Machine Translation

Jordan Boyd-Graber

University of Maryland

Phrase-Based Models

Adapted from material by Philipp Koehn

Motivation

- Word-Based Models translate words as atomic units
- Phrase-Based Models translate phrases as atomic units
- Advantages:
  - many-to-many translation can handle non-compositional phrases
  - use of local context in translation
  - the more data, the longer phrases can be learned
- “Standard Model” before neural revolution

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- “Standard Model” before neural revolution
- Led to much of the decoding black magic of today

Anstellen

English	German

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turn on the AC	stell die Klimaanlage an

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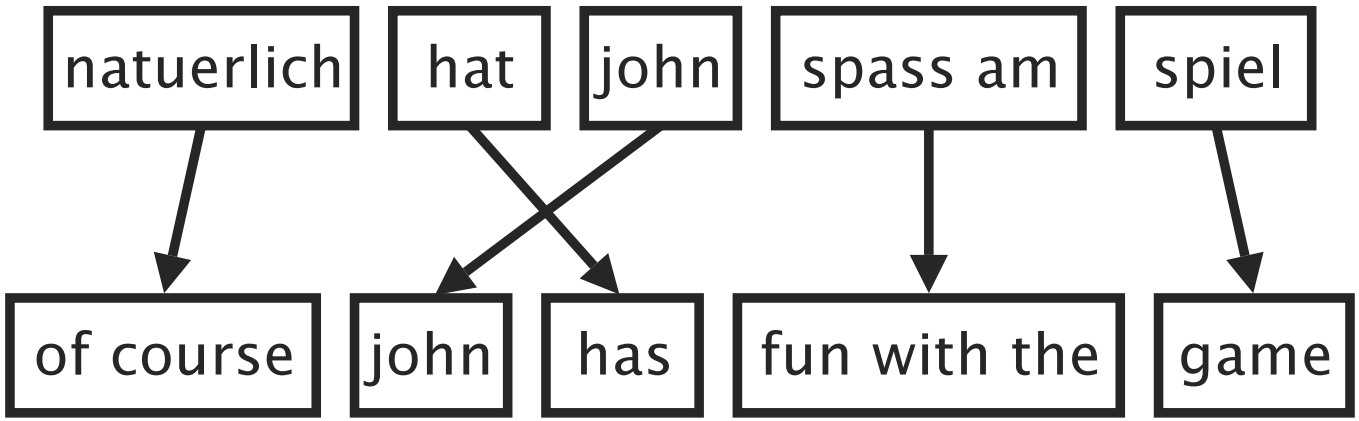
Phrase-Based Model



- Foreign input is segmented in phrases
- Each phrase is translated into English
- Phrases are reordered

Phrase Translation Table

- Main knowledge source: table with phrase translations and their probabilities
- Example: phrase translations for **natuerlich**

of course	0.5
naturally	0.3
of course ,	0.15
, of course ,	0.05

Real Example

- Phrase translations for den Vorschlag learned from the Europarl corpus:

English	$\phi(\bar{e}\|\bar{f})$	English	$\phi(\bar{e}\|\bar{f})$
the proposal	0.6227	the suggestions	0.0114
's proposal	0.1068	the proposed	0.0114
a proposal	0.0341	the motion	0.0091
the idea	0.0250	the idea of	0.0091
this proposal	0.0227	the proposal ,	0.0068
proposal	0.0205	its proposal	0.0068
of the proposal	0.0159	it	0.0068
the proposals	0.0159	...	...

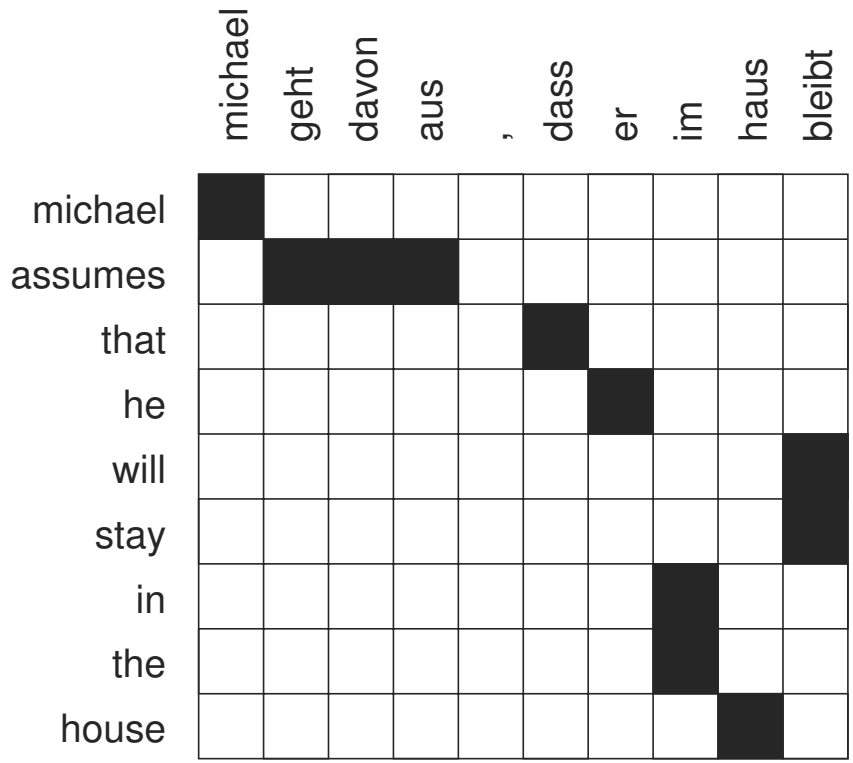
  - lexical variation (proposal vs suggestions)
  - morphological variation (proposal vs proposals)
  - included function words (the, a, ...)
  - noise (it)

Linguistic Phrases?

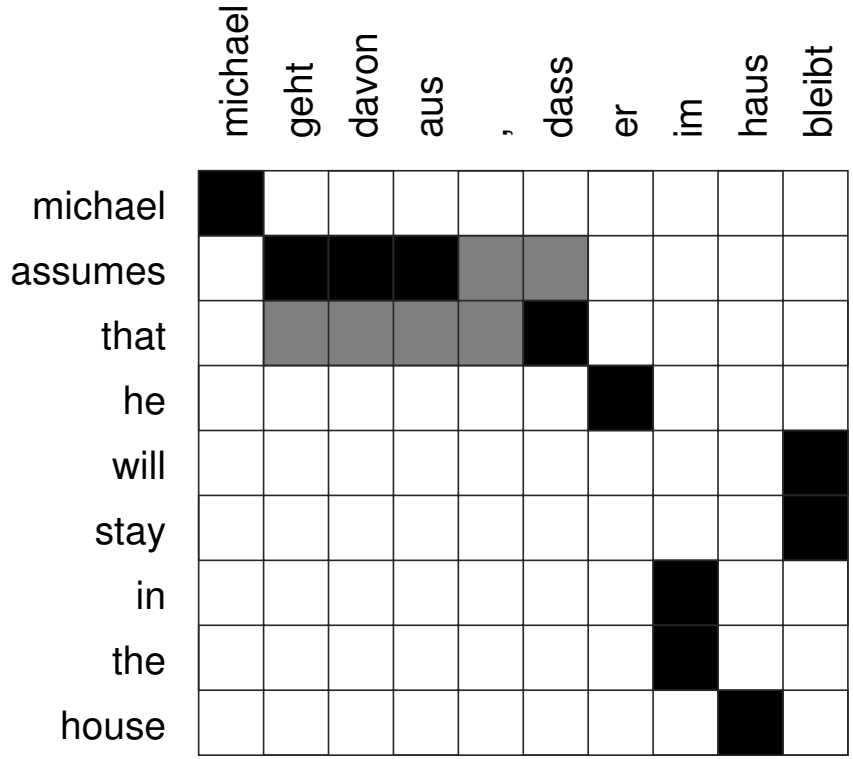
- Model is not limited to linguistic phrases
  (noun phrases, verb phrases, prepositional phrases, ...)
- Example non-linguistic phrase pair

  spass am ⟶ fun with the
- Prior noun often helps with translation of preposition
- Experiments show that limitation to linguistic phrases hurts quality

Word Alignment



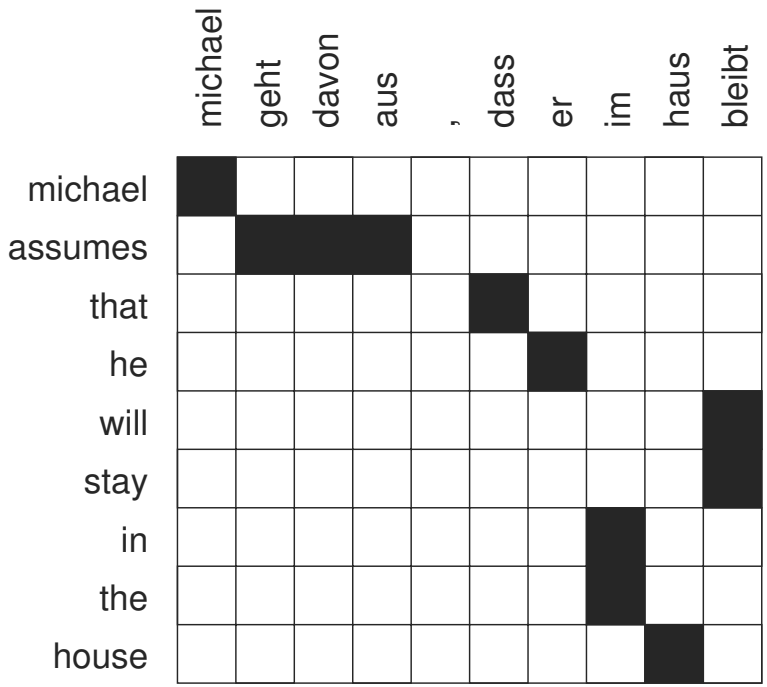
Extracting Phrase Pairs



extract phrase pair consistent with word alignment:

assumes that / geht davon aus , dass

Phrase Pair Extraction



Smallest phrase pairs:

michael — michael

assumes — geht davon aus / geht davon aus ,

that — dass / , dass

he — er

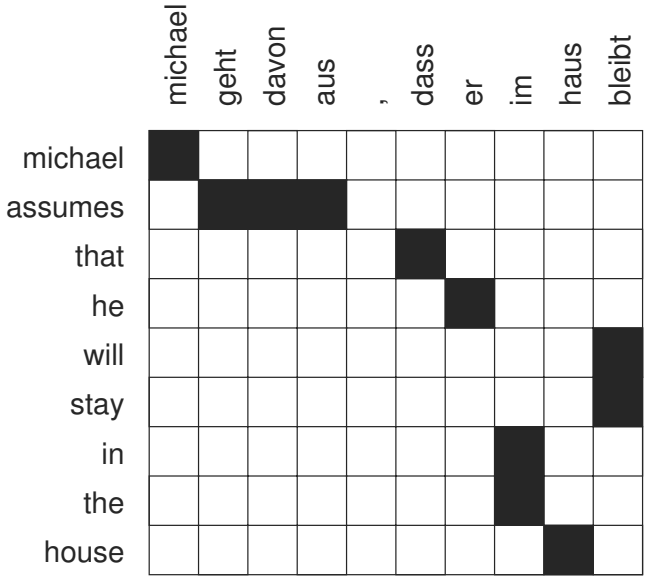
will stay — bleibt

in the — im

house — haus

unaligned words (here: German comma) lead to multiple translations

Larger Phrase Pairs



michael assumes — michael geht davon aus / michael geht davon aus ,
assumes that — geht davon aus , dass ; assumes that he — geht davon aus , dass er
that he — dass er / , dass er ; in the house — im haus
michael assumes that — michael geht davon aus , dass
michael assumes that he — michael geht davon aus , dass er
michael assumes that he will stay in the house — michael geht davon aus , dass er im haus bleibt
assumes that he will stay in the house — geht davon aus , dass er im haus bleibt
that he will stay in the house — dass er im haus bleibt ; dass er im haus bleibt ,
he will stay in the house — er im haus bleibt ; will stay in the house — im haus bleibt

Objective Function

- Bayes rule

$$\begin{aligned} \mathbf{e_{best}} &= \mathbf{argmax_e}\, p(\mathbf{e}|\mathbf{f}) \\ &= \mathbf{argmax_e}\, p(\mathbf{f}|\mathbf{e})\, p_{\mathrm{lm}}(\mathbf{e}) \end{aligned}$$

  - translation model $p(\mathbf{e}|\mathbf{f})$
  - language model $p_{\mathrm{lm}}(\mathbf{e})$

- Decomposition of the translation model

$$p(\bar{f}_1^I|\bar{e}_1^I) = \prod_{i=1}^{I} \phi(\bar{f}_i|\bar{e}_i)\, d(start_i - end_{i-1} - 1)$$

  - phrase translation probability ϕ
  - reordering probability d

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- Phrases are mostly independent (LM is glue)
- Would like to use wider context
- And have fuzzy phrase boundaries

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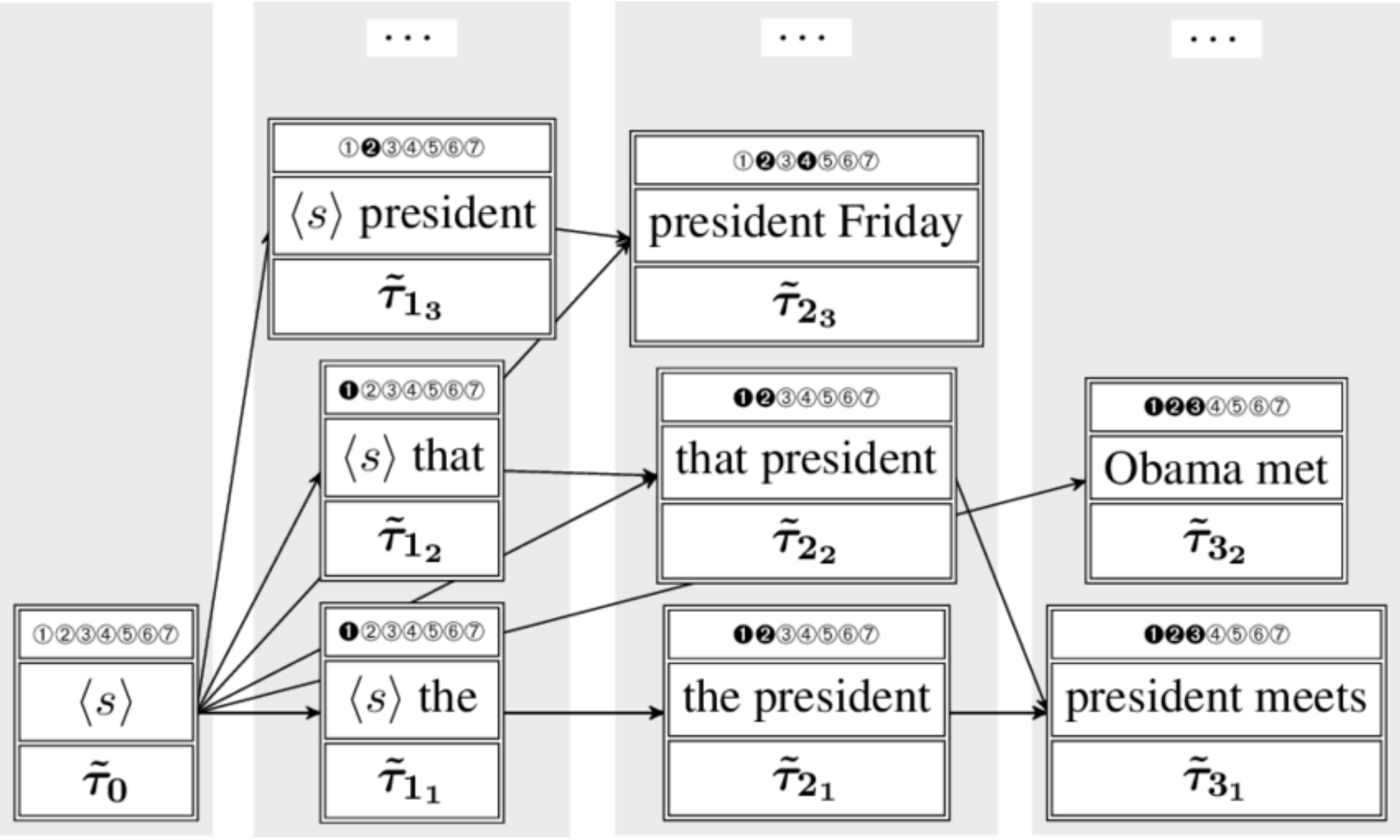
- And have fuzzy phrase boundaries
- Neural models!



Phrase-based Decoding (Slide from Chris Callison-Burch)