Preference Grammars and Soft Syntactic Constraints for GHKM Syntax-based SMT

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Introduction

Feature-based integration of syntactic information
into GHKM string-to-tree translation

- Preference grammars:
  soft target-side syntax
  - Target syntax as a feature
    rather than via labeled non-terminals in the SCFG

- Soft syntactic constraints:
  non-restrictive source-syntactic enhancement
  - No hard source-syntactic constraints
    (as in standard tree-to-tree translation)
    imposed in extraction or decoding

Our empirical evaluation: English→German WMT task

Related Work

- GHKM string-to-tree translation: *Galley et al. (2004)*
- Open-source Moses implementation for GHKM translation
  - GHKM rule extraction: *Williams and Koehn (2012)*
  - Decoding with CYK+ parsing and cube pruning: *Hoang et al. (2009)*
  - Competitive results for European language pairs: *Nadejde et al. (2013); Williams et al. (2014)*
- Preference grammars: beneficial as a syntactic extension of hierarchical systems *(Venugopal et al., 2009; Stein et al., 2010)*
- Soft syntactic constraints: related source-syntactic techniques improved hierarchical *(Marton and Resnik, 2008; Vilar et al., 2008; Hoang and Koehn, 2010)* and other syntax-based systems *(Zhang et al., 2011; Huang et al., 2013)* on Chinese→English and Arabic→English tasks

Preference Grammars

- Target-side non-terminals not decorated with syntactic labels, but with a single generic non-terminal symbol

baseline	**preference grammar system**
$X, ADJD \rightarrow \langle \text{present}, \text{anwesend} \rangle$ $X, ADV \rightarrow \langle \text{present}, \text{anwesend} \rangle$ $X, AP\text{-}PD \rightarrow \langle \text{present}, \text{anwesend} \rangle$ $\ldots$	$X, X \rightarrow \langle \text{present}, \text{anwesend} \rangle$

- Distribution of implicit target label vectors stored as additional information with each translation rule

$$X, X \rightarrow \langle \text{present}, \text{anwesend} \rangle \;\#\; (ADJD)\ 0.98\ (ADV)\ 0.001\ (AP\text{-}PD)\ 0.01\ \ldots$$

- Computation of a tree-wellformedness feature during decoding

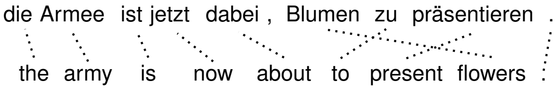
Soft Source Syntactic Constraints

- Parse source-side data as well
- GHKM extractor stores an additional rule property: source syntactic label vectors

- Provide parsed input data to the decoder
- During decoding, score matches and mismatches of source label vectors and input labels
- Soft features, no hard constraints

rule	**source label vectors**
$X, \mathit{VP\text{-}OC} \rightarrow \langle$present, zu präsentieren$\rangle$	$(\mathit{VB}), (\mathit{NN})$
$X, \mathit{ADJD} \rightarrow \langle$present, anwesend$\rangle$	$(\mathit{ADJP}), (\mathit{ADVP}), \ldots$
$X, \mathit{TOP} \rightarrow \langle X^{\sim 0}$ is now $X^{\sim 1}$. , jetzt ist $\mathit{NP\text{-}SB}^{\sim 0}$ $\mathit{VP\text{-}OC}^{\sim 1}$.$\rangle$	$(\mathit{TOP}, \mathit{NP}, \mathit{ADJP}), \ldots$
$X, \hat{~}\mathit{S\text{-}TOP} \rightarrow \langle$is $X^{\sim 0}$ $X^{\sim 1}$, ist $\mathit{ADV}^{\sim 0}$ $\mathit{ADJD}^{\sim 1}\rangle$	$(\mathit{VP}, \mathit{ADVP}, \mathit{ADJP}), \ldots$

the army is now about to present flowers .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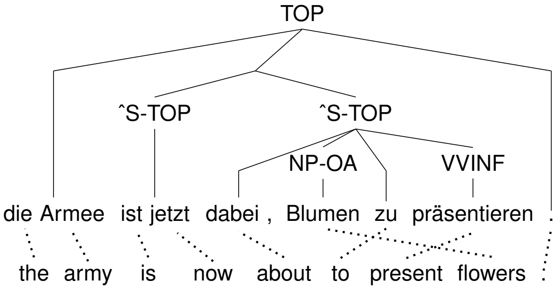
the army is now about to present flowers .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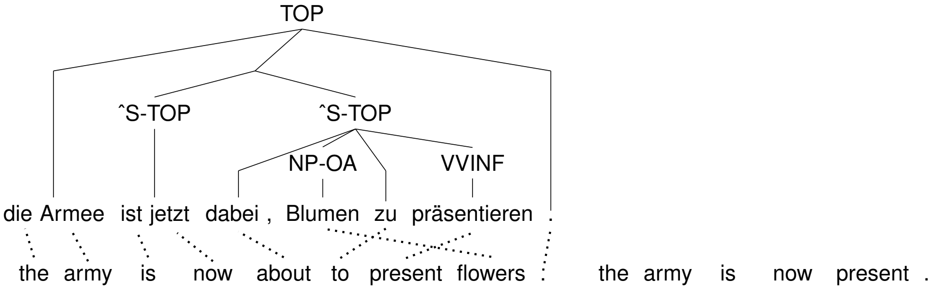
TOP
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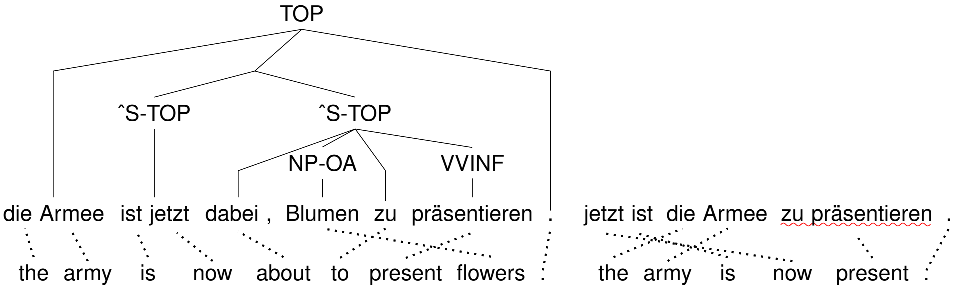
die Armee ist jetzt dabei , Blumen zu präsentieren .
the army is now about to present flowers :
the army is now present .


TOP
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NP-OA
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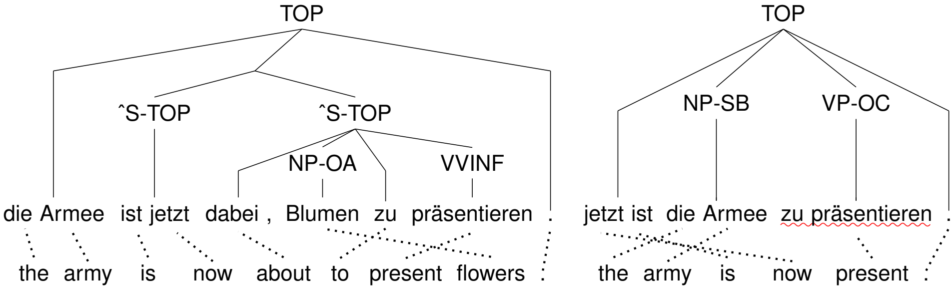
die Armee ist jetzt dabei , Blumen zu präsentieren .
the army is now about to present flowers .
jetzt ist die Armee zu präsentieren .
the army is now present .



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NP-OA
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die Armee ist jetzt dabei , Blumen zu präsentieren .
the army is now about to present flowers .
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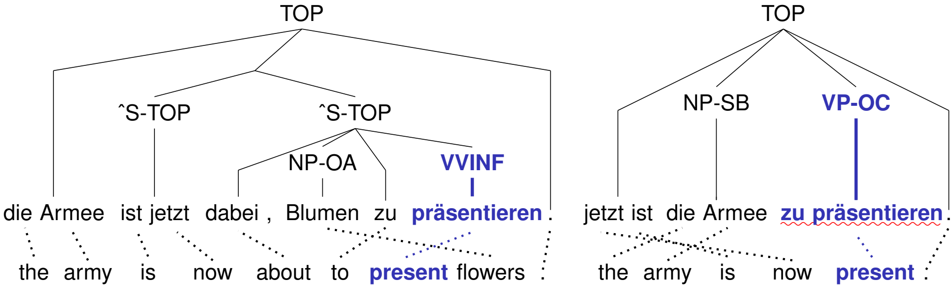
jetzt ist die Armee zu präsentieren .
the army is now present .


TOP
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die Armee ist jetzt dabei , Blumen zu präsentieren .
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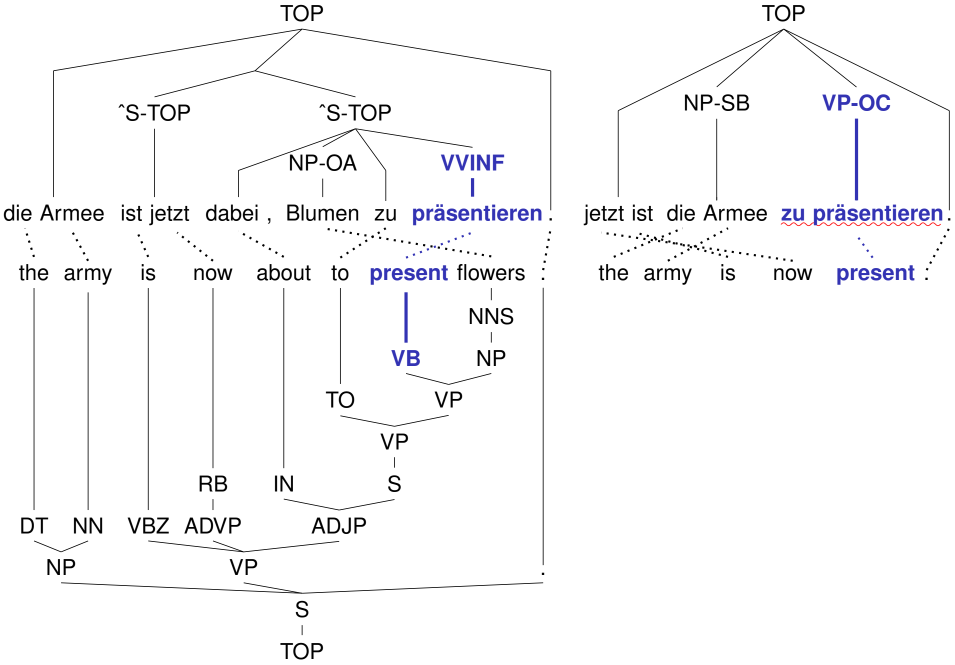
NP-SB
VP-OC
jetzt ist die Armee zu präsentieren .
the army is now present .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VVINF
die Armee ist jetzt dabei , Blumen zu präsentieren .
the army is now about to present flowers .
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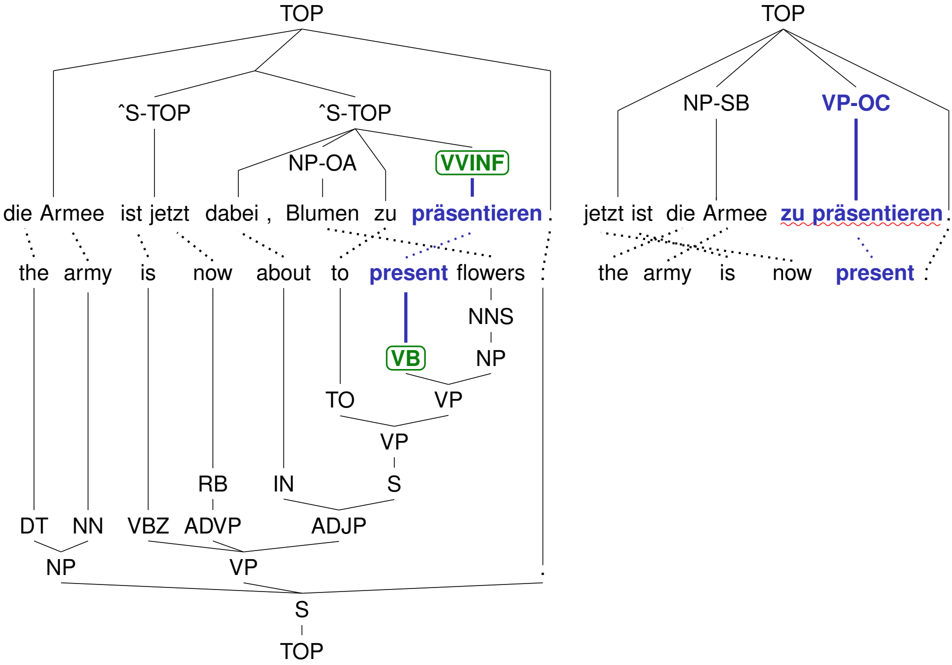
jetzt ist die Armee zu präsentieren .
the army is now present .



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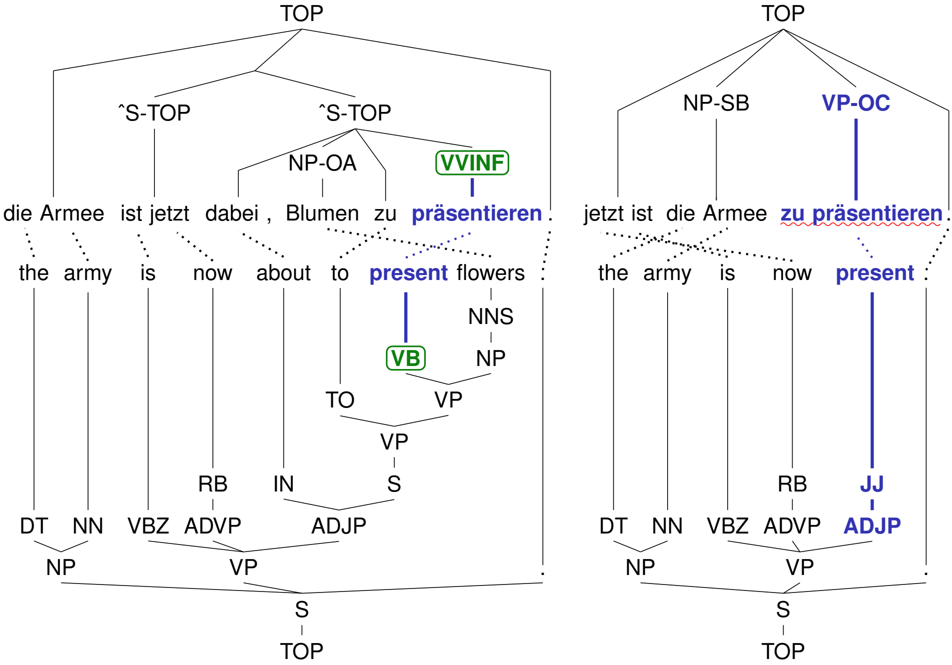
jetzt ist die Armee zu präsentieren .
the army is now present .



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jetzt ist die Armee zu präsentieren .
the army is now present .
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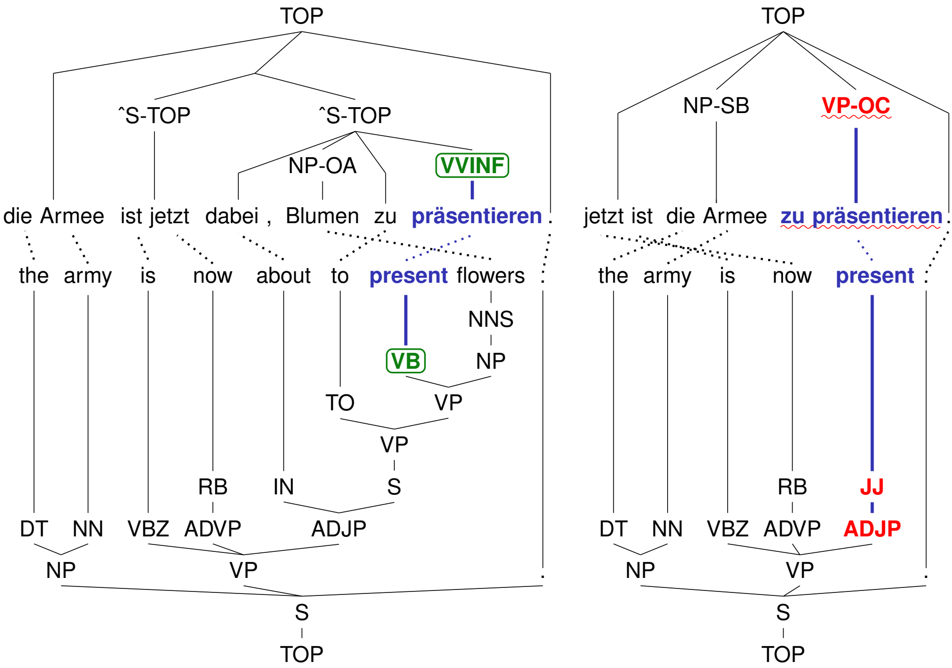
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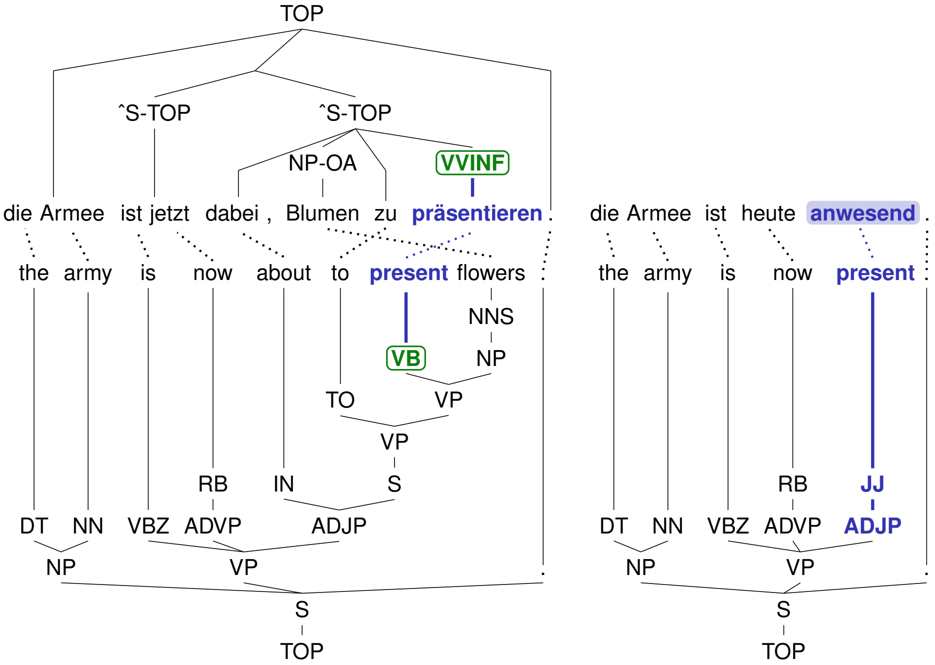

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TOP
die Armee ist heute anwesend .
the army is now present .
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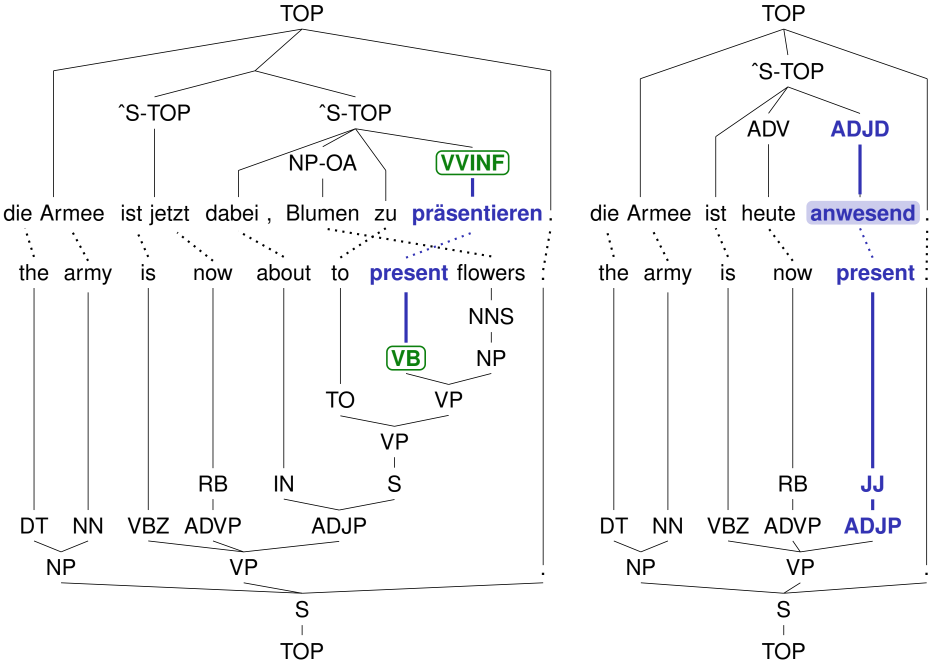
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die Armee ist heute anwesend .
the army is now present .
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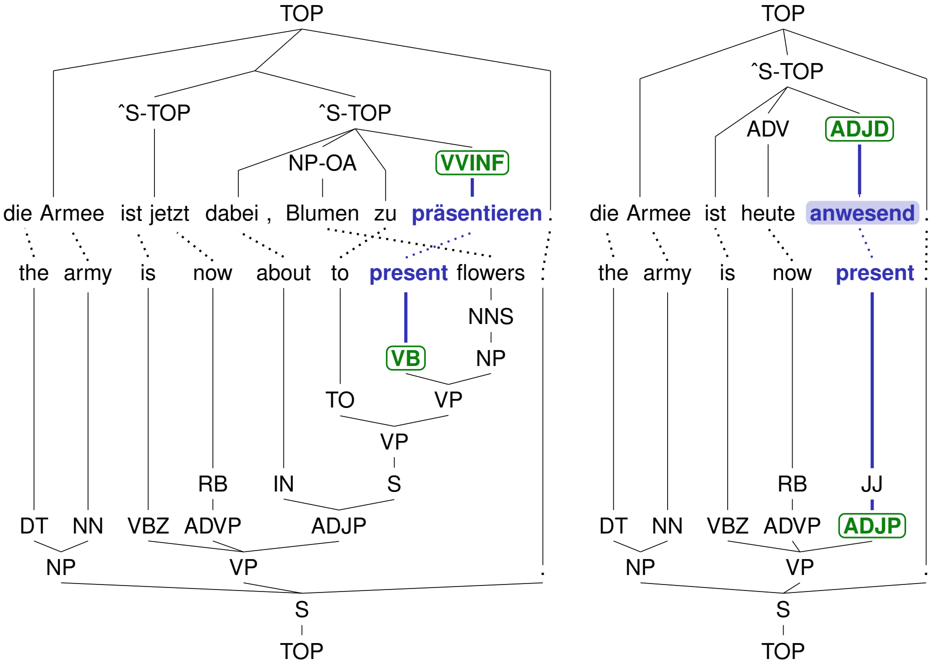

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Motivation

Feature-based integration of syntactic information into GHKM string-to-tree statistical machine translation

- The hard target-side syntactic constraints that are imposed by the target non-terminal labels might be too restrictive. Should we soften them?

> **Preference grammars** promote syntactic well-formedness on the target language side while also allowing for derivations that are not linguistically motivated (as in hierarchical translation)

- Tree-to-tree translation often underperforms. How can we effectively enhance a strong string-to-tree baseline with source-side syntactic information?

> **Soft syntactic constraints** augment the system with additional source-side syntax features while not modifying the set of string-to-tree translation rules or the baseline feature scores

Preference Grammars

Training:

- Target-side non-terminals not decorated with syntactic labels, but with a **single generic non-terminal symbol**
- Extracted rules which differ only with respect to their non-terminal labels are collapsed to a single entry in the rule table, and their rule counts are pooled

baseline	preference grammar system
$X, \mathit{ADJD} \rightarrow \langle$present, anwesend$\rangle$ $X, \mathit{ADV} \rightarrow \langle$present, anwesend$\rangle$ $X, \mathit{AP\text{-}PD} \rightarrow \langle$present, anwesend$\rangle$ …	$X, X \rightarrow \langle$present, anwesend$\rangle$

- **Distribution of implicit target label vectors** stored as additional information with each translation rule

$X, X \rightarrow \langle$present, anwesend$\rangle$ # (ADJD) 0.98 (ADV) 0.001 $(\mathit{AP\text{-}PD})$ 0.01 …

Decoding:

- Computation of a **tree-wellformedness feature**

Soft Source Syntactic Constraints

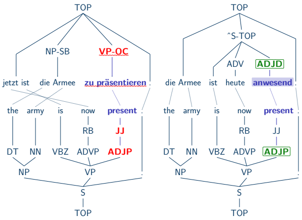
Training:

- Provide **syntactic parses of the source side** of the data
- GHKM extractor collects the **source syntactic labels that cover the source-side span of non-terminals**
- Sets of source syntactic label vectors are memorized with the rules as an **additional property**

Decoding:

- Input data parsed in a preprocessing step
- Computation of three dense **features which score matches and mismatches of input labels** and source label vectors that are associated with translation rules

rule	source label vectors
$X, \mathit{VP\text{-}OC} \rightarrow \langle$present, zu präsentieren$\rangle$	$(\mathit{VB}), (\mathit{NN})$
$X, \mathit{ADJD} \rightarrow \langle$present, anwesend$\rangle$	$(\mathit{ADJP}), (\mathit{ADVP}), \ldots$
$X, \mathit{TOP} \rightarrow \langle X^{\sim 0}$ is now $X^{\sim 1}$. , jetzt ist $\mathit{NP\text{-}SB}^{\sim 0}\ \mathit{VP\text{-}OC}^{\sim 1}$.$\rangle$	$(\mathit{TOP}, \mathit{NP}, \mathit{ADJP}), \ldots$
$X, \hat{}\mathit{S\text{-}TOP} \rightarrow \langle$is $X^{\sim 0}\ X^{\sim 1}$, ist $\mathit{ADV}^{\sim 0}\ \mathit{ADJD}^{\sim 1}\rangle$	$(\mathit{VP}, \mathit{ADVP}, \mathit{ADJP}), \ldots$



Dense features:

- a source syntactic label vector fully matches the input labels
- left-hand side non-terminal label mismatch
- number of right-hand side non-terminals label mismatches

Experimental Setup

- English→German WMT task (4.5 M sentence pairs)
- Syntactic annotation: BitPar for German, Berkeley Parser for English
- Right binarization of target parse trees
- SAMT-style composite labels on source side
- Singleton hierarchical rules are discarded
- No more than 50 most frequent label vectors per rule stored
- Decoding with CYK+ and cube pruning
- Tuning with batch MIRA
- Development set: 2000 selected sentences from newstest2008-2012

Experimental Results (English→German)

system	dev		newstest2013		newstest2014	
	BLEU	TER	BLEU	TER	BLEU	TER
GHKM string-to-tree baseline	34.7	47.3	20.0	63.3	19.4	65.6
+ hard source syntactic constraints	34.6	47.4	19.9	63.4	19.4	65.6
+ soft source syntactic constraints	35.1	47.0	20.3	62.7	19.7	64.9
string-to-string (GHKM syntax-directed extraction)	33.8	48.0	19.3	63.8	18.7	66.2
+ preference grammar	33.9	47.7	19.3	63.7	18.8	66.0
+ soft source syntactic constraints	34.6	47.0	19.8	62.9	19.5	65.2

Sparse Features for Soft Syntactic Constraints

- Large number of binary features which depend on the label identity
- Separate weight tuned for each of them
- Optionally: Restrict the number of sparse features by specifying a core set of labels

core = non-composite – plain constituent labels as given by the syntactic parser (no SAMT-style composite labels)
core = dev-min-occ100 – labels in the input data on the development set with minimum occurrence count threshold 100

system (tuned on newstest2012)	newstest2012		newstest2013		newstest2014	
	BLEU	TER	BLEU	TER	BLEU	TER
GHKM string-to-tree baseline	17.9	65.7	19.9	63.2	19.4	65.3
+ soft source syntactic constraints	18.2	65.3	20.3	62.6	19.7	64.7
+ sparse features	18.6	64.9	20.4	62.5	19.8	64.7
+ sparse features (core = non-composite)	18.4	65.1	20.3	62.7	19.8	64.7
+ sparse features (core = dev-min-occ100)	18.4	64.8	20.6	62.2	19.9	64.4

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