Statistical Machine Translation, Part II

Can a Machine Translation Without Knowing What a Verb Is?

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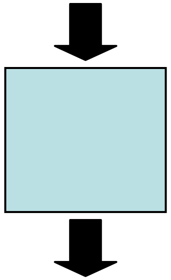
Topics

- Quick review of statistical machine translation essentials
  - bilingual text
  - phrase substitution models
  - language models
  - decoding
- Syntactic Approaches
  - syntax-based translation models
  - learning syntactic rules from data
  - decoding

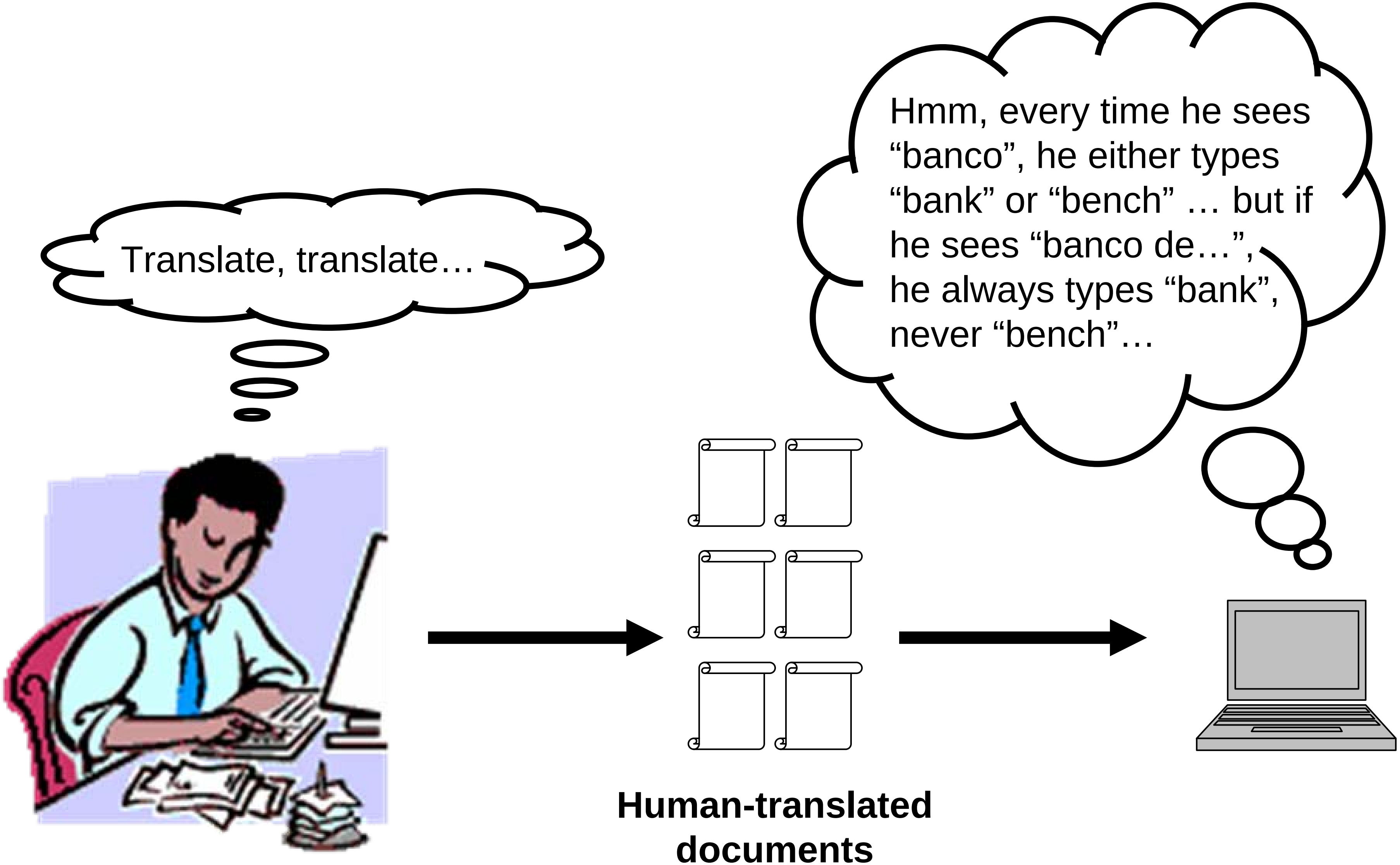
Machine Translation

美国关岛国际机场及其办公室均接获一名自称沙地阿拉伯富商拉登等发出的电子邮件，威胁将会向机场等公众地方发动生化袭击後，关岛经保持高度戒备。



The U.S. island of Guam is maintaining a high state of alert after the Guam airport and its offices both received an e-mail from someone calling himself the Saudi Arabian Osama bin Laden and threatening a biological/chemical attack against public places such as the airport.

Statistical Machine Translation



Translate, translate…

Hmm, every time he sees “banco”, he either types “bank” or “bench” … but if he sees “banco de…”, he always types “bank”, never “bench”…

Human-translated documents

Spanish/English corpus

1a. Garcia and associates .
1b. Garcia y asociados .

2a. Carlos Garcia has three associates .
2b. Carlos Garcia tiene tres asociados .

3a. his associates are not strong .
3b. sus asociados no son fuertes .

4a. Garcia has a company also .
4b. Garcia tambien tiene una empresa .

5a. its clients are angry .
5b. sus clientes estan enfadados .

6a. the associates are also angry .
6b. los asociados tambien estan enfadados .

7a. the clients and the associates are enemies .
7b. los clients y los asociados son enemigos .

8a. the company has three groups .
8b. la empresa tiene tres grupos .

9a. its groups are in Europe .
9b. sus grupos estan en Europa .

10a. the modern groups sell strong pharmaceuticals .
10b. los grupos modernos venden medicinas fuertes .

11a. the groups do not sell zenzanine .
11b. los grupos no venden zanzanina .

12a. the small groups are not modern .
12b. los grupos pequenos no son modernos .

Spanish/English corpus

Translate: Clients do not sell pharmaceuticals in Europe.

1a. Garcia and associates .
1b. Garcia y asociados .

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Centauri/Arcturan [Knight 97]

Your assignment, translate this to Arcturan: farok crrrok hihok yorok clok kantok ok-yurp

1a. ok-voon ororok sprok .

1b. at-voon bichat dat .

2a. ok-drubel ok-voon anok plok sprok .

2b. at-drubel at-voon pippat rrat dat .

3a. erok sprok izok hihok ghirok .

3b. totat dat arrat vat hilat .

4a. ok-voon anok drok brok jok .

4b. at-voon krat pippat sat lat .

5a. wiwok farok izok stok .

5b. totat jjat quat cat .

6a. lalok sprok izok jok stok .

6b. wat dat krat quat cat .

7a. lalok farok ororok lalok sprok izok enemok .

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8b. iat lat pippat rrat nnat .

9a. wiwok nok izok kantok ok-yurp .

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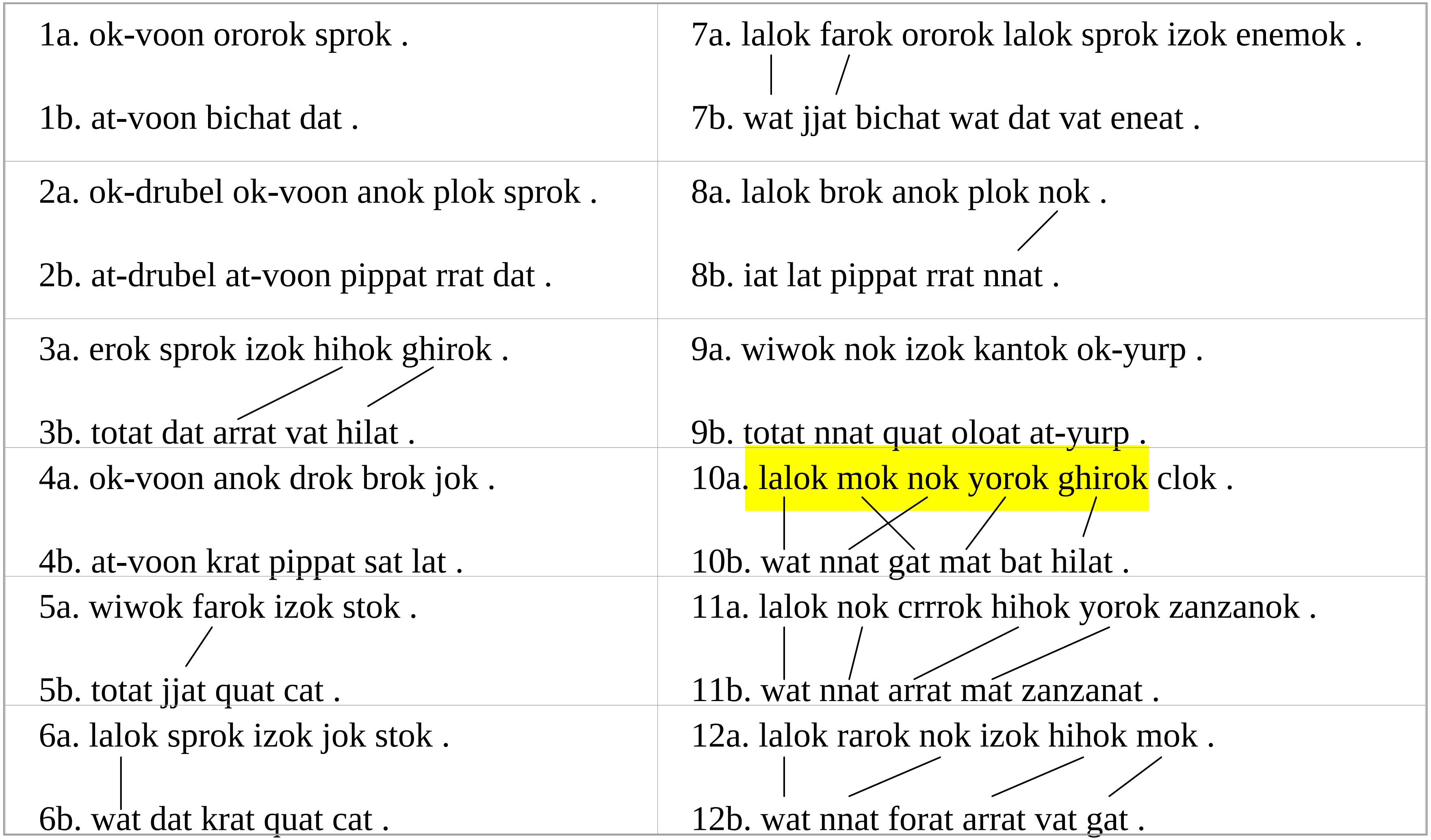

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process of elimination

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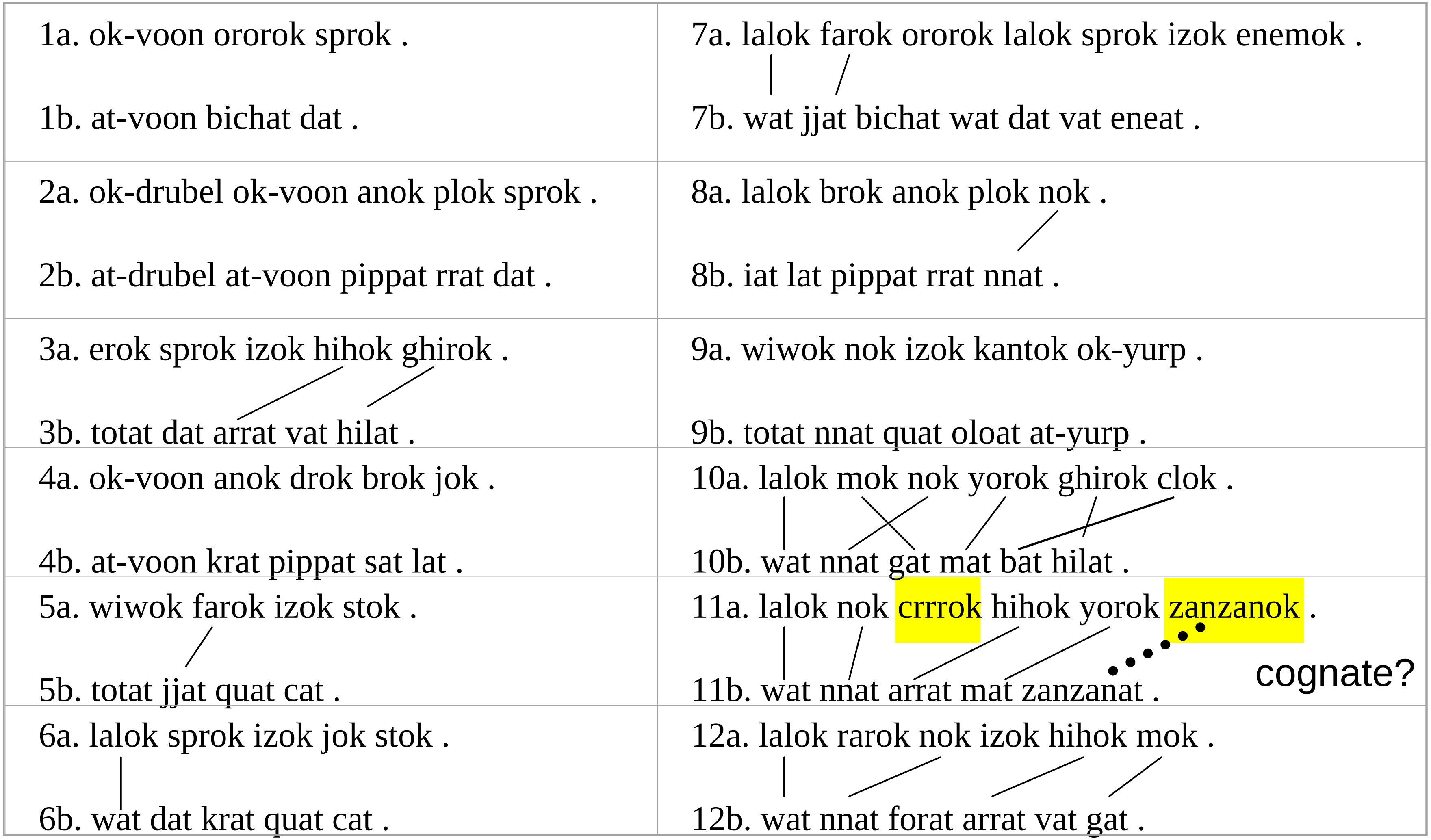

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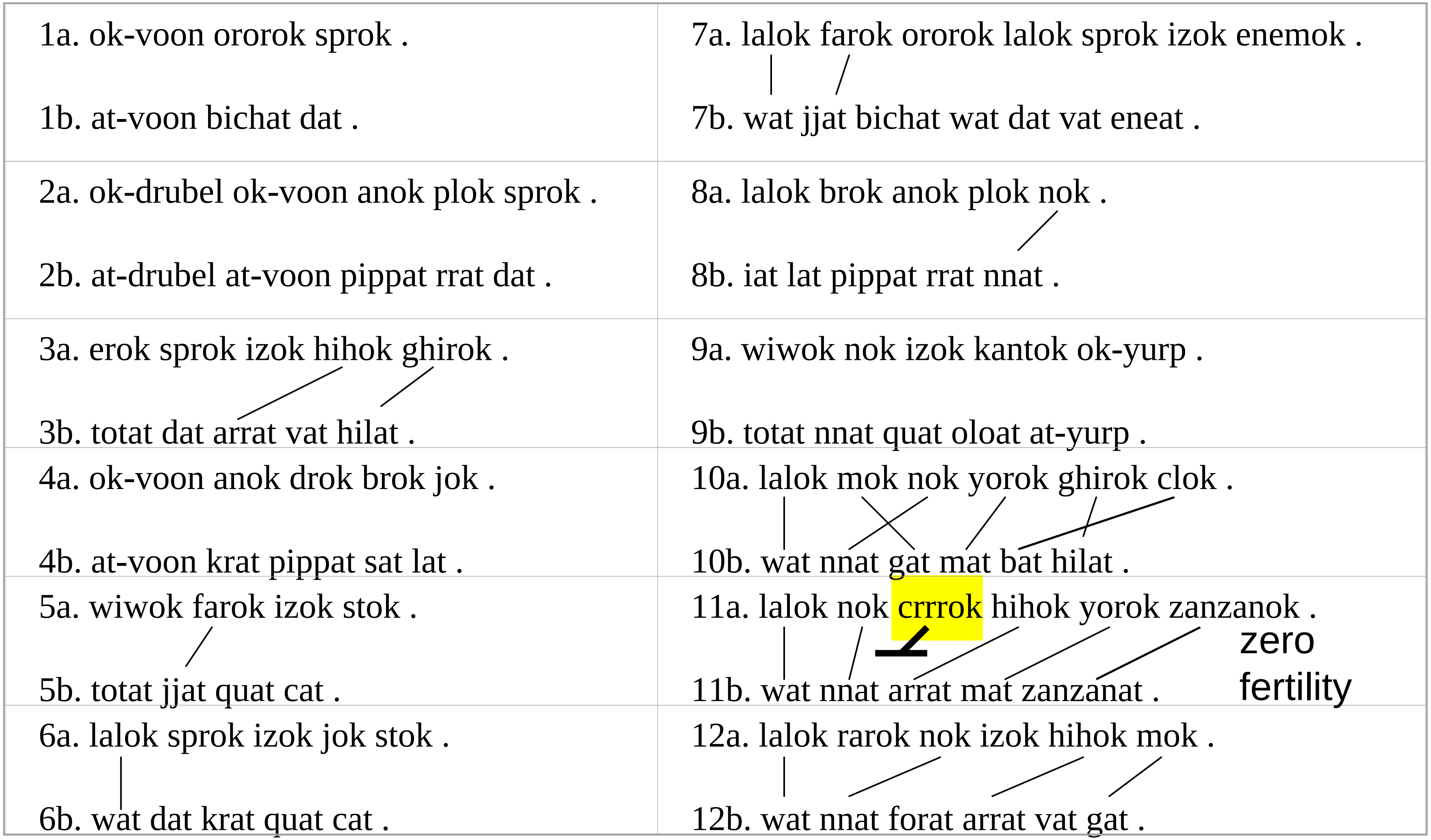
cognate?

Centauri/Arcturan [Knight 97]

Your assignment, put these words in order: **{ jjat, arrat, mat, bat, oloat, at-yurp }**



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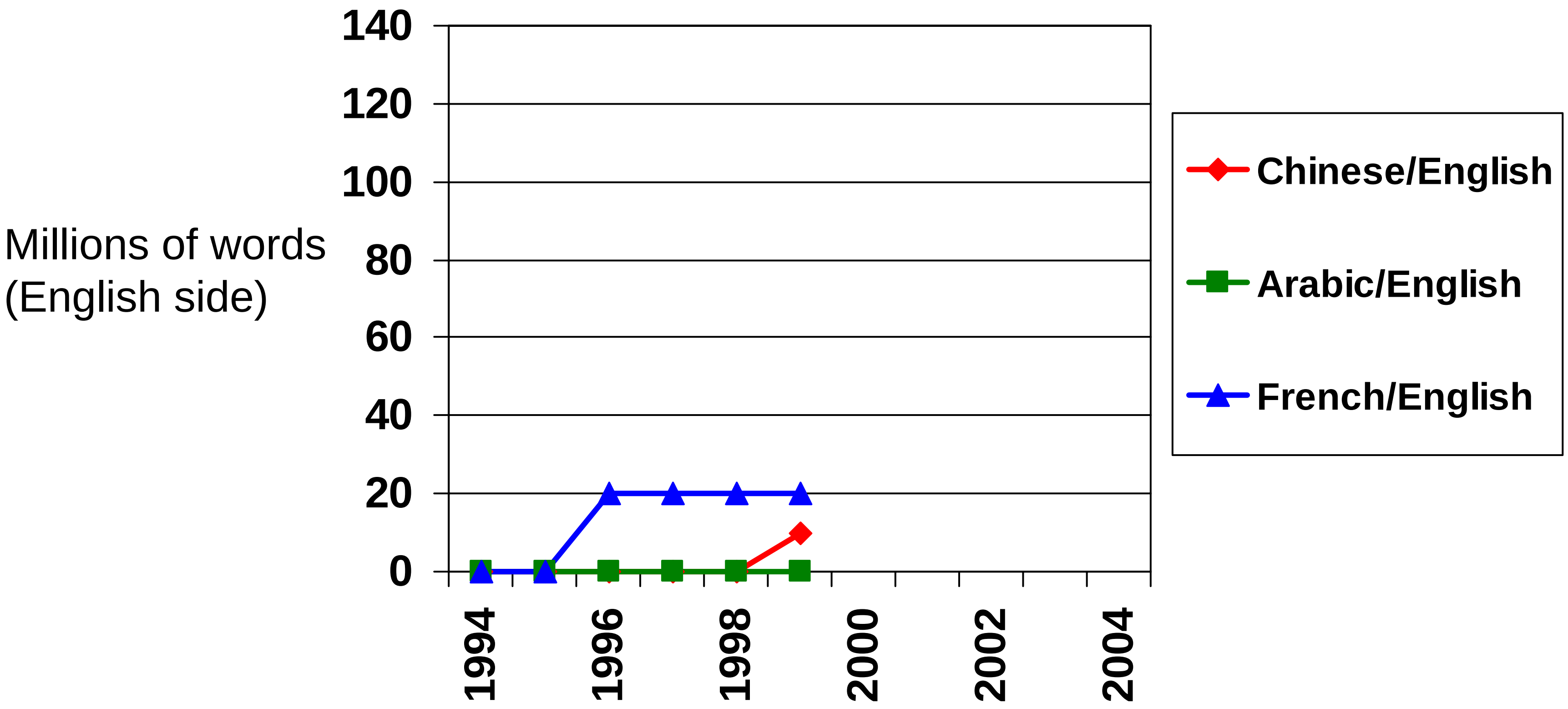
Ready-to-Use Online Bilingual Data



(Data stripped of formatting, in sentence-pair format, available from the Linguistic Data Consortium at UPenn).

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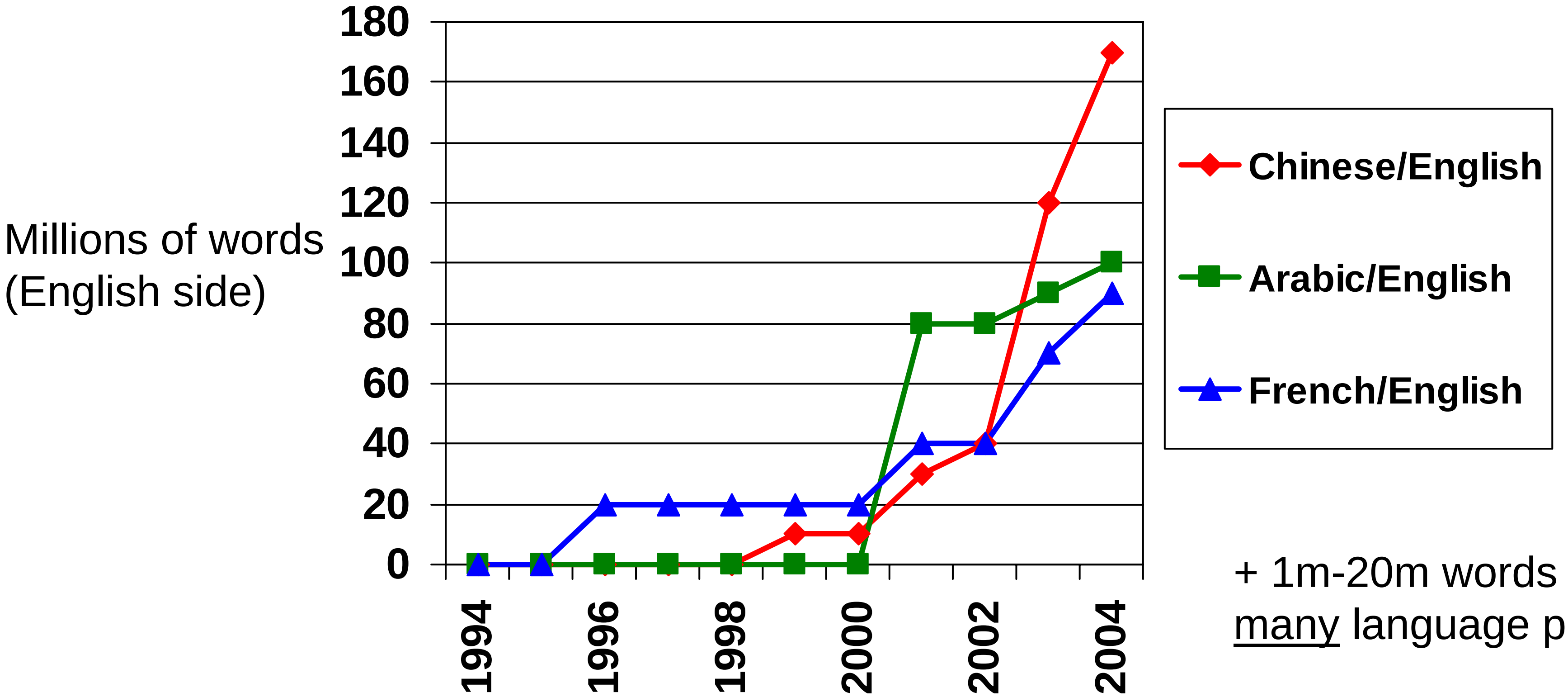

+ 1m-20m words for
<u>many</u> language pairs

(Data stripped of formatting, in sentence-pair format, available from the Linguistic Data Consortium at UPenn).

Bilingual Text (200m words)

English strings - - - - - - - - - - - - - - - … - - - - -

Bilingual text

Chinese strings - - - - - - - - - - - - - - - … - - - - -

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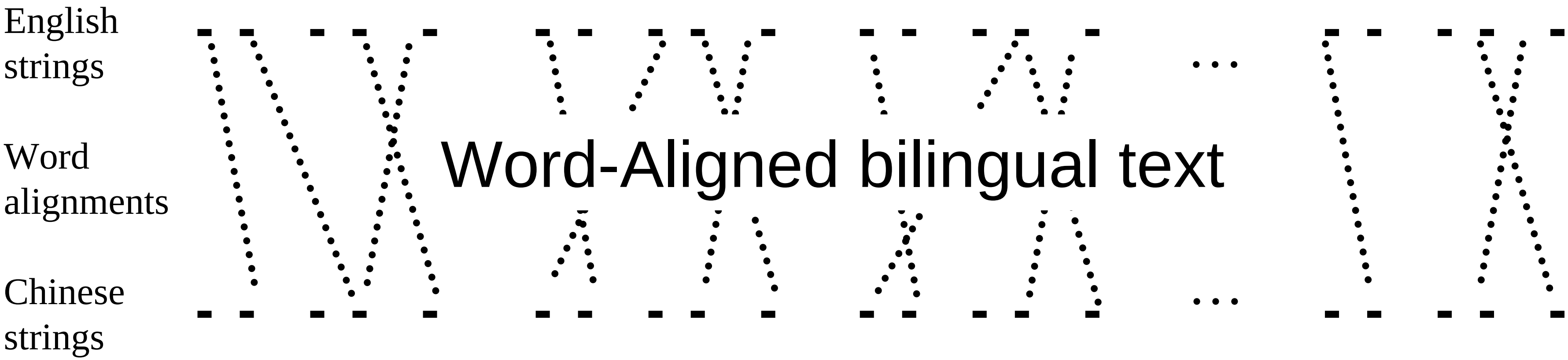

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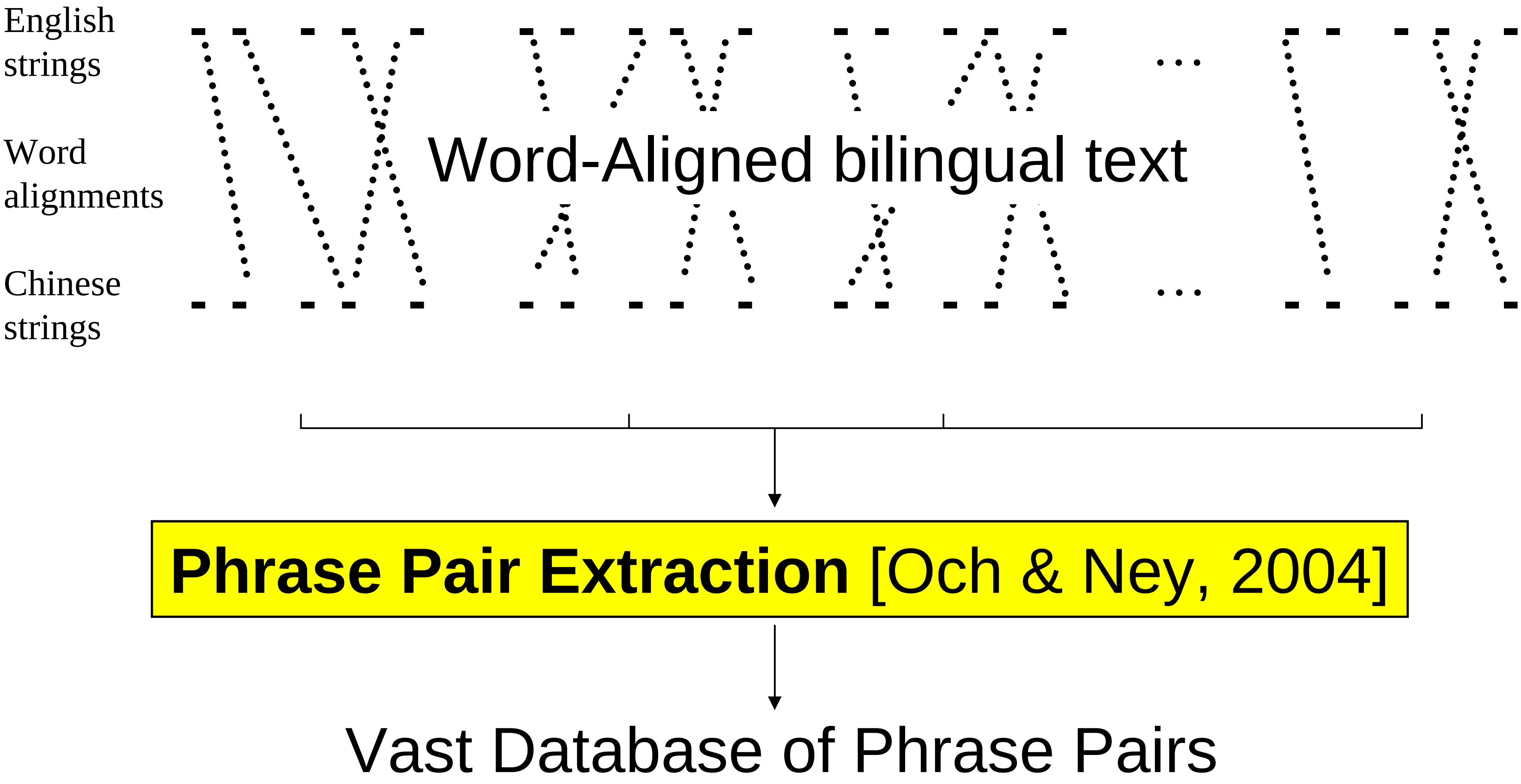


English strings

Word alignments

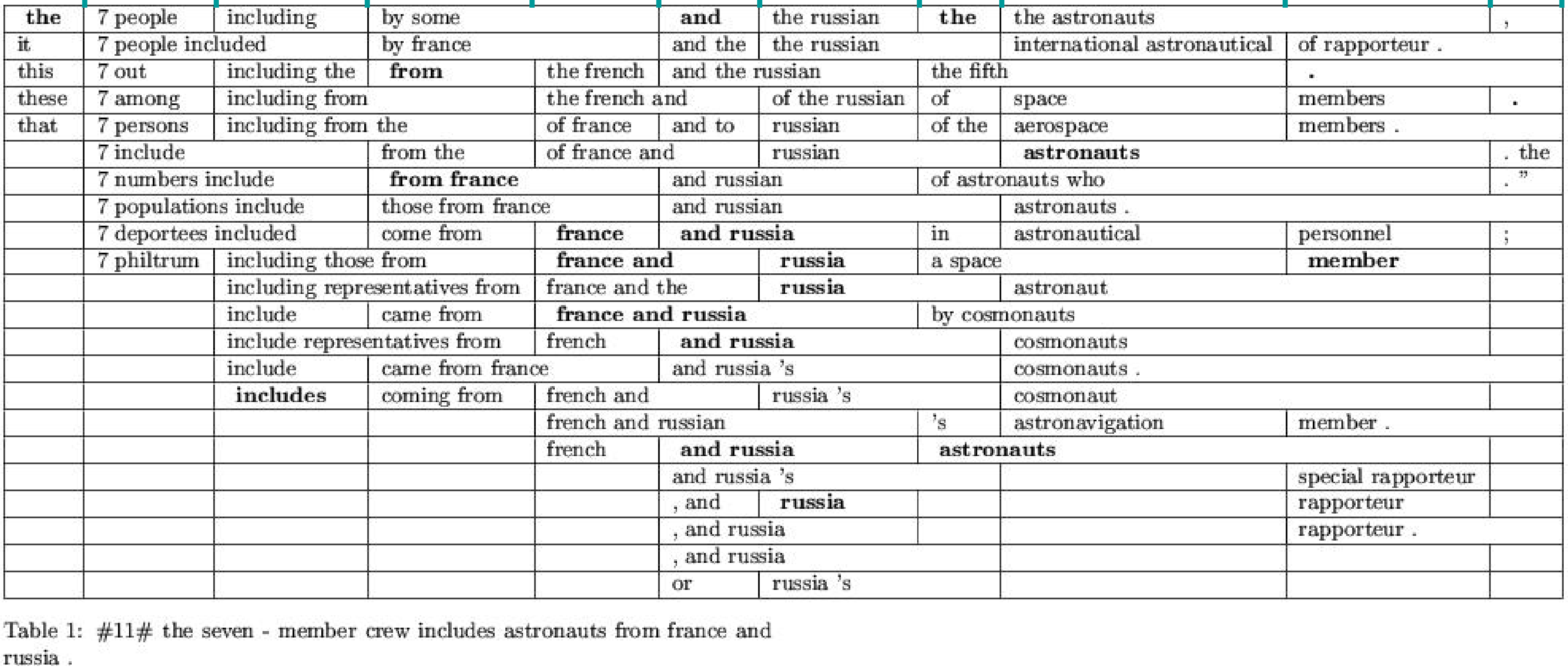
Chinese strings

Word-Aligned bilingual text

Phrase Pair Extraction [Och & Ney, 2004]

Vast Database of Phrase Pairs

Phrase-Based Translation

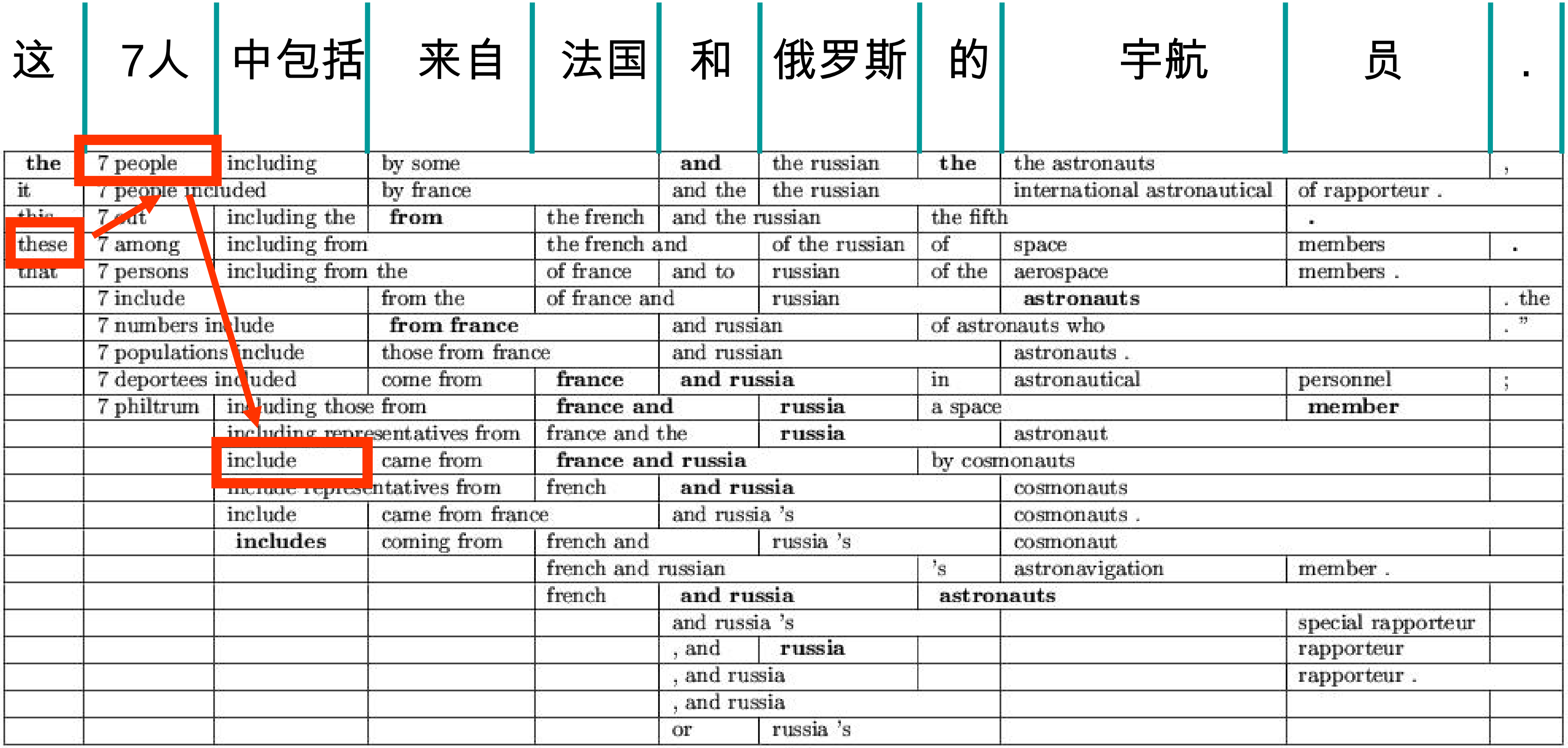


这	7人	中包括	来自	法国	和	俄罗斯	的	宇航	员	.
the	7 people	including	by some		**and**	the russian	**the**	the astronauts		,
it	7 people included		by france		and the	the russian		international astronautical	of rapporteur .	
this	7 out	including the	**from**	the french	and the russian		the fifth		.	
these	7 among	including from		the french and		of the russian	of	space	members	.
that	7 persons	including from the		of france	and to	russian	of the	aerospace	members .	
	7 include		from the	of france and		russian		**astronauts**		. the
	7 numbers include		**from france**		and russian		of astronauts who			. ”
	7 populations include		those from france		and russian			astronauts .		
	7 deportees included		come from	**france**	**and russia**		in	astronautical	personnel	;
	7 philtrum	including those from		**france and**		**russia**	a space		**member**	
		including representatives from		france and the		**russia**		astronaut		
		include	came from	**france and russia**			by cosmonauts			
		include representatives from		french	**and russia**			cosmonauts		
		include	came from france		and russia ’s			cosmonauts .		
		includes	coming from	french and		russia ’s		cosmonaut		
				french and russian			’s	astronavigation	member .	
				french	**and russia**		**astronauts**			
					and russia ’s				special rapporteur	
					, and	**russia**			rapporteur	
					, and russia				rapporteur .	
					, and russia					
					or	russia ’s				

Table 1: #11# the seven - member crew includes astronauts from france and russia .

Scoring: Try to use phrase pairs that have been frequently observed.
Try to output a sentence with frequent English word sequences.

Phrase-Based Translation



这	7人	中包括	来自	法国	和	俄罗斯	的	宇航	员	.
the	7 people	including	by some		and	the russian	the	the astronauts		,
it	7 people included		by france		and the	the russian		international astronautical	of rapporteur .	
this	7 out	including the	from	the french	and the russian		the fifth		.	
these	7 among	including from		the french and		of the russian	of	space	members	.
that	7 persons	including from the		of france	and to	russian	of the	aerospace	members .	
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	7 numbers include		from france		and russian		of astronauts who			. ”
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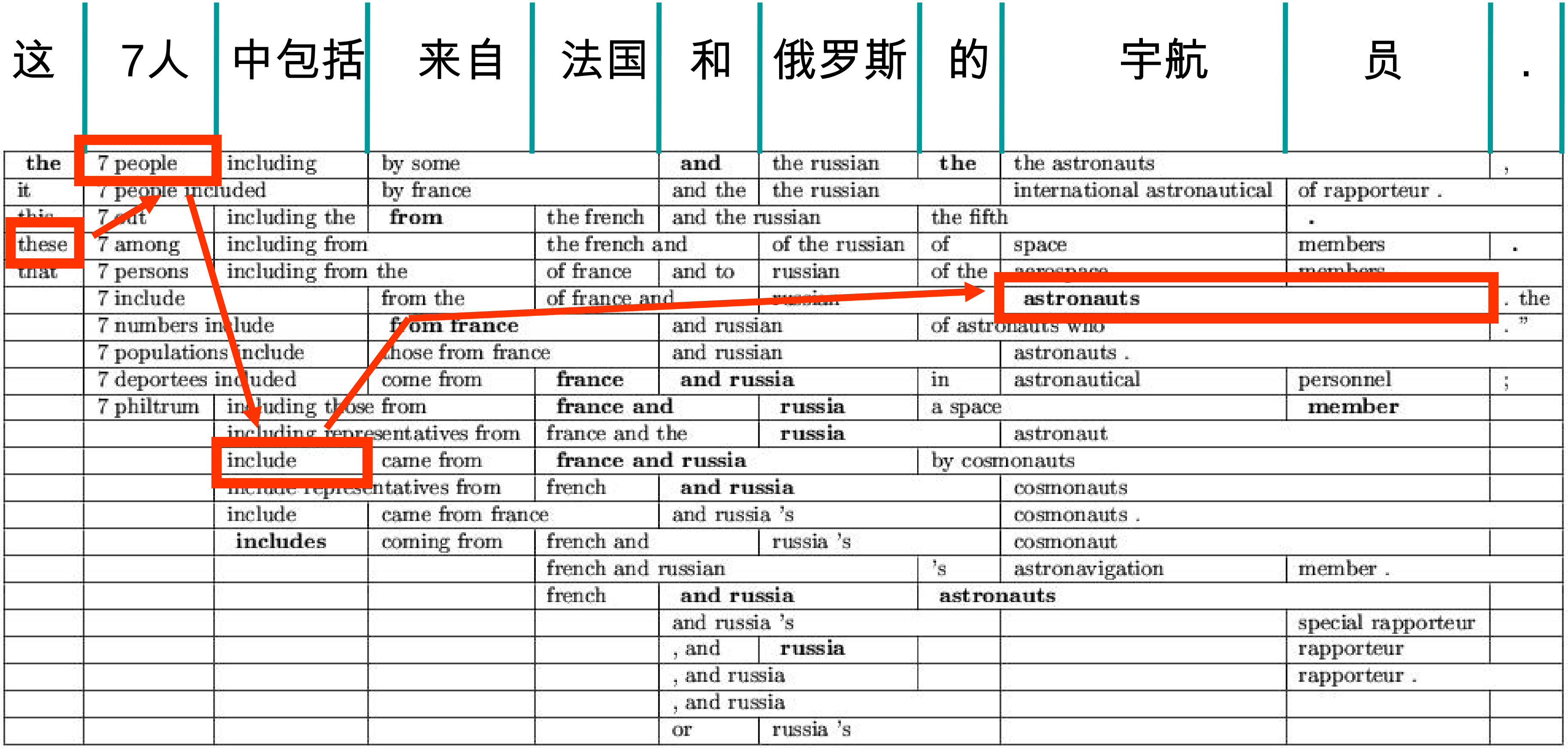

这	7人	中包括	来自	法国	和	俄罗斯	的	宇航	员	.
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					or	russia 's				

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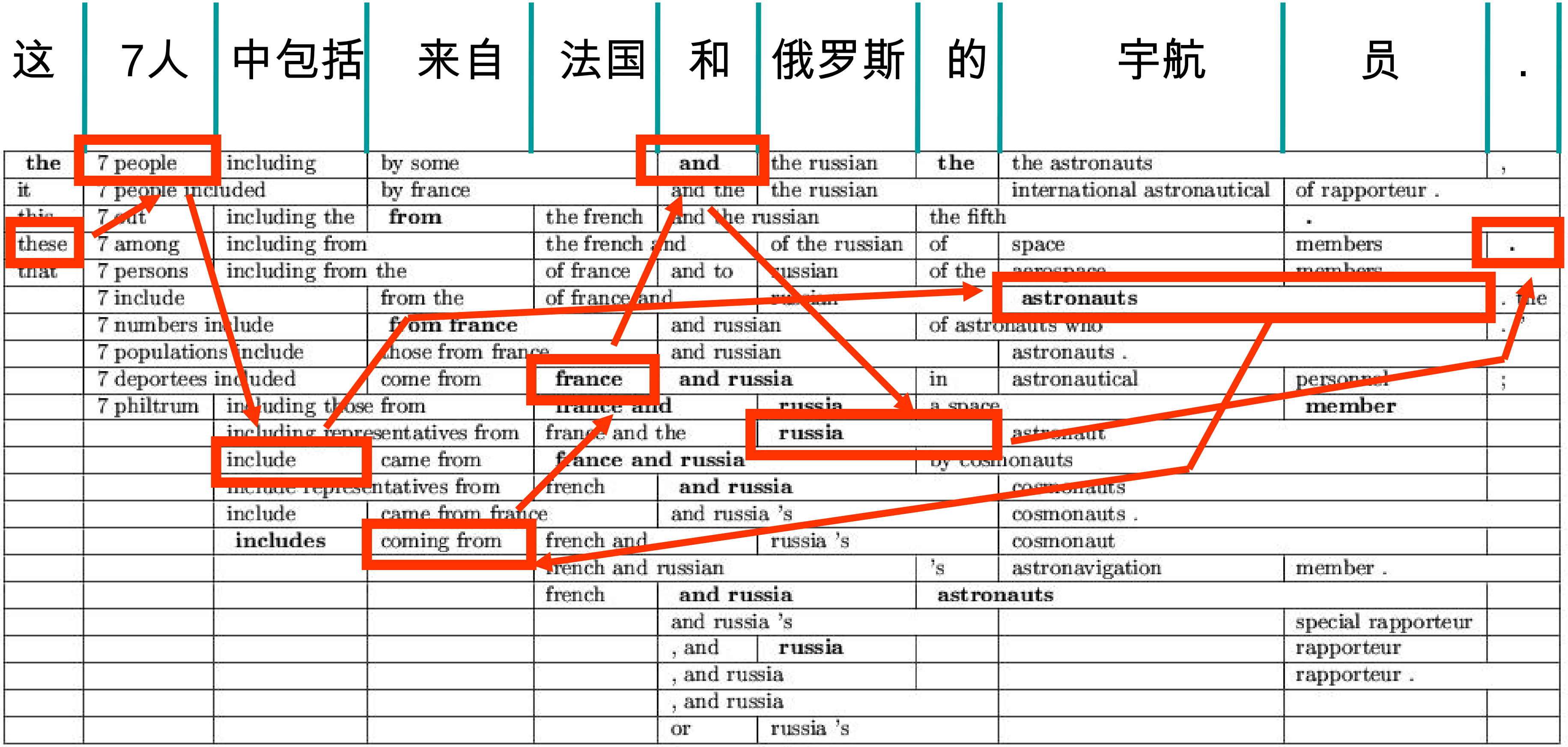

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Table 1: #11# the seven - member crew includes astronauts from france and russia .

Scoring: Try to use phrase pairs that have been frequently observed.
Try to output a sentence with frequent English word sequences.

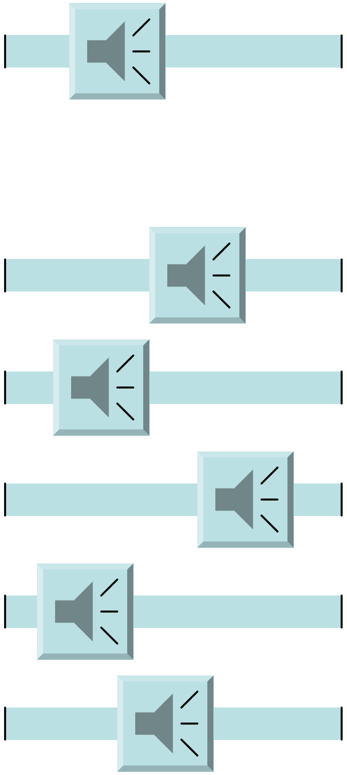
Components

- Training algorithms
  - Word alignment, phrase pair extraction…
    - P(chinese | english) = product of conditional phrase pair probabilities
  - English n-gram models…
    - P(english) = product of trigram probabilities
    - P(w3 | w1 w2)
- Decoding algorithm
  - argmax e P(chinese | english) =

    argmax e P(english) * P(chinese | english)

Features and Tuning

- English trigram language model
- Phrase pairs
  - Corpus probability of phrase pair
  - Bad-phrase spotter
  - Word-drop spotter
  - “Move Me” preference
- English output length



We compute a total score for each possible translation -- a linear weighted combination of these six values. This generalizes the formula from the previous slide, if we switch to log probs.

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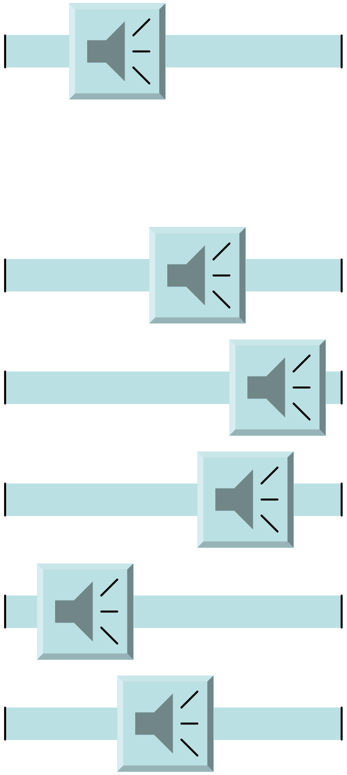

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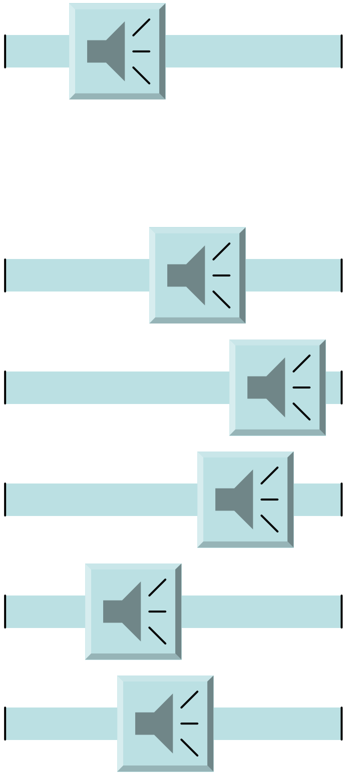

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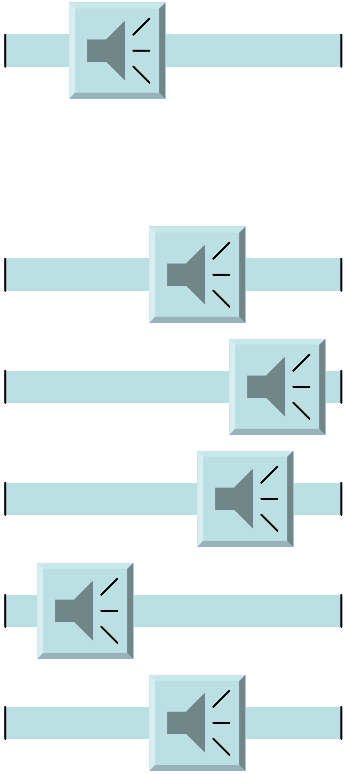
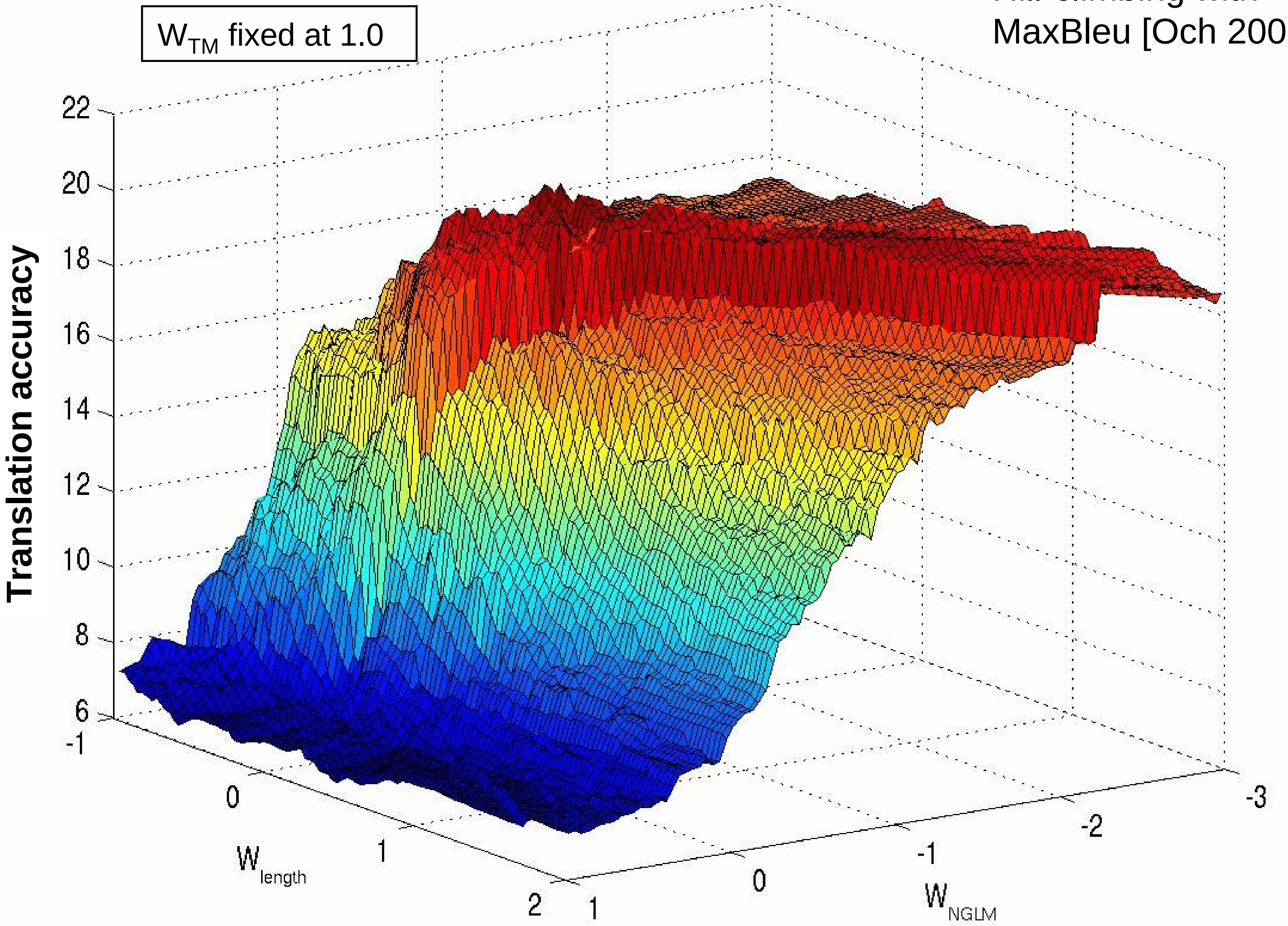


These six weights (plus about six more) are set by [Och 03]’s **Maximum BLEU training**, which optimizes similarity of MT outputs to human reference translations.

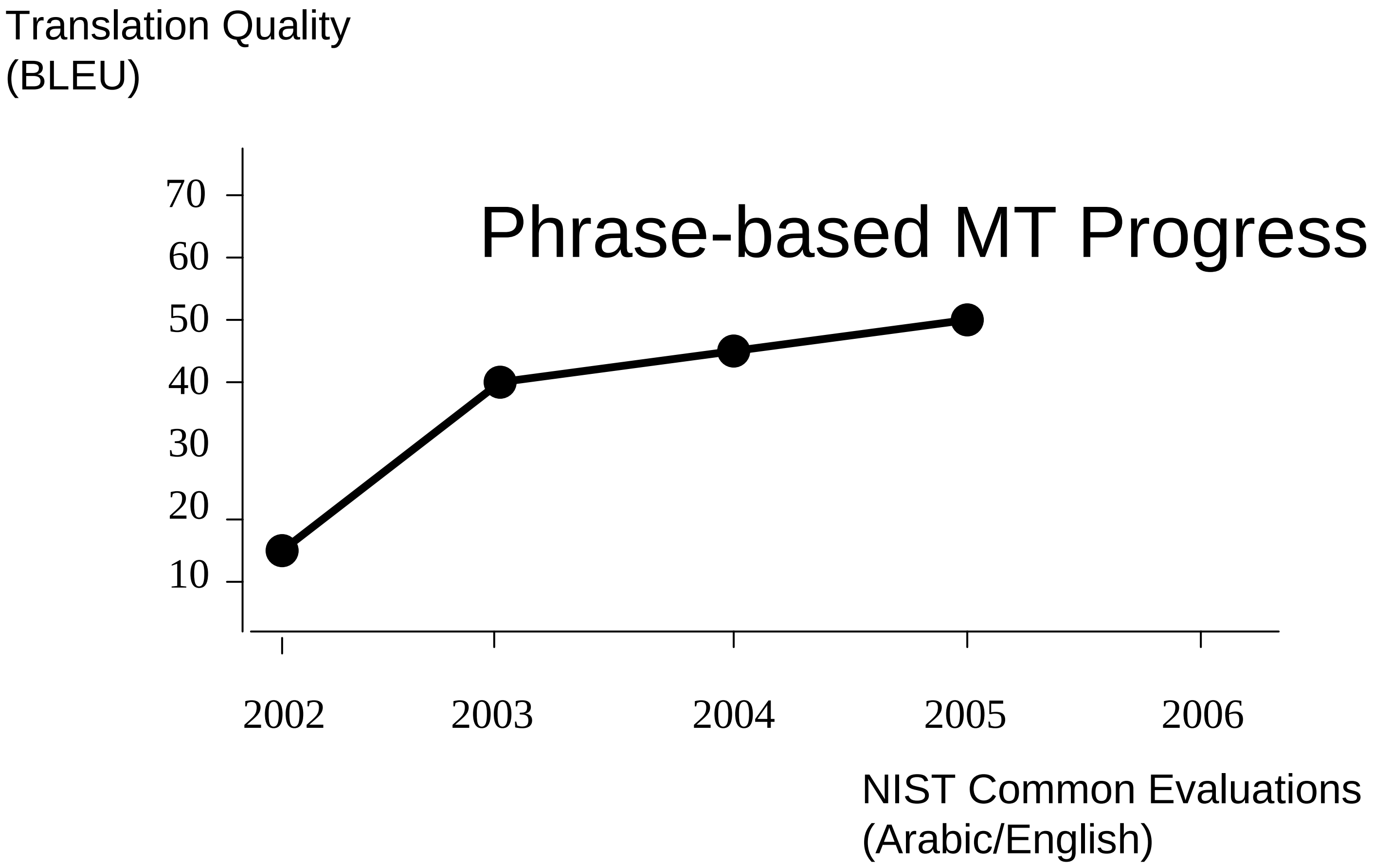
Hill-climbing with MaxBleu [Och 2003]



W_{TM} fixed at 1.0

plot by Emil Ettelaie

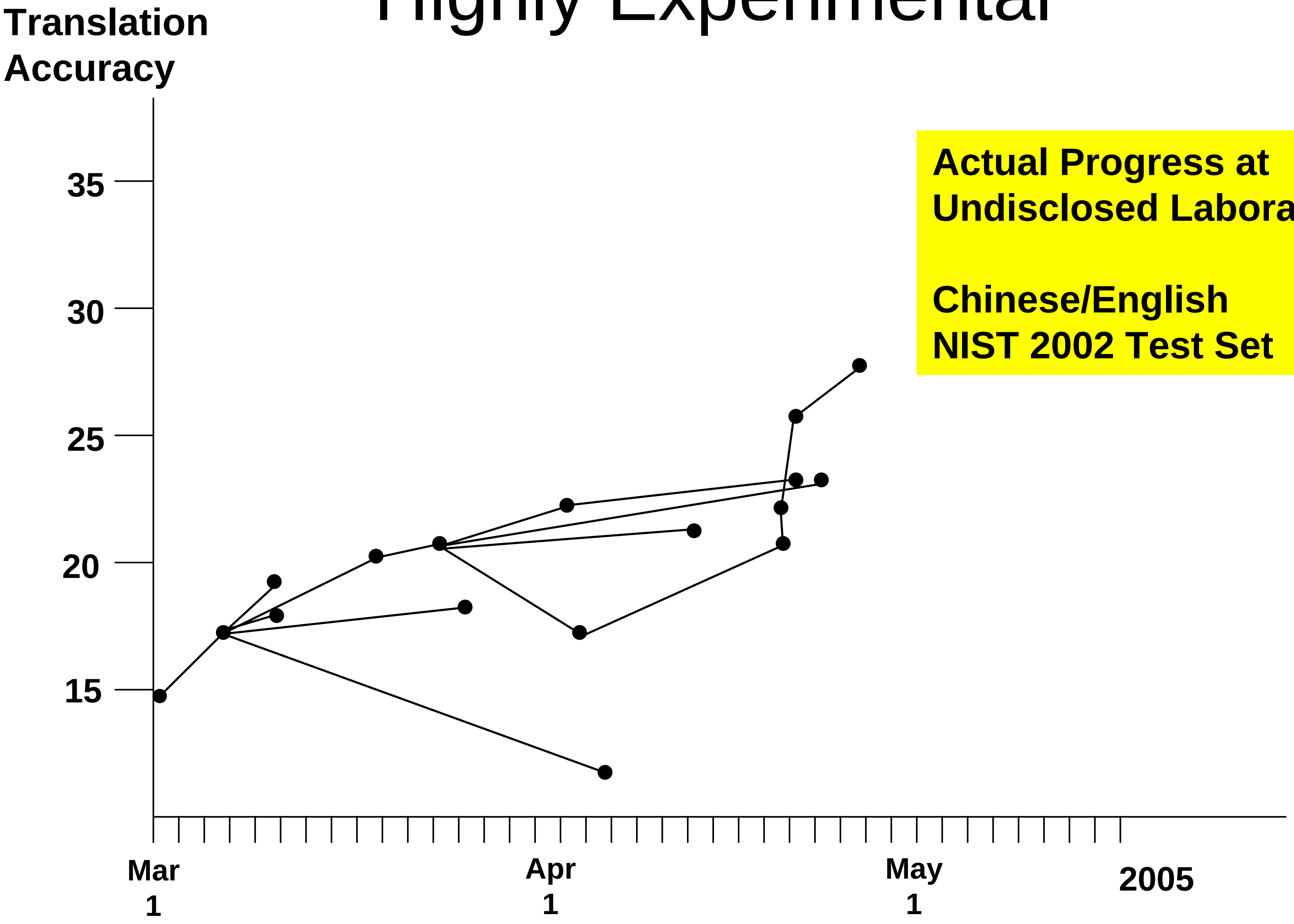
These Ideas Work!



Some Lessons

- The simpler, the better
- It takes a long time just to get the bugs out!
- Every change has to be carefully checked
- **Good ideas** often don’t help
- Have to try lots of things
- It’s highly experimental

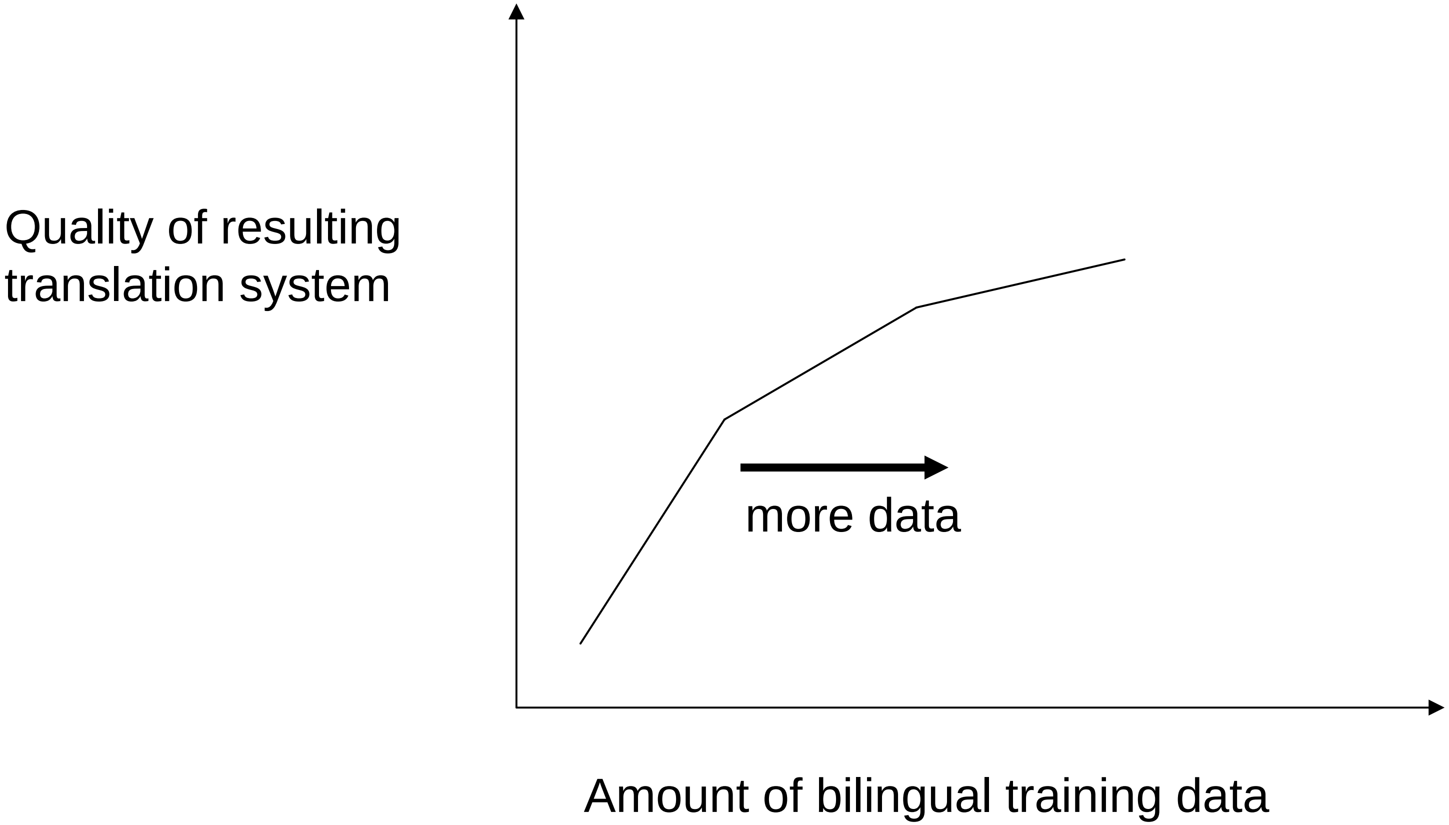
This Kind of MT Research is Highly Experimental



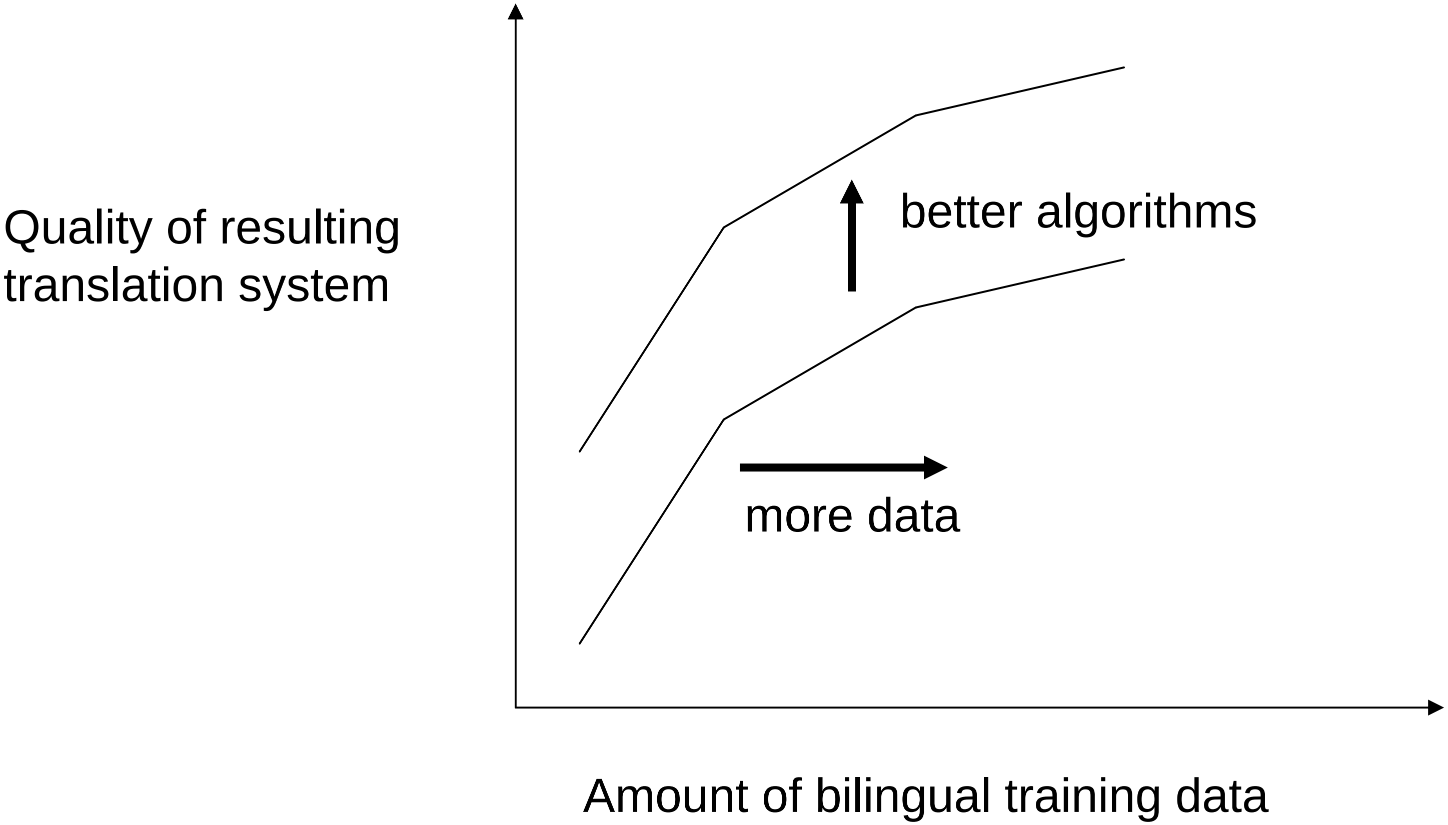
Actual Progress at Undisclosed Laboratory!

Chinese/English NIST 2002 Test Set

Two Ways to Improve Translation Systems



Two Ways to Improve Translation Systems



Can a machine translate between Chinese and English without knowing what a verb is?

- Of course
- But the output is often bad

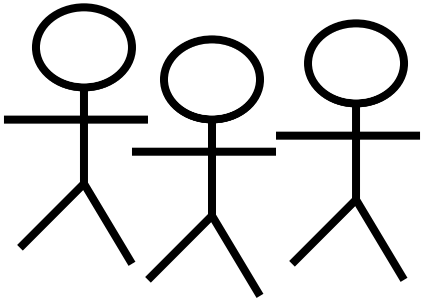
> “Frequent high-tech exports are bright spots for foreign trade growth of Guangdong has made important contributions.”

- This phrase-based story is a little bit crazy

Syntax

Maybe we need some grammar?

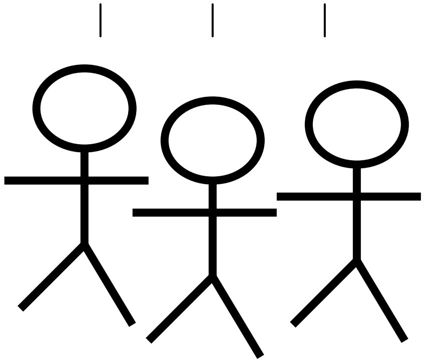
MT Research Landscape



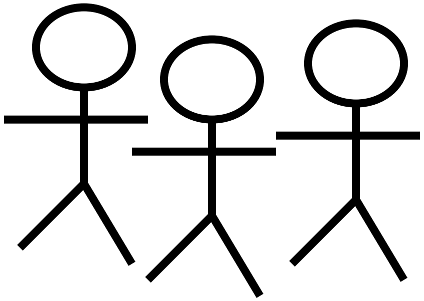
Working on syntax-based approach to translation (nouns, verbs, prepositional phrases…)

MT Research Landscape

Syntax will never work!
We’re better off without syntax!
Syntax has been *shown* to make things worse!
It has never worked in speech recognition!
You are crazy!



Language Engineers



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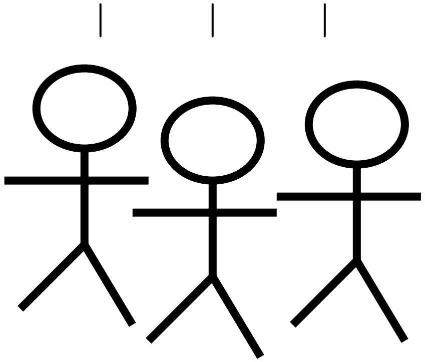
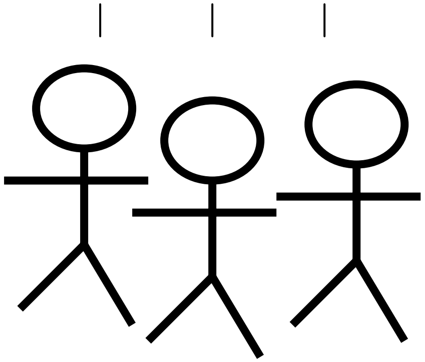
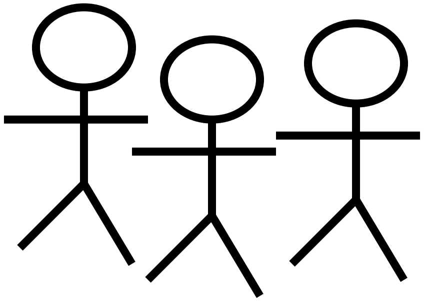


Language Engineers

Syntax will never work!
You need *semantics*!
Language is about the world!
You are crazy!



AI Fellows



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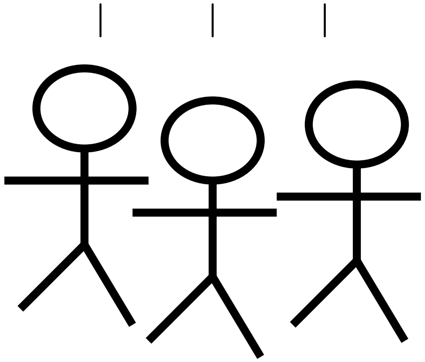

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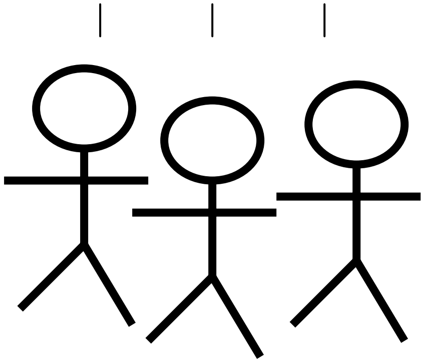

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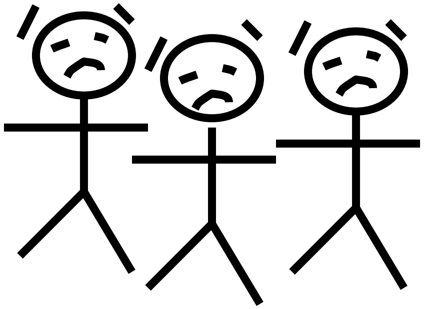

Working on syntax-based approach
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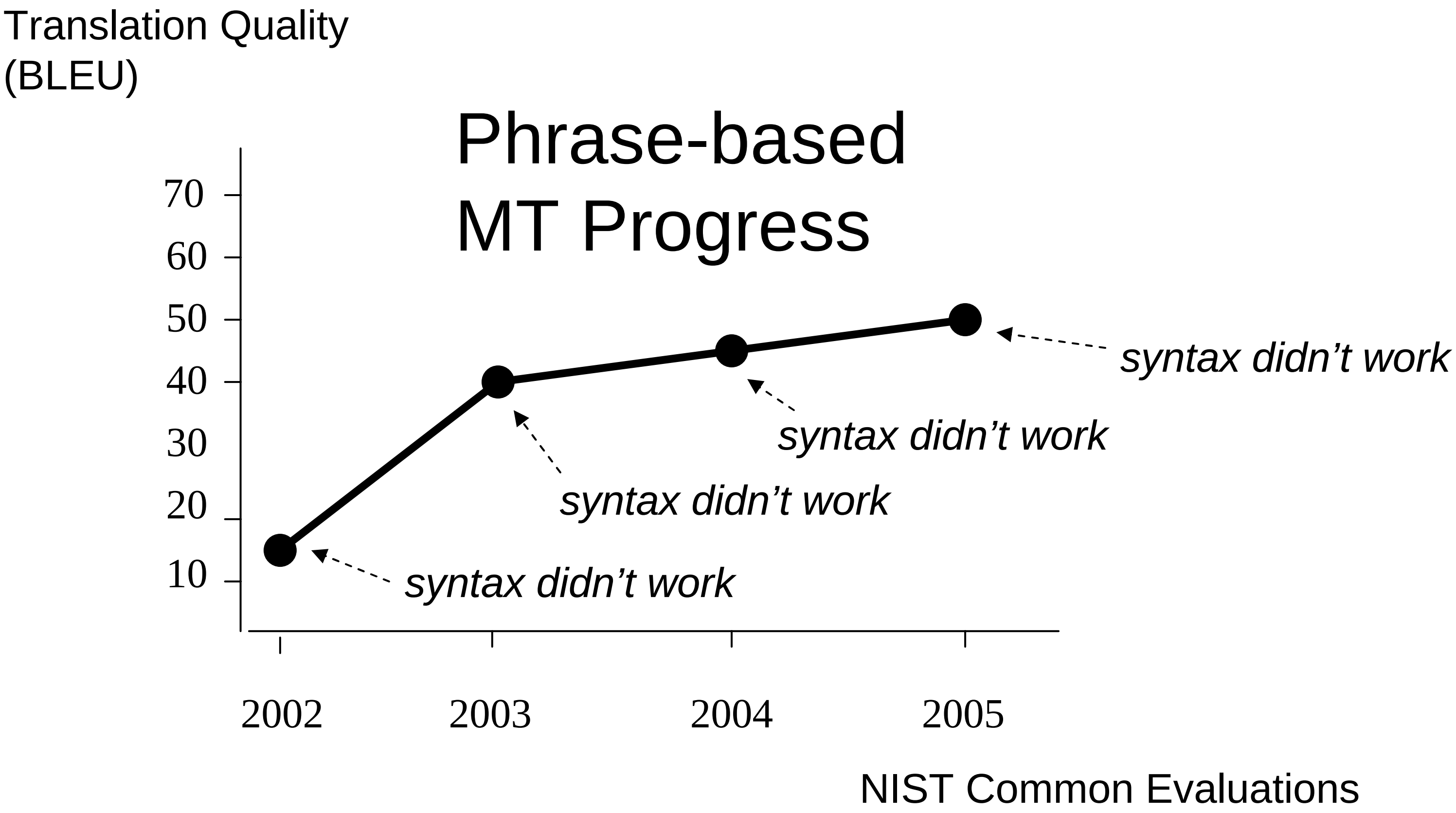
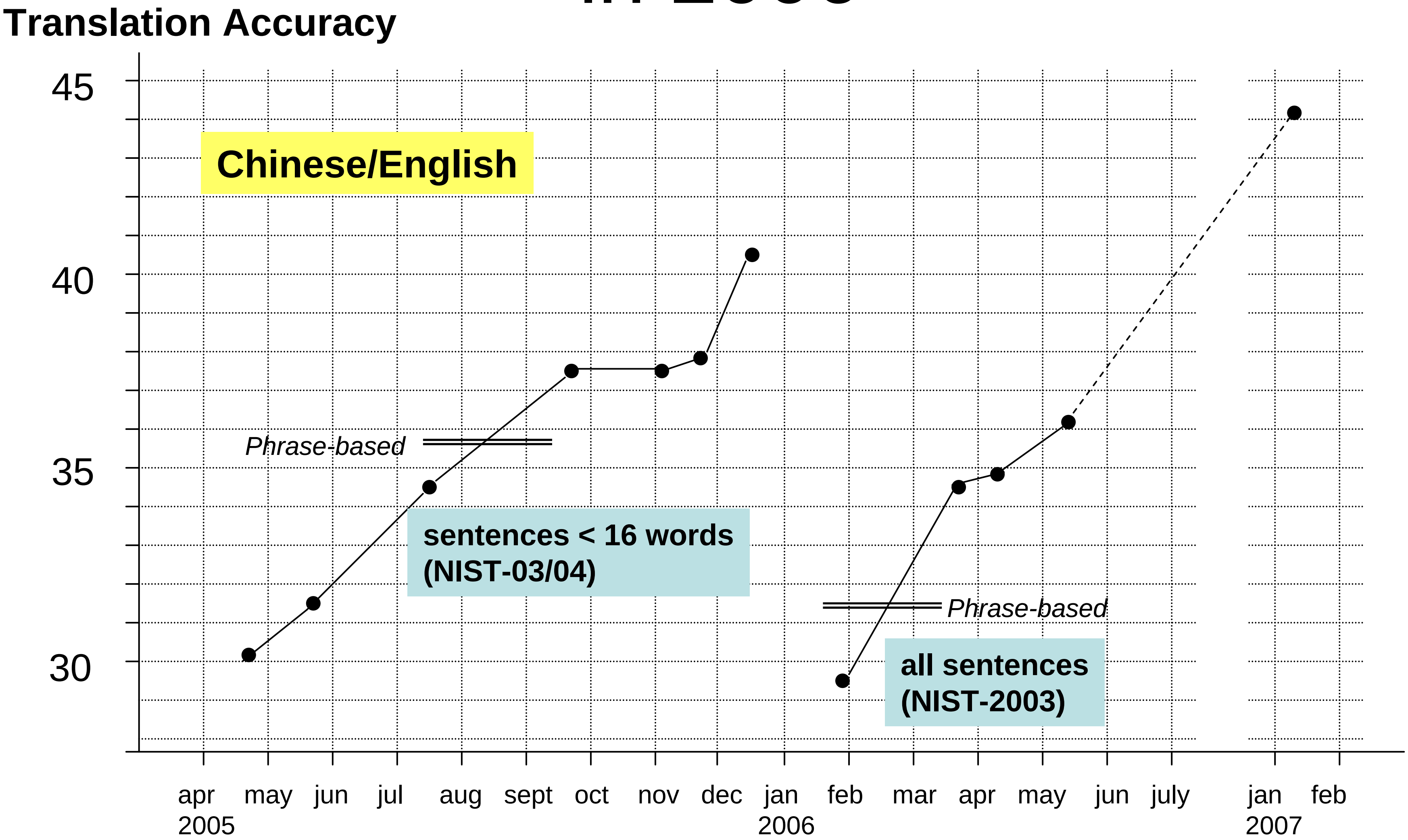
MT Progress


Translation Quality
(BLEU)
Phrase-based
MT Progress
70
60
50
40
30
20
10
syntax didn't work
syntax didn't work
syntax didn't work
syntax didn't work
2002
2003
2004
2005
NIST Common Evaluations

Syntax Started to Be Helpful in 2006

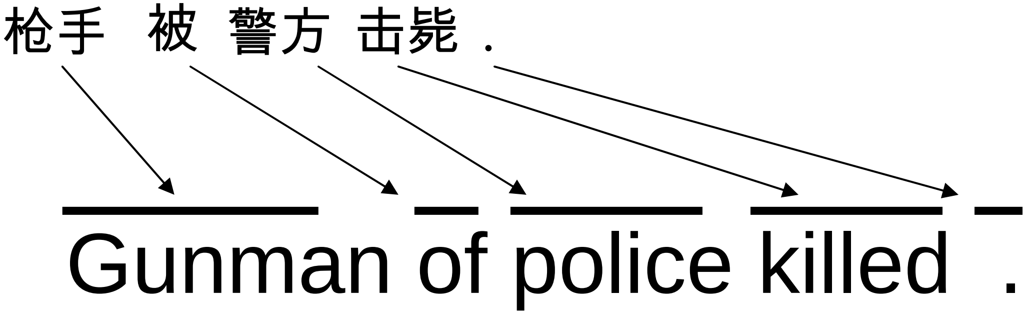


How to Add Syntax?

- Automatically parse training data
  - Add syntactic features to phrase-based system
  - Syntactically re-order source sentences into target-language word order (for training and decoding)
  - Build tree-to-tree translation systems
    - many approaches!
  - Build tree-to-string translation systems
    - many approaches!
  - Build string-to-tree translation systems
    - many approaches!

- Let’s take just one approach & investigate

Phrase-Based Output

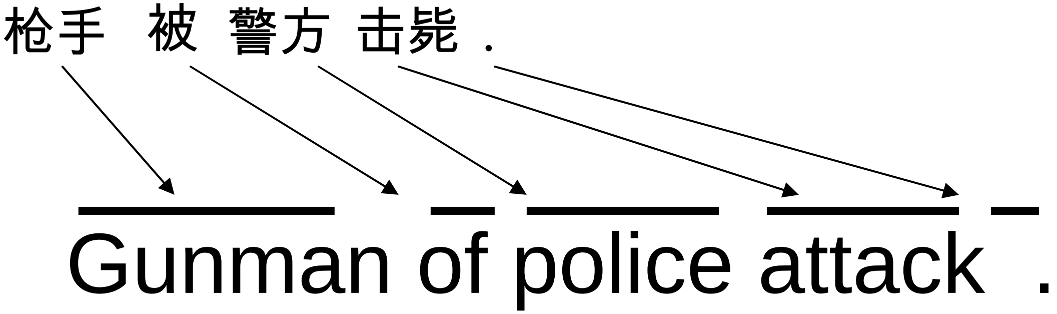


枪手 被 警方 击毙 .

Gunman of police killed .

Decoder
Hypothesis #1

Phrase-Based Output

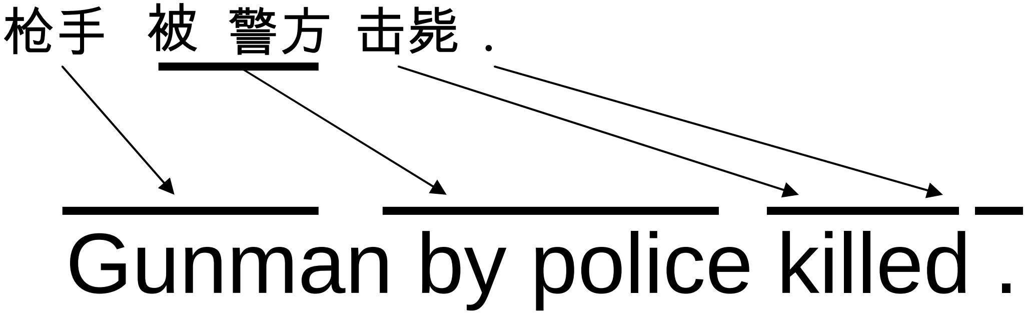


枪手 被 警方 击毙 .

Gunman of police attack .

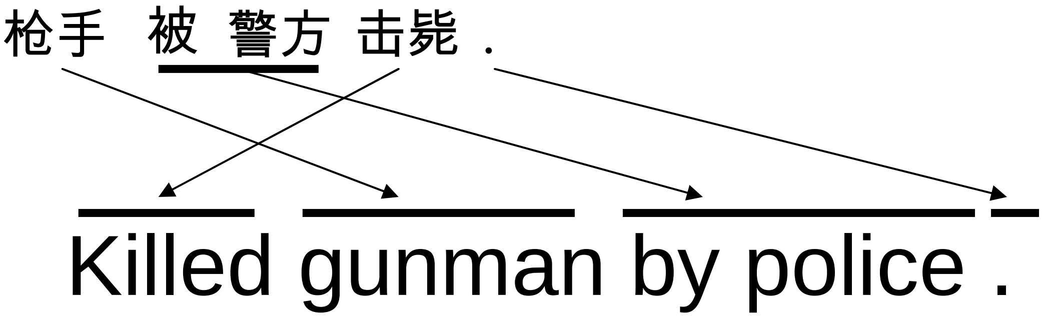
Decoder Hypothesis #7

Phrase-Based Output



Decoder Hypothesis #12

Phrase-Based Output

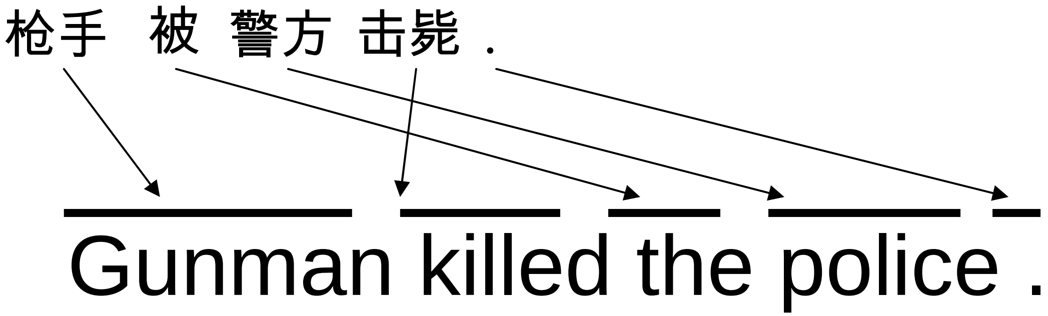


枪手 被 警方 击毙 .

Killed gunman by police .

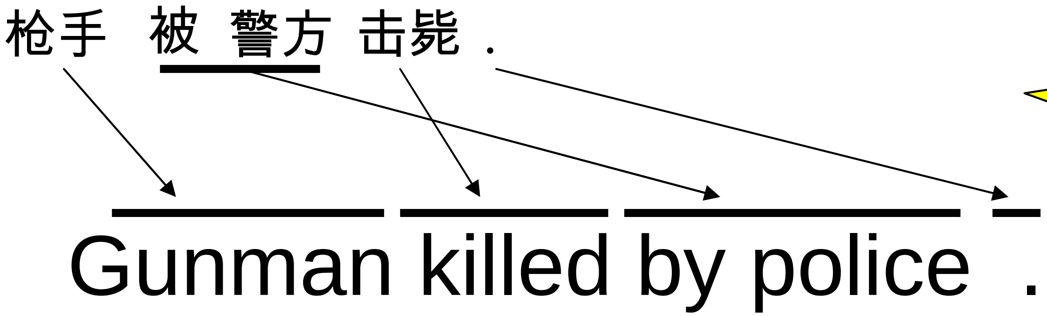
Decoder Hypothesis #134

Phrase-Based Output



Decoder Hypothesis #9,329

Phrase-Based Output



highest scoring output, phrase-based model

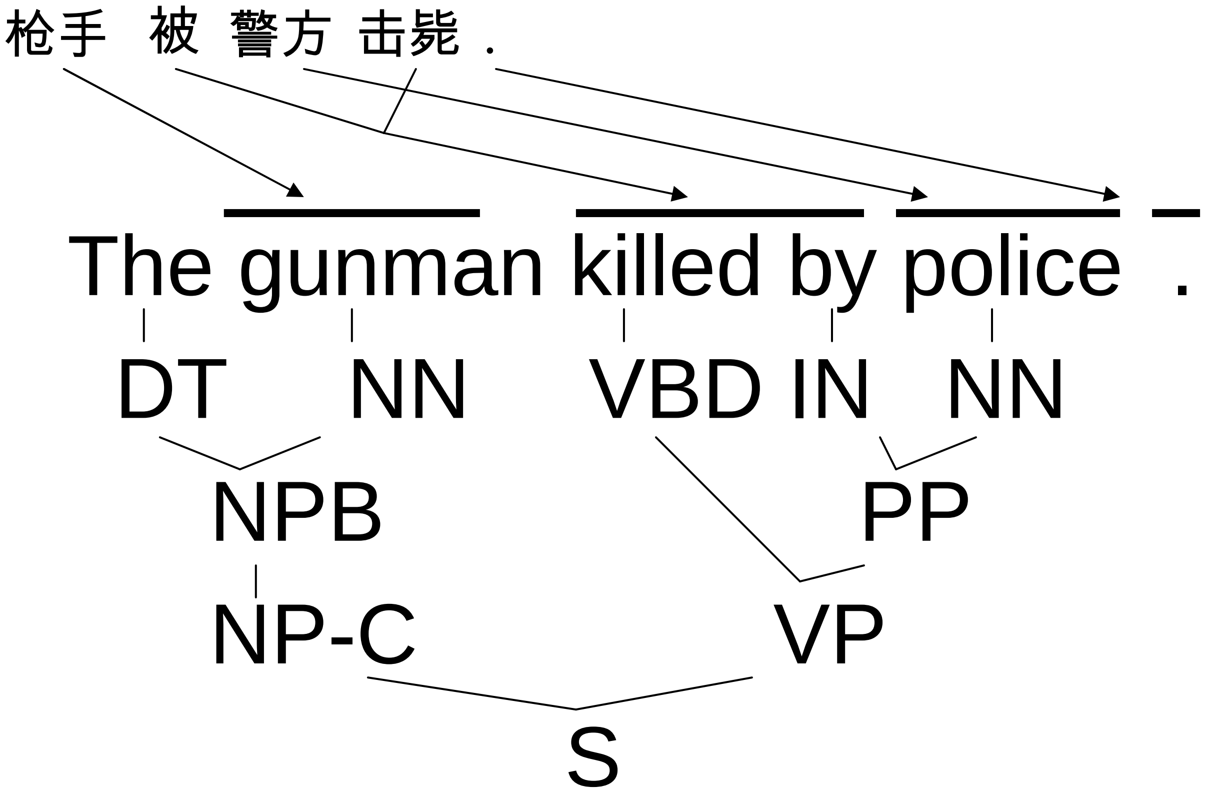
Decoder Hypothesis #50,654

Problematic:

- VBD “killed” needs a direct object
- VBN “killed” needs an auxiliary verb (“was”)
- countable “gunman” needs an article (“a”, “the”)
- “passive marker” in Chinese controls re-ordering

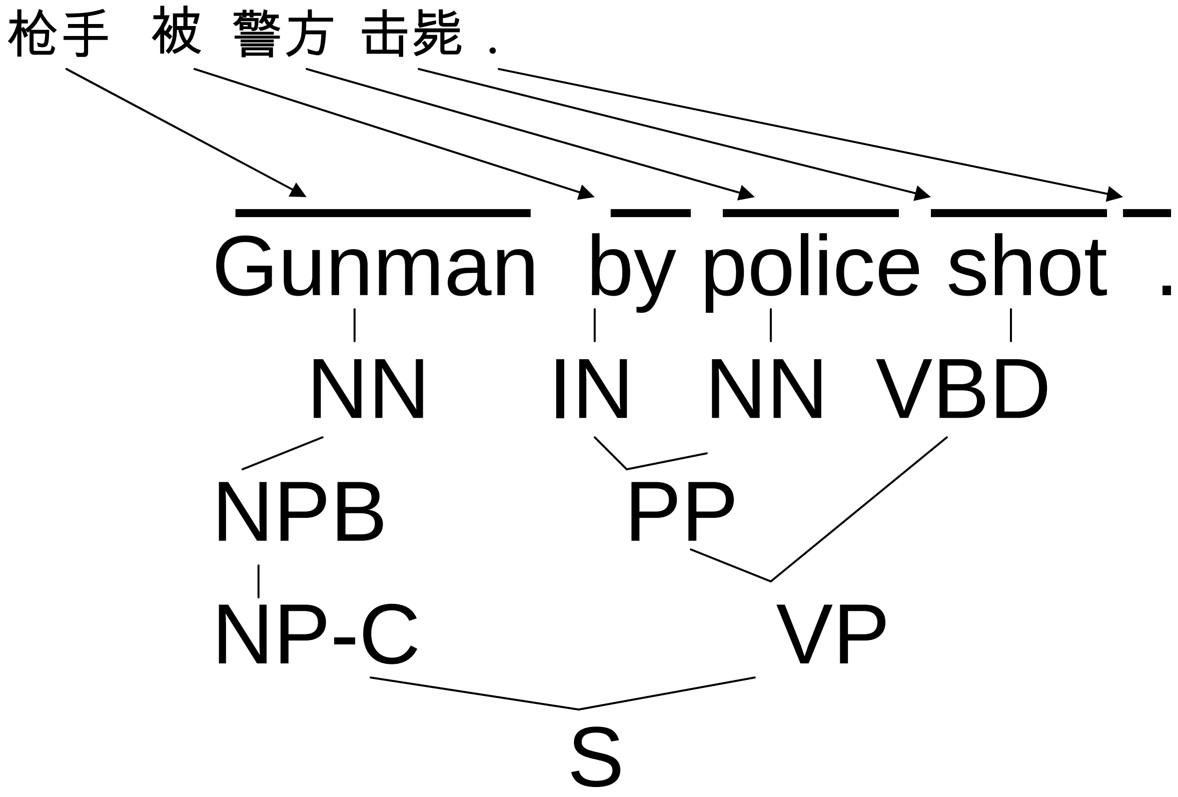
Can’t enforce/encourage any of this!

Syntax-Based Output



Decoder Hypothesis #1

Syntax-Based Output



枪手 被 警方 击毙 .

Gunman by police shot .

NN IN NN VBD

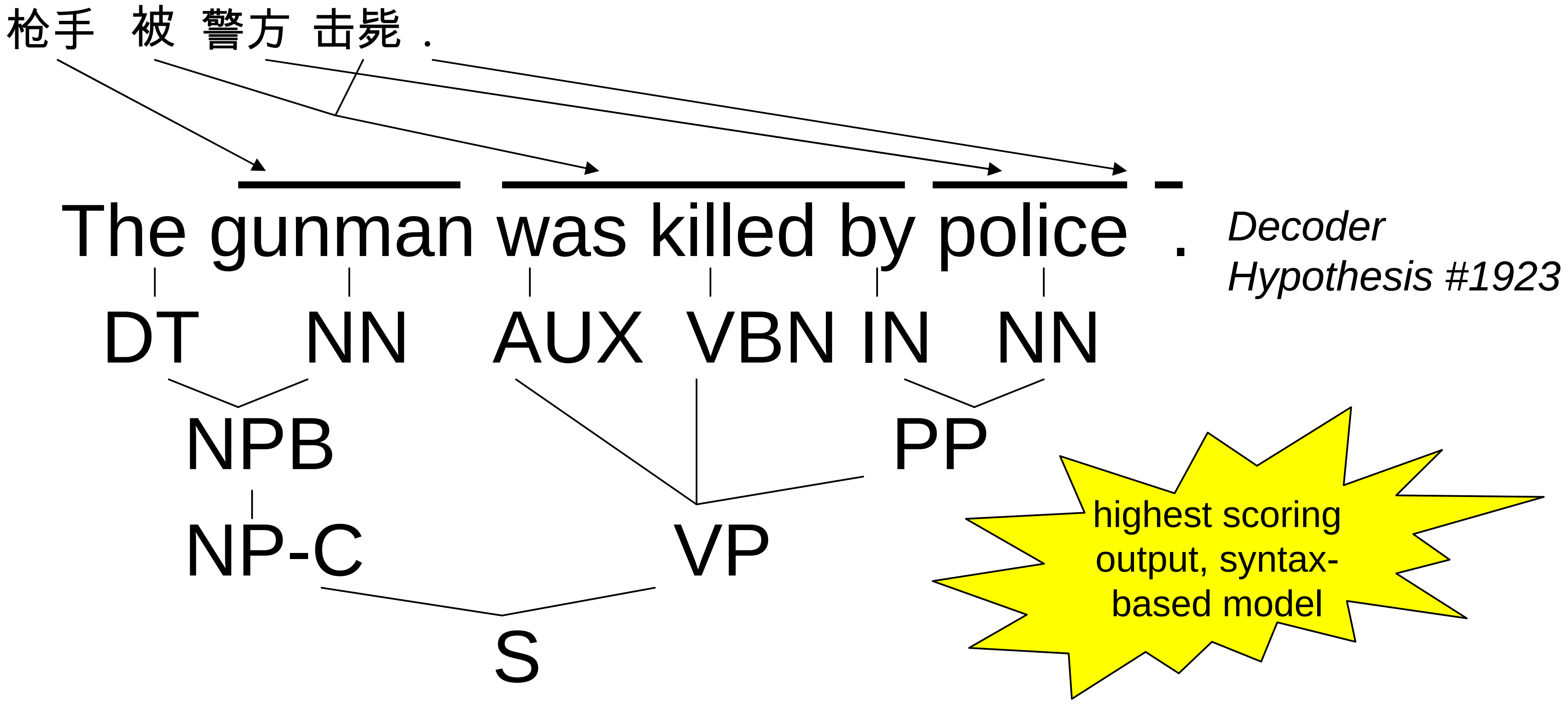
NPB PP

NP-C VP

S

Decoder
Hypothesis #16

Syntax-Based Output



枪手 被 警方 击毙 .

The gunman was killed by police .

DT NN AUX VBN IN NN

NPB PP

NP-C VP

S

Decoder Hypothesis #1923

highest scoring output, syntax-based model

Syntax-Based Output

- Better modeling of target language structure
  - Always a verb
  - Verb is always in the right place
- Better handling of function words
  - They often don’t translate
  - They control translation
- Better generalization in translation patterns