Delimiting Morphosyntactic Search Space with Source-Side Reordering Models

Joachim Daiber

Institute for Logic, Language and Computation
University of Amsterdam

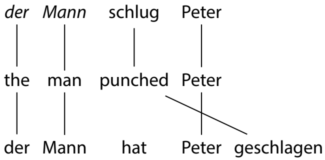
Introduction

- Joachim Daiber
- Institute for Logic, Language and Computation (ILLC), University of Amsterdam
- Supervisor: Prof. Khalil Sima'an

Motivation

- Current MT models work well if languages are structurally similar
- Difficulties with morphologically rich languages:
  - freer word order
  - more productive morphological processes
  - agreement over long distances

Motivation



"Germans like to buy holiday homes in Florida"

- Deutsche kaufen sich meistens in Florida eine Ferienwohnung
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From: *Frankurter Allgemeine Zeitung (August 31, 2015)*

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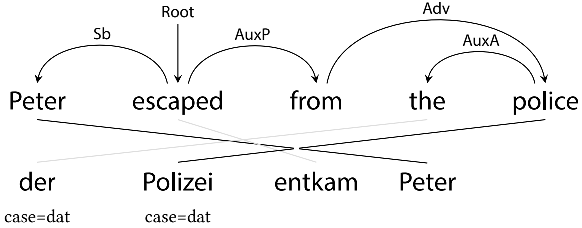
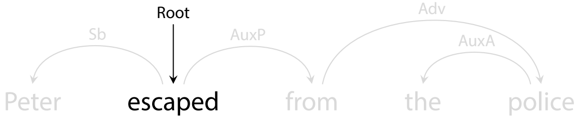
Preordering source trees



- Source dependency trees are good fit for preordering:
  - Lerner and Petrov (2013) present two classifier-based dep. tree preordering models
  - Jehl et al. (2014) and de Gispert et al. (2015) preorder dep. trees via branch-and-bound search

Preordering source trees

- Lerner and Petrov (2013) preorder trees starting at the root
- Order all children (model 1) or left and right children (model 2)



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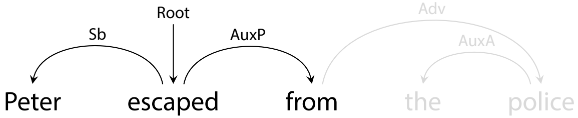

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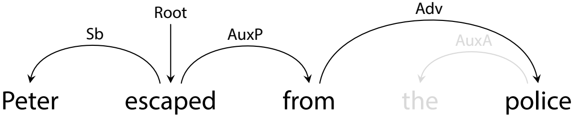

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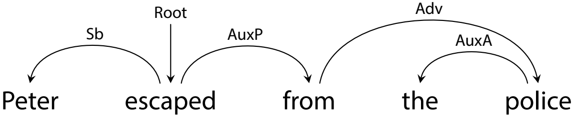

Generating the space of potential word order choices

- Both Lerner and Petrov (2013) and Jehl et al. (2014) make only *single-best* predictions
- We want:
  - *ALL REASONABLE* predictions instead of *SINGLE BEST*
  - More flexible model

Producing multiple predictions

Multiple predictions:

- Bad: Mistakes in order decisions propagate

$\rightarrow$ Extract *n*-best decisions from the model to pass to subsequent model

Producing multiple predictions

Model over possible orders of source words:

$$P(\mathrm{s}' \mid \mathrm{s}, \tau) = \prod_{h \in \tau} P_T(\pi_h \mid \mathrm{s}, h, \tau)$$

Producing multiple predictions

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- Preordered s

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- Preordered s
- Source dep. tree

Producing multiple predictions

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- Preordered s
- Source dep. tree
- Heads of all families

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- Preordered s
- Source dep. tree
- Heads of all families
- Local permutation

Producing multiple predictions

Model over possible orders of source words:

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- Pivot decision

Producing multiple predictions

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- Pivot decision
- Left order decision

Producing multiple predictions

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$$P_T(\pi \mid \mathrm{s}, h, \tau) = P(\psi \mid \mathrm{s}, h, \tau) \; P_L(\pi_L \mid \mathrm{s}, h, \tau) \; P_R(\pi_R \mid \mathrm{s}, h, \tau)$$

- Pivot decision
- Left order decision
- Right order decision

Producing multiple predictions

Model over possible orders of source words:

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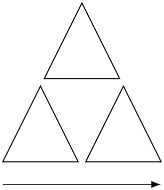

$P(\mathrm{s}' \mid \mathrm{s}, \tau)$

Producing multiple predictions

Model over possible orders of source words:

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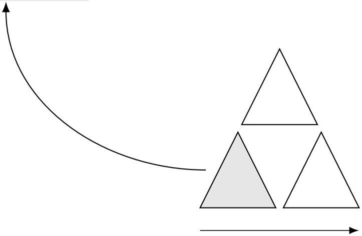
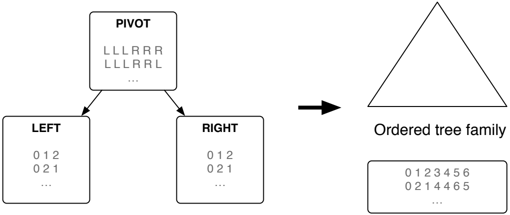


$$P(\mathrm{s}' \mid \mathrm{s}, \tau)$$

Preordering alogrithm

- Produce k_P best pivot decisions for all the children in the family
- For every of the k_P pivot decisions:
  - Produce k_L best left order decisions
  - Produce k_R best right order decisions



Preordering with arbitrary non-local features

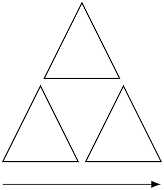
Making the model more flexible:

- Bad: Order decisions are local to tree families
- Khalilov and Sima'an (2012) show even weak LM helps with shortcomings

Preordering with arbitrary non-local features

Decoding:

- Non-local features ruin our day...
- Cube pruning to the rescue (Chiang, 2007)!



$$P(\mathrm{s}' \mid \mathrm{s}, \tau)$$

Preordering with arbitrary non-local features

Preordering model:

- Standard log-linear model (Och and Ney, 2002):

$$\hat{\mathbf{s}}' = \arg\max_{\mathbf{s}'} \sum_{i} \lambda_i \log \phi_i(\mathbf{s}')$$

- Where to get the weights?
  - PRO: *tuning as ranking* (Hopkins and May, 2011)
  - Scoring functions:
    1. Kendall's τ coefficient
    2. Simulate word level MT system, score by BLEU

Preordering with arbitrary non-local features

Local features:

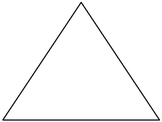
- Lexicalized preordering model $P(\mathrm{s}' \mid \mathrm{s}, \tau)$ from before
- Unlexicalized preordering model $P_W(\pi \mid h, cs)$ as less sparse backoff

Non-local features:

- ngram language models over s'
  - words
  - part-of-speech tags
  - word classes

Applicability of this model

- General model is applicable to any *n*-best preordering model over source trees
- **Example:**
  - Preordering model:
    Pairwise neural network-based model
    (de Gispert et al., 2015)
  - Parsing algorithm:
    k-best ITG-based CKY parsing
    (similar to Tromble and Eisner (2009)).



Ordered tree family

0 1 2 3 4 5 6
0 2 1 4 4 6 5
...

Intrinsic: Do non-local features help?

- Intrinsic evaluation of preordering quality
- Language pair English-to-German

Model	Kendall's tau	BLEU ($\hat{s}' \rightarrow s'$)
First-best $-$LM	92.16	68.1
First-best $+$LM (cube)	92.27	68.7

Translation: Quality of potential word order choices

- Translation experiments with the space of word order choices
- Experiments with top 10 preordering outputs of this model

	Distortion	BLEU	MTR	TER
Baseline	7	15.20	35.43	66.62
Best out of *k* ($k = 10$)		17.26	37.97	62.64

Discussion

Preordering with non-local features

- Integration of LM helps improve preordering quality
  - Slight Kendall τ improvement
  - BLEU preorder score shows benefits mostly in small local windows

Quality of the space of potential word order choices

- Experiments show significant potential improvement contained in the space
- With arbitrary *n* or lattice, space is small enough to be handled by subseq. models

Conclusion

- Source preordering has big limitations but has proven very successful
- We are interested in source-side adaptation models more suitable for morph. rich languages
- As first step:
  - Introduced preordering model that can delimit space instead of first-best predictions
  - Made the model more flexible with arbitrary non-local features and cube pruning

Thank You!

Any questions?

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