MTE-to-UD conversion of morphology.
- Exception: abbreviations
- Released as part of hr500k 1.0, in CONLL-U and TEI XML

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MTE

**`Numeral, Form=letter, Type=ordinal`**

e.g. *prvi* 'first', *drugi* 'second', *tretji* 'third' …

UD

**`ADJ, NumType=Ord`**

# Lexicons of inflected forms

## Sloleks

- The largest manually compiled collection of inflected forms for Slovenian (~2.7M forms, 100k lemmas).
- Additional information on lemma, grammatical features (JOS/MTE), pronunciation, frequency of usage.
- Conversion using the JOS-to-UD mappings from ssj500k.
- Lexicon with UPOS and FEATS released as part of Sloleks 2.0 (CLARIN.SI), tab-separated list only.

CLARIN.SI



## hrLex

- The largest semi-automatically compiled collection of inflected forms for Croatian (~6.4M forms, 170k lemmas).
- Additional information on lemma, grammatical features (MTE), frequency of usage.
- Conversion using the MTE-to-UD mappings from hr500k.
- Lexicon with UPOS and FEATS released as part of hrLex 1.3 (CLARIN.SI), tab-separated list.

CLARIN.SI

# EXPERIMENTS

# Tool

- StanfordNLP tool (Qi et al. 2018)
  - full neural network pipeline for robust text analytics on various levels
  - https://stanfordnlp.github.io/stanfordnlp/
- one of the best-performing systems in CoNLL Shared Task 2017-18
  - top-three for all metrics for Slovenian and Croatian
- pipeline architecture
  - morphological tagging + features → lemmatization → parsing

# Experiment setup

1. extended training corpora for morphology
   - training on the official UD (baseline) vs. training on full ssj500k/hr500k

   →tagging + lemmatization + parsing

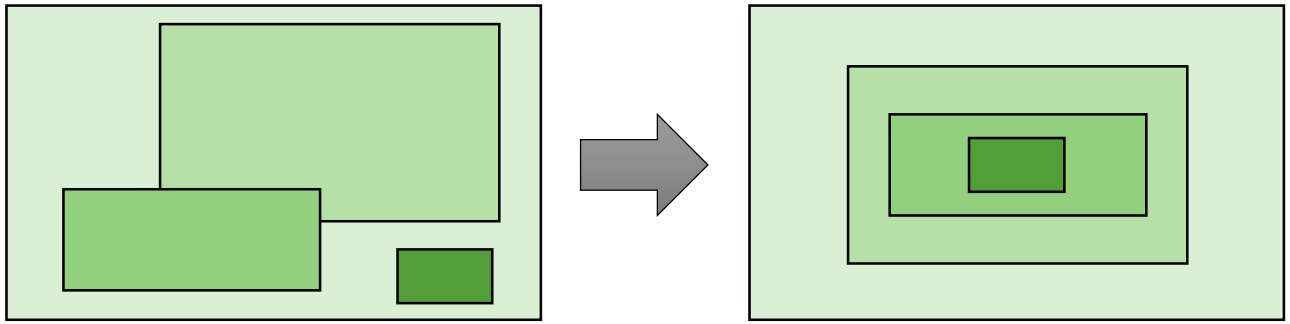
2. lexicon lookup for lemmatization
   - looking up training data lexicon (baseline) vs. looking up Sloleks/hrLex

   → lemmatization + parsing

- gold segmentation
- CoNLL 2018 evaluation script

# Data split

- *babushka-bench*: a benchmarking platform for South Slavic languages
  - https://github.com/clarinsi/babushka-bench
- a universal split for variously-sized subsets of the same dataset
- no spillage between train, dev or test for different annotation layers



- different to official UD splits (but comparable)

# Data split

| | sl-UD | ssj500k | hr-UD | hr500k |
|---|---|---|---|---|
| train | 110,711 | 474,322 | 165,989 | 415,328 |
| dev | 16,589 | 62,967 | 14,184 | 39,765 |
| test | 13,370 | 48,959 | 16,855 | 51,364 |
| **Total** | **140,670** | **586,248** | **197,028** | **506,457** |

# RESULTS

# 1. Larger training sets for UD morphology

| | sl-UD | ssj500k | hr-UD | hr500k |
|---|---|---|---|---|
| LEMMA | 95.88 | **97.44** | 95.30 | **96.21** |
| UPOS | 98.45 | **98.69** | 97.91 | **98.05** |
| XPOS | 95.65 | **97.00** | 94.60 | **95.12** |
| FEATS | 95.95 | **97.23** | 95.13 | **95.66** |
| UAS | 93.40 | **93.72** | 90.22 | **90.76** |
| LAS | 91.62 | **92.28** | 85.30 | **86.00** |
| MLAS | 84.24 | **86.22** | 75.54 | **76.88** |
| BLEX | 84.04 | **86.96** | 76.45 | **78.56** |

# 1. Larger training sets for UD morphology

| | sl-UD | ssj500k | | hr-UD | hr500k | |
|---|---|---|---|---|---|---|
| LEMMA | 95.88 | **97.44** | +1.56 | 95.30 | **96.21** | +0.91 |
| UPOS | 98.45 | **98.69** | | 97.91 | **98.05** | |
| XPOS | 95.65 | **97.00** | | 94.60 | **95.12** | |
| FEATS | 95.95 | **97.23** | | 95.13 | **95.66** | |
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| UPOS | 98.45 | **98.69** | | 97.91 | **98.05** | |
| XPOS | 95.65 | **97.00** | +1.35 | 94.60 | **95.12** | +0.53 |
| FEATS | 95.95 | **97.23** | +1.28 | 95.13 | **95.66** | +0.52 |
| UAS | 93.40 | **93.72** | | 90.22 | **90.76** | |
| LAS | 91.62 | **92.28** | | 85.30 | **86.00** | |
| MLAS | 84.24 | **86.22** | | 75.54 | **76.88** | |
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| XPOS | 95.65 | **97.00** | | 94.60 | **95.12** | |
| FEATS | 95.95 | **97.23** | | 95.13 | **95.66** | |
| UAS | 93.40 | **93.72** | | 90.22 | **90.76** | |
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| XPOS | 95.65 | **97.00** | | 94.60 | **95.12** | |
| FEATS | 95.95 | **97.23** | | 95.13 | **95.66** | |
| UAS | 93.40 | **93.72** | +0.32 | 90.22 | **90.76** | +0.54 |
| LAS | 91.62 | **92.28** | +0.66 | 85.30 | **86.00** | +0.70 |
| MLAS | 84.24 | **86.22** | +1.98 | 75.54 | **76.88** | +1.34 |
| BLEX | 84.04 | **86.96** | +2.92 | 76.45 | **78.56** | +2.11 |

# 2. Larger lexicons of inflected forms

| | sl-UD | +Sloleks | ssj500k | +Sloleks |
|---|---|---|---|---|
| LEMMA | 95.88 | **98.48** | 97.44 | **98.89** |
| UAS | 93.40 | **93.43** | 93.72 | 93.72 |
| LAS | 91.62 | **91.75** | 92.28 | 92.27 |
| MLAS | 84.24 | **84.34** | 86.22 | 86.05 |
| BLEX | 84.04 | **88.00** | 86.96 | **89.01** |

| | hr-UD | +hrLex | hr500k | +hrLex |
|---|---|---|---|---|
| LEMMA | 95.30 | **97.24** | 96.21 | **97.29** |
| UAS | 90.22 | **90.53** | 90.76 | 90.44 |
| LAS | 85.30 | **85.81** | 86.00 | 85.85 |
| MLAS | 75.54 | **76.16** | 76.88 | 76.83 |
| BLEX | 76.45 | **79.60** | 78.56 | **80.04** |

# 2. Larger lexicons of inflected forms

| | sl-UD | +Sloleks | | ssj500k | +Sloleks |
|---|---|---|---|---|---|
| LEMMA | 95.88 | **98.48** | +2.6 | 97.44 | **98.89** |
| UAS | 93.40 | **93.43** | | 93.72 | 93.72 |
| LAS | 91.62 | **91.75** | | 92.28 | 92.27 |
| MLAS | 84.24 | **84.34** | | 86.22 | 86.05 |
| BLEX | 84.04 | **88.00** | | 86.96 | **89.01** |

| | hr-UD | +hrLex | | hr500k | +hrLex |
|---|---|---|---|---|---|
| LEMMA | 95.30 | **97.24** | +1.94 | 96.21 | **97.29** |
| UAS | 90.22 | **90.53** | | 90.76 | 90.44 |
| LAS | 85.30 | **85.81** | | 86.00 | 85.85 |
| MLAS | 75.54 | **76.16** | | 76.88 | 76.83 |
| BLEX | 76.45 | **79.60** | | 78.56 | **80.04** |

# 2. Larger lexicons of inflected forms

| | sl-UD | +Sloleks | ssj500k | +Sloleks | |
|---|---|---|---|---|---|
| LEMMA | 95.88 | **98.48** | 97.44 | **98.89** | +1.45 |
| UAS | 93.40 | **93.43** | 93.72 | 93.72 | |
| LAS | 91.62 | **91.75** | 92.28 | 92.27 | |
| MLAS | 84.24 | **84.34** | 86.22 | 86.05 | |
| BLEX | 84.04 | **88.00** | 86.96 | **89.01** | |

| | hr-UD | +hrLex | hr500k | +hrLex | |
|---|---|---|---|---|---|
| LEMMA | 95.30 | **97.24** | 96.21 | **97.29** | +1.08 |
| UAS | 90.22 | **90.53** | 90.76 | 90.44 | |
| LAS | 85.30 | **85.81** | 86.00 | 85.85 | |
| MLAS | 75.54 | **76.16** | 76.88 | 76.83 | |
| BLEX | 76.45 | **79.60** | 78.56 | **80.04** | |

# 2. Larger lexicons of inflected forms

| | sl-UD | +Sloleks | | ssj500k | +Sloleks |
|---|---|---|---|---|---|
| LEMMA | 95.88 | **98.48** | | 97.44 | **98.89** |
| UAS | 93.40 | **93.43** | +0.03 | 93.72 | 93.72 |
| LAS | 91.62 | **91.75** | +0.13 | 92.28 | 92.27 |
| MLAS | 84.24 | **84.34** | +0.10 | 86.22 | 86.05 |
| BLEX | 84.04 | **88.00** | +3.96 | 86.96 | **89.01** |

| | hr-UD | +hrLex | | hr500k | +hrLex |
|---|---|---|---|---|---|
| LEMMA | 95.30 | **97.24** | | 96.21 | **97.29** |
| UAS | 90.22 | **90.53** | +0.29 | 90.76 | 90.44 |
| LAS | 85.30 | **85.81** | +0.51 | 86.00 | 85.85 |
| MLAS | 75.54 | **76.16** | +0.72 | 76.88 | 76.83 |
| BLEX | 76.45 | **79.60** | +3.15 | 78.56 | **80.04** |

# 2. Larger lexicons of inflected forms

| | sl-UD | +Sloleks | ssj500k | +Sloleks | |
|---|---|---|---|---|---|
| LEMMA | 95.88 | **98.48** | 97.44 | **98.89** | |
| UAS | 93.40 | **93.43** | 93.72 | 93.72 | +0.0 |
| LAS | 91.62 | **91.75** | 92.28 | 92.27 | -0.01 |
| MLAS | 84.24 | **84.34** | 86.22 | 86.05 | -0.17 |
| BLEX | 84.04 | **88.00** | 86.96 | **89.01** | +2.05 |

| | hr-UD | +hrLex | hr500k | +hrLex | |
|---|---|---|---|---|---|
| LEMMA | 95.30 | **97.24** | 96.21 | **97.29** | |
| UAS | 90.22 | **90.53** | 90.76 | 90.44 | -0.32 |
| LAS | 85.30 | **85.81** | 86.00 | 85.85 | -0.15 |
| MLAS | 75.54 | **76.16** | 76.88 | 76.83 | -0.05 |
| BLEX | 76.45 | **79.60** | 78.56 | **80.04** | +1.45 |

# Conclusions

- four new open-source language resources conformant with UD morphological specifications for Croatian and Slovenian

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- four new open-source language resources conformant with UD morphological specifications for Croatian and Slovenian
- improvements of baseline StanfordNLP performance obtained on official released UD treebanks
  - esp. for lemmatization and morphological feature prediction
  - retrained models already in use
- such satellite UD resources are likely to exist or emerge in many other languages
  - a need for a standardized format and distribution?
  - system architectures that enable lexicon plug-ins

*Kaja Dobrovoljc, Tomaž Erjavec, Nikola Ljubešić*

Improving UD processing via satellite resources for morphology

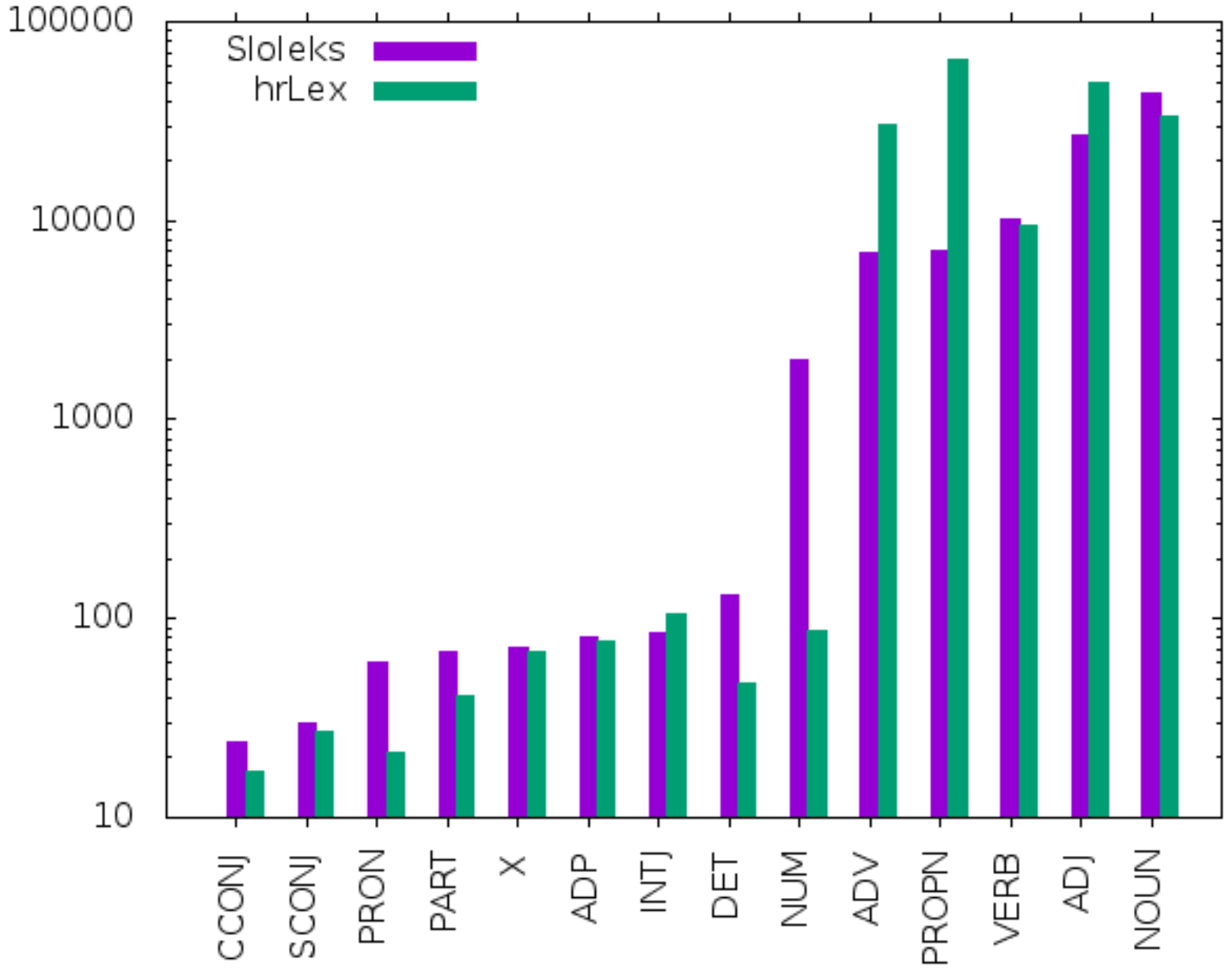
# THANK YOU

code available at
https://github.com/clarinsi/jos2ud
https://github.com/clarinsi/babushka-bench

# Overview

| | Tokens | Types | Wforms | Lemmas | Tags | Ambiguity |
|---|---|---|---|---|---|---|
| ssj500k | 586,248 | 98,641 | 78,707 | 38,818 | 1,304 | 1.25 |
| hr500k | 506,457 | 84,789 | 66,797 | 34,321 | 768 | 1.27 |

| | Entries | Wforms | Lemmas | Tags | Ambiguity |
|---|---|---|---|---|---|
| Sloleks | 2,792,003 | 921,869 | 96,593 | 1,900 | 3.03 |
| hrLex | 6,427,709 | 1,697,943 | 164,206 | 900 | 3.79 |


100000
10000
1000
100
10
Sloleks
hrLex
CCONJ
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X
ADP
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DET
NUM
ADV
PROPN
VERB
ADJ
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