Computer Aided Translation

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Why Machine Translation?

Assimilation — reader initiates translation, wants to know content

- user is tolerant of inferior quality
- focus of majority of research (GALE program, etc.)

Communication — participants don't speak same language, rely on translation

- users can ask questions, when something is unclear
- chat room translations, hand-held devices
- often combined with speech recognition, IWSLT campaign

Dissemination — publisher wants to make content available in other languages

- high demands for quality
- currently almost exclusively done by human translators

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Goal: Helping Human Translators

If you can't beat them, join them.

- How can machine translation help human translators?
- First question: What do translators do?

Overview

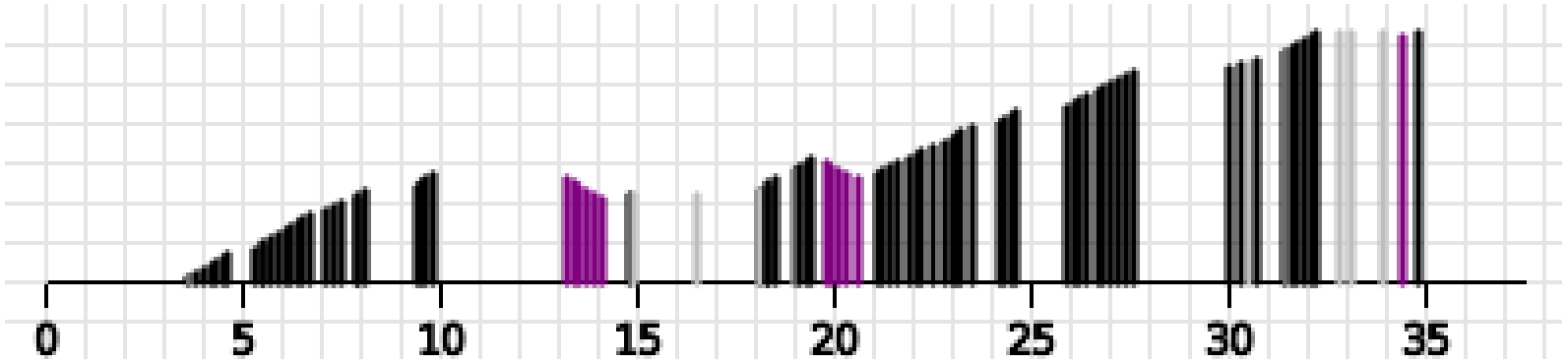
- **Human Translation**
- Assistance to Human Translators
- User Study
- Assistance to Monolingual Translators
- Integration of Translation Memory and MT

Setup

- 10 students at the University of Edinburgh
  - half native French speakers
  - half native English speakers with advanced French
- Each student translated
  - news stories
  - French-English
  - about 40 sentences
  - easy task: familiar content, no specialized terminology
- Keystroke log

Keystroke Log

Input: Au premier semestre, l'avionneur a livr 97 avions.
Output: The manufacturer has delivered 97 planes during the first half.



(37.5 sec, 3.4 sec/word)

black: keystroke, purple: deletion, grey: cursor move
height: length of sentence

Analysis

- We can observe
  - slow typing
  - fast typing
  - pauses
- Pauses
  - beginning pause: reading the input sentence
  - final pause: reviewing the translation
  - short pauses (2-6 seconds): hesitation
  - medium pauses (6-60 seconds): problem solving
  - big pauses (>60 seconds): serious problem

Time Spent on Activities

User	total	Pauses					keystroke
		initial	final	short	medium	big	
L1a	3.3s	0.1s	0.1s	0.2s	1.0s	0.1s	1.8s
L1b	7.7s	1.3s	0.1s	0.3s	1.8s	1.9s	2.3s
L1c	3.9s	0.2s	0.2s	0.3s	0.7s	-	2.5s
L1d	2.8s	0.2s	0.0s	0.2s	0.4s	0.1s	1.8s
L1e	5.2s	0.3s	0.0s	0.3s	1.9s	0.5s	2.2s
L2a	5.7s	0.5s	0.1s	0.3s	1.8s	0.7s	2.2s
L2b	3.2s	0.1s	0.1s	0.2s	0.4s	0.1s	2.2s
L2c	5.8s	0.3s	0.2s	0.5s	1.5s	0.3s	3.1s
L2d	3.4s	0.7s	0.1s	0.3s	0.6s	-	1.8s
L2e	2.8s	0.3s	0.2s	0.2s	0.3s	0.1s	1.9s

L1 = native French, L2 = native English

average time per input word

Time Spent on Activities

not much time

User	total	Pauses					keystroke
		initial	final	short	medium	big	
L1a	3.3s	0.1s	0.1s	0.2s	1.0s	0.1s	1.8s
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L1d	2.8s	0.2s	0.0s	0.2s	0.4s	0.1s	1.8s
L1e	5.2s	0.3s	0.0s	0.3s	1.9s	0.5s	2.2s
L2a	5.7s	0.5s	0.1s	0.3s	1.8s	0.7s	2.2s
L2b	3.2s	0.1s	0.1s	0.2s	0.4s	0.1s	2.2s
L2c	5.8s	0.3s	0.2s	0.5s	1.5s	0.3s	3.1s
L2d	3.4s	0.7s	0.1s	0.3s	0.6s	-	1.8s
L2e	2.8s	0.3s	0.2s	0.2s	0.3s	0.1s	1.9s

L1 = native French, L2 = native English

average time per input word

Time Spent on Activities

not much time

similar

User	total	initial	final	Pauses short	medium	big	keystroke
L1a	3.3s	0.1s	0.1s	0.2s	1.0s	0.1s	1.8s
L1b	7.7s	1.3s	0.1s	0.3s	1.8s	1.9s	2.3s
L1c	3.9s	0.2s	0.2s	0.3s	0.7s	-	2.5s
L1d	2.8s	0.2s	0.0s	0.2s	0.4s	0.1s	1.8s
L1e	5.2s	0.3s	0.0s	0.3s	1.9s	0.5s	2.2s
L2a	5.7s	0.5s	0.1s	0.3s	1.8s	0.7s	2.2s
L2b	3.2s	0.1s	0.1s	0.2s	0.4s	0.1s	2.2s
L2c	5.8s	0.3s	0.2s	0.5s	1.5s	0.3s	3.1s
L2d	3.4s	0.7s	0.1s	0.3s	0.6s	-	1.8s
L2e	2.8s	0.3s	0.2s	0.2s	0.3s	0.1s	1.9s

L1 = native French, L2 = native English

average time per input word

Time Spent on Activities

		not much time		Pauses	differences		similar
User	total	initial	final	short	medium	big	keystroke
L1a	3.3s	0.1s	0.1s	0.2s	1.0s	0.1s	1.8s
L1b	7.7s	1.3s	0.1s	0.3s	1.8s	1.9s	2.3s
L1c	3.9s	0.2s	0.2s	0.3s	0.7s	-	2.5s
L1d	2.8s	0.2s	0.0s	0.2s	0.4s	0.1s	1.8s
L1e	5.2s	0.3s	0.0s	0.3s	1.9s	0.5s	2.2s
L2a	5.7s	0.5s	0.1s	0.3s	1.8s	0.7s	2.2s
L2b	3.2s	0.1s	0.1s	0.2s	0.4s	0.1s	2.2s
L2c	5.8s	0.3s	0.2s	0.5s	1.5s	0.3s	3.1s
L2d	3.4s	0.7s	0.1s	0.3s	0.6s	-	1.8s
L2e	2.8s	0.3s	0.2s	0.2s	0.3s	0.1s	1.9s

L1 = native French, L2 = native English

average time per input word

Pauses Reconsidered

- Our classification of pauses is arbitrary (2-6sec, 6-60sec, >60sec)

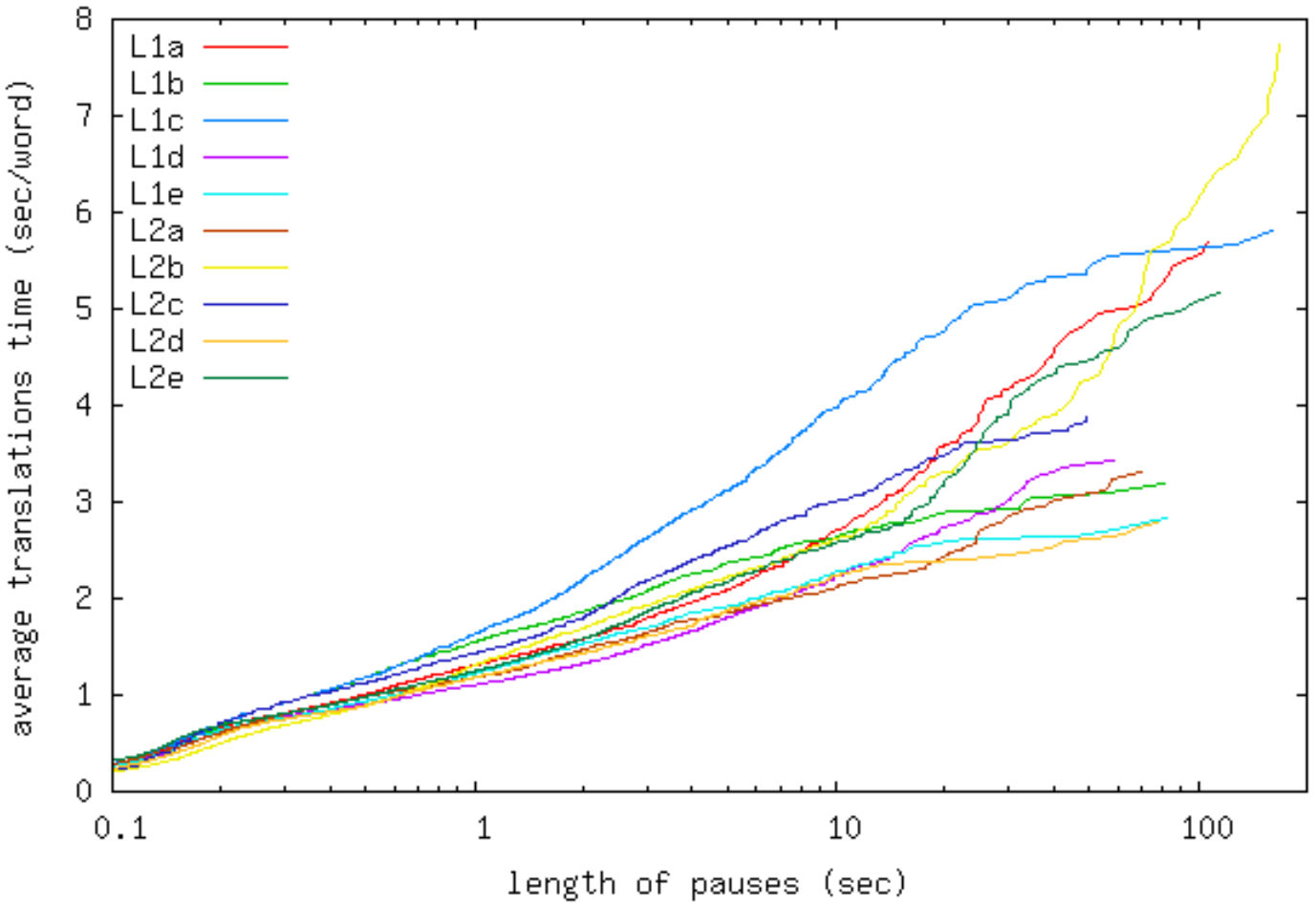
- Extreme view: all you see is pauses
  - keystrokes take no observable time
  - all you see is pauses between action points

- Visualizing range of pauses:

  time t spent in pauses $p \in P$ up to a certain length l

$$sum(t) = \frac{1}{Z} \sum_{p \in P, l(p) \leq t} l(p)$$

Results


L1a
L1b
L1c
L1d
L1e
L2a
L2b
L2c
L2d
L2e
average translations time (sec/word)
length of pauses (sec)
0
1
2
3
4
5
6
7
8
0.1
1
10
100

Overview

- Human Translation
- **Assistance to Human Translators**
- User Study
- Assistance to Monolingual Translators
- Integration of Translation Memory and MT

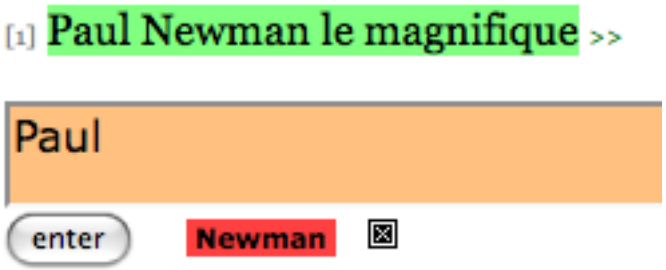
Our Types of Assistance

- Sentence completion
  - tool suggests how to complete the translation
  - one phrase at a time
- Translation options
  - most likely translations for each word and phrase
  - ordered and color-highlighted by probability
- Postediting machine translation
  - start with machine translation output
  - user edits, tool shows changes

Technical Notes

- Online at `http://www.caitra.org/`
- User uploads source text, translates one sentence at a time
- Implementation
  - AJAX Web 2.0 using Ruby on Rails, mySQL
  - Back end: Moses machine translation system

Predicting Sentence Completion



- Tool makes a suggestion how to continue (in red)
- User can accept it (by pressing TAB), or type in her own translation
- Same idea as TransType, with minor modifications
  - show only short text chunks, not full sentence completion
  - show only one suggestion, not alternatives

How does it work?

- Uses search graph of SMT decoding

- Matches partial user translation against search graph, by optimizing

  1. minimal string edit distance between path in graph and user translation
  2. best full path probability, including best completion to end

- Technical notes

  – search graph is pre-computed and stored in database
  – matching is done server-side, typically takes less than 1 second
  – completion path is returned to client (web brower)

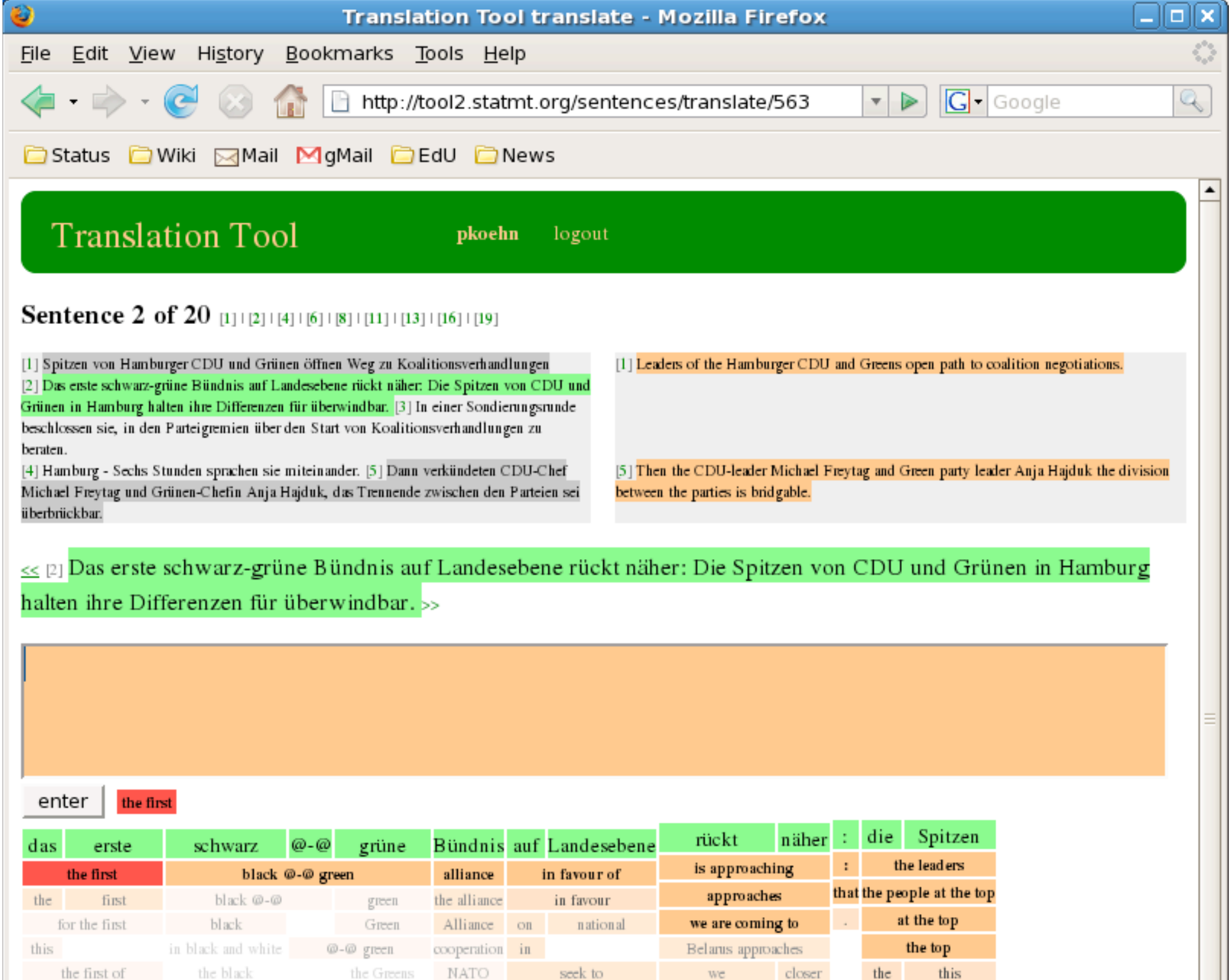
Translation Options

Paul	Newman	le	magnifique
Paul	**Newman**	**the**	**wonderful**
Mr	Newman ,	**the magnificent**	
Mr Paul	Newman here	the wonderful	
as Paul	Committee		beautiful
another	Newman , who speaks		magnificent
with Paul		the splendid	
, Paul		the excellent	
of Paul		the beautiful	
work of Paul			It
the words of Paul			great

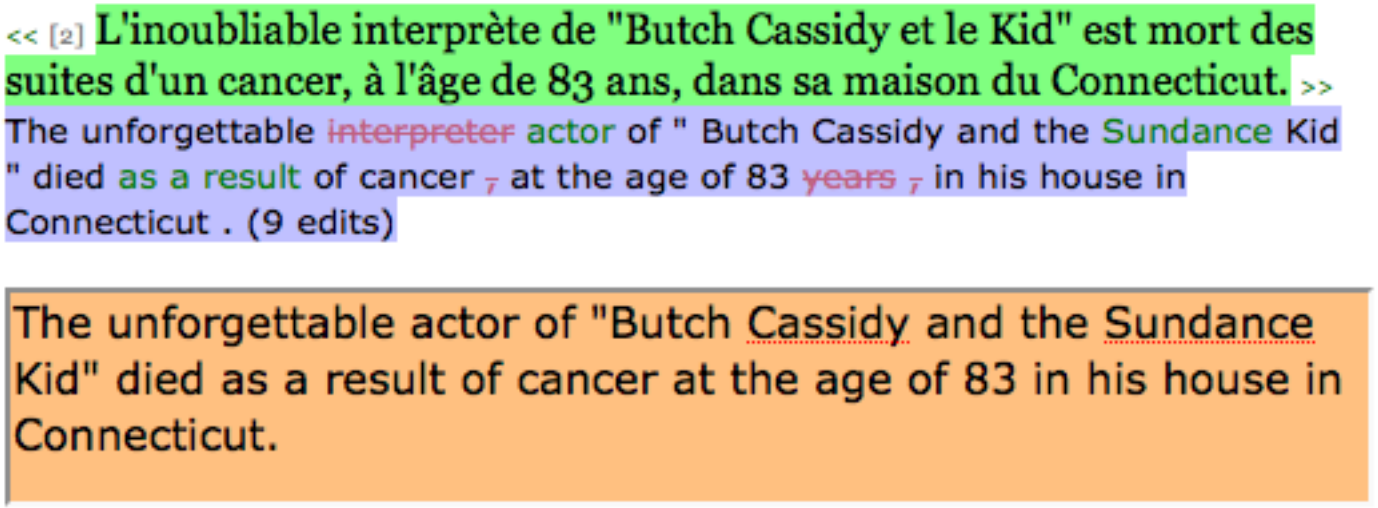
- For each word and phrases: suggested translations
- Ranked (and color-highlighted) by probability
- User may click on suggestion → appended to text box

Translation Options - How does it work?

- Uses phrase translation table of SMT system
- Translation score: future cost estimate
  - conditional probabilities $\phi(\bar{e}|\bar{f})$, $\phi(\bar{f}|\bar{e})$
  - lexical probabilities lex$(\bar{e}|\bar{f})$, lex$(\bar{f}|\bar{e})$
  - word count feature
  - language model estimate
- Ranking of shorter vs. longer phrases by including outside future cost estimate


Translation Tool translate - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://tool2.statmt.org/sentences/translate/563
Google
Status Wiki Mail gMail EdU News
Translation Tool
pkoehn logout
Sentence 2 of 20 [1] | [2] | [4] | [6] | [8] | [11] | [13] | [16] | [19]
[1] Spitzen von Hamburger CDU und Grünen öffnen Weg zu Koalitionsverhandlungen
[2] Das erste schwarz-grüne Bündnis auf Landesebene rückt näher: Die Spitzen von CDU und Grünen in Hamburg halten ihre Differenzen für überwindbar. [3] In einer Sondierungsrunde beschlossen sie, in den Parteigremien über den Start von Koalitionsverhandlungen zu beraten.
[4] Hamburg - Sechs Stunden sprachen sie miteinander. [5] Dann verkündeten CDU-Chef Michael Freytag und Grünen-Chefin Anja Hajduk, das Trennende zwischen den Parteien sei überbrückbar.
[1] Leaders of the Hamburger CDU and Greens open path to coalition negotiations.
[5] Then the CDU-leader Michael Freytag and Green party leader Anja Hajduk the division between the parties is bridgable.
<< [2] Das erste schwarz-grüne Bündnis auf Landesebene rückt näher: Die Spitzen von CDU und Grünen in Hamburg halten ihre Differenzen für überwindbar. >>
enter
the first
das erste schwarz @-@ grüne Bündnis auf Landesebene rückt näher : die Spitzen
the first black @-@ green alliance in favour of is approaching : the leaders
the first black @-@ green the alliance in favour approaches that the people at the top
for the first black Green Alliance on national we are coming to . at the top
this in black and white @-@ green cooperation in Belarus approaches the top
the first of the black the Greens NATO seek to we closer the this

Postediting Machine Translation



- Textbox is initially filled with machine translation
- User edits translation
- String edit distance to machine translation is shown (blue background)

Overview

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Evaluation

- Recall setup
  - 10 students, half native French, half native English
  - each student translated French-English news stories
  - about 40 sentences for each condition of assistance

- Five different conditions
  - unassisted
  - prediction (sentence completion)
  - options
  - predictions and options
  - post-editing

Quality

- We want faster translators, but not worse

- Assessment of translation quality
  - show translations to bilingual judges, with source
  - judgment: fully correct? yes/no

    > Indicate whether each user's input represents a fully fluent and meaning-equivalent translation of the source. The source is shown with context, the actual sentence is bold.

- Average score: 50% correct — lower than expected
  - judges seemed to be too harsh
  - when given several translations, tendency to judge half as bad

Example of Quality Judgments

Src.	Sans se démonter, il s'est montré concis et précis.	
MT	Without dismantle, it has been concise and accurate.	
1/3	Without fail, he has been concise and accurate.	*(Prediction+Options, L2a)*
4/0	Without getting flustered, he showed himself to be concise and precise.	*(Unassisted, L2b)*
4/0	Without falling apart, he has shown himself to be concise and accurate.	*(Postedit, L2c)*
1/3	Unswayable, he has shown himself to be concise and to the point.	*(Options, L2d)*
0/4	Without showing off, he showed himself to be concise and precise.	*(Prediction, L2e)*
1/3	Without dismantling himself, he presented himself consistent and precise.	*(Prediction+Options, L1a)*
2/2	He showed himself concise and precise.	*(Unassisted, L1b)*
3/1	Nothing daunted, he has been concise and accurate.	*(Postedit, L1c)*
3/1	Without losing face, he remained focused and specific.	*(Options, L1d)*
3/1	Without becoming flustered, he showed himself concise and precise.	*(Prediction, L1e)*

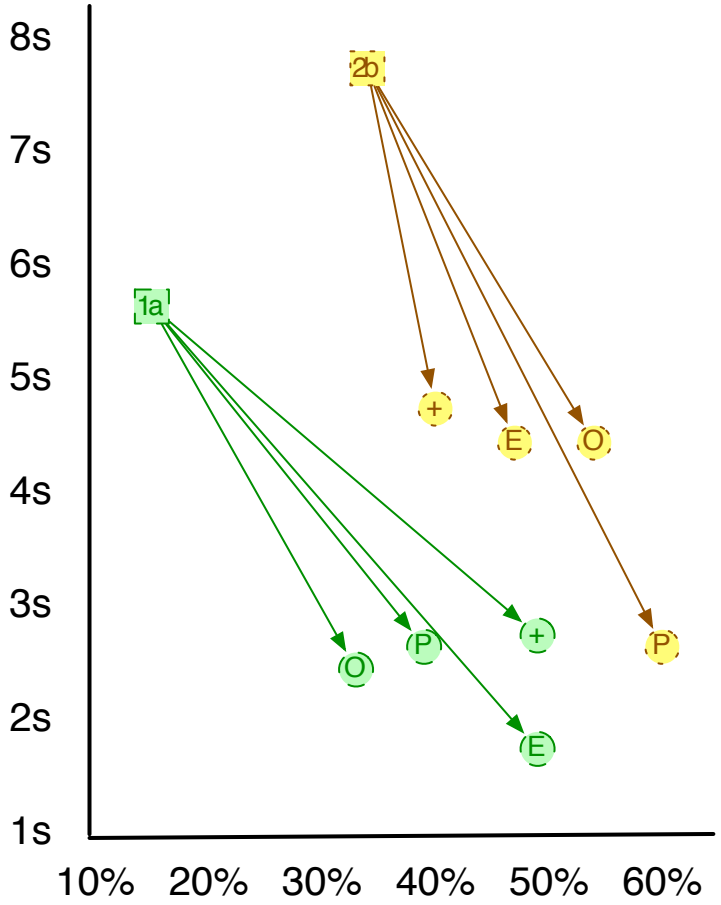
Faster and Better

Assistance	**Speed**	**Quality**
Unassisted	4.4s/word	47% correct
Postedit	2.7s (-1.7s)	55% (+8%)
Options	3.7s (-0.7s)	51% (+4%)
Prediction	3.2s (-1.2s)	54% (+7%)
Prediction+Options	3.3s (-1.1s)	53% (+6%)

Faster and Better, Mostly

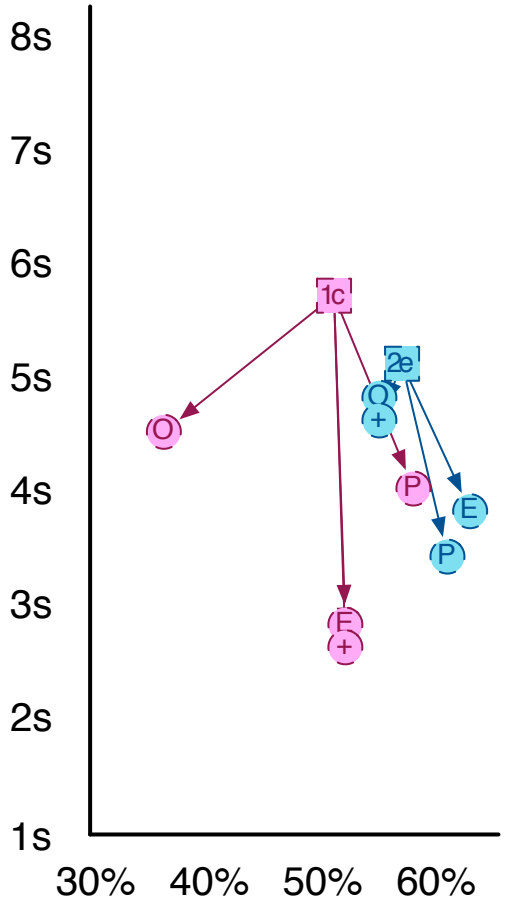
User	Unassisted	Postedit		Options		Prediction		Prediction+Options	
L1a	3.3sec/word 23% correct	**1.2s** **39%**	**-2.2s** **+16%)**	**2.3s** **45%**	**-1.0s** **+22%**	**1.1s** **30%**	**-2.2s** **+7%)**	**2.4s** **44%**	**-0.9s** **+21%**
L1b	7.7sec/word 35% correct	**4.5s** **48%**	**-3.2s)** **+13%**	**4.5s** **55%**	**-3.3s** **+20%**	**2.7s** **61%**	**-5.1s** **+26%**	**4.8s** **41%**	**-3.0s** **+6%**
L1c	3.9sec/word 50% correct	**1.9s** **61%**	**-2.0s** **+11%**	**3.8s** **54%**	**-0.1s** **+4%**	**3.1s** **64%**	**-0.8s** **+14%**	**2.5s** **61%**	**-1.4s** **+11%**
L1d	2.8sec/word 38% correct	**2.0s** **46%**	**-0.7s** **+8%**	2.9s 59%	(+0.1s) (+21%)	2.4s 37%	(-0.4s) (-1%)	**1.8s** **45%**	**-1.0s** **+7%**
L1e	5.2sec/word 58% correct	**3.9s** **64%**	**-1.3s** **+6%**	4.9s 56%	(-0.2s) (-2%)	**3.5s** **62%**	**-1.7s** **+4%**	4.6s 56%	(-0.5s) (-2%)
L2a	5.7sec/word 16% correct	**1.8s** **50%**	**-3.9s** **+34%**	**2.5s** **34%**	**-3.2s** **+18%**	**2.7s** **40%**	**-3.0s** **+24%**	**2.8s** **50%**	**-2.9s** **+34%**
L2b	3.2sec/word 64% correct	2.8s 56%	(-0.4s) (-8%)	*3.5s* *60%*	*+0.3s* *-4%*	*6.0s* *61%*	*+2.8s* *-3%*	*4.6s* *57%*	*+1.4s* *-7%*
L2c	5.8sec/word 52% correct	**2.9s** **53%**	**-3.0s** **+1%**	4.6s 37%	(-1.2s) (-15%)	**4.1s** **59%**	**-1.7s** **+7%**	**2.7s** **53%**	**-3.1s** **+1%**
L2d	3.4sec/word 49% correct	3.1s 49%	(-0.3s) (+0%)	4.3s 51%	(+0.9s) (+2%)	3.8s 53%	(+0.4s) (+4%)	3.7s 58%	(+0.3s) (+9%)
L2e	2.8sec/word 68% correct	**2.6s** **79%**	**-0.2s** **+11%**	*3.5s* *59%*	*+0.7s* *-9%*	2.8s 64%	(-0.0s) (-4%)	*3.0s* *66%*	*+0.2s* *-2%*
avg.	4.4sec/word 47% correct	**2.7s** **55%**	**-1.7s** **+8%**	**3.7s** **51%**	**-0.7s** **+4%**	**3.2s** **54%**	**-1.2s** **+7%**	**3.3s** **53%**	**-1.1s** **+6%**

Slow Users 1: Faster and Better



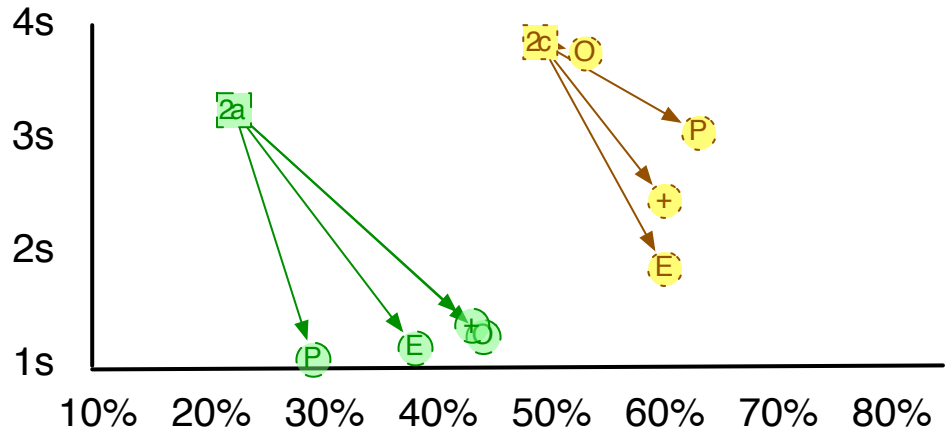
- Unassisted
  - more than 5 seconds per input word
  - very bad (35%, 16%)
- With assistance
  - much faster and better
  - reaching roughly average performance

Slow Users 2: Only Faster



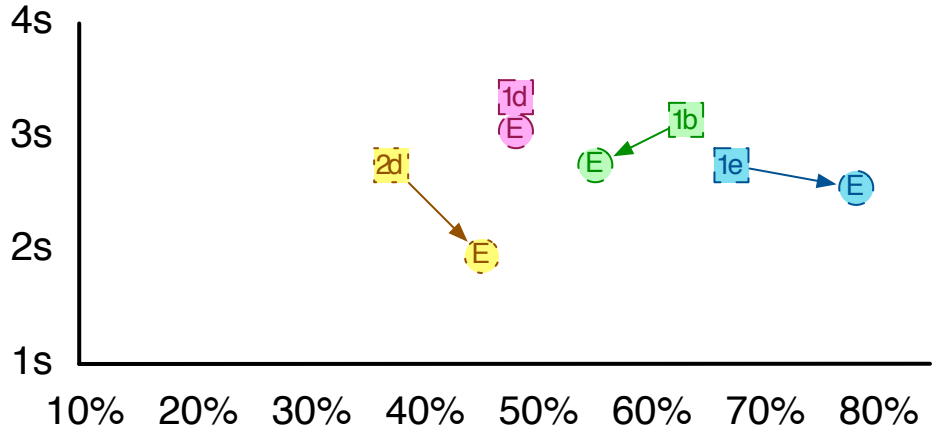
- Unassisted
  - more than 5 seconds per input word
  - average quality
- With assistance
  - faster and but not better

Fast Users



- Unassisted
  - fast: 3-4 seconds per input word
  - L1a is very bad (23%), L1c is average (50%)
- With assistance
  - faster and better
  - L1a closer to average (30-45%), L1c becomes very good (54-61%)

Refuseniks

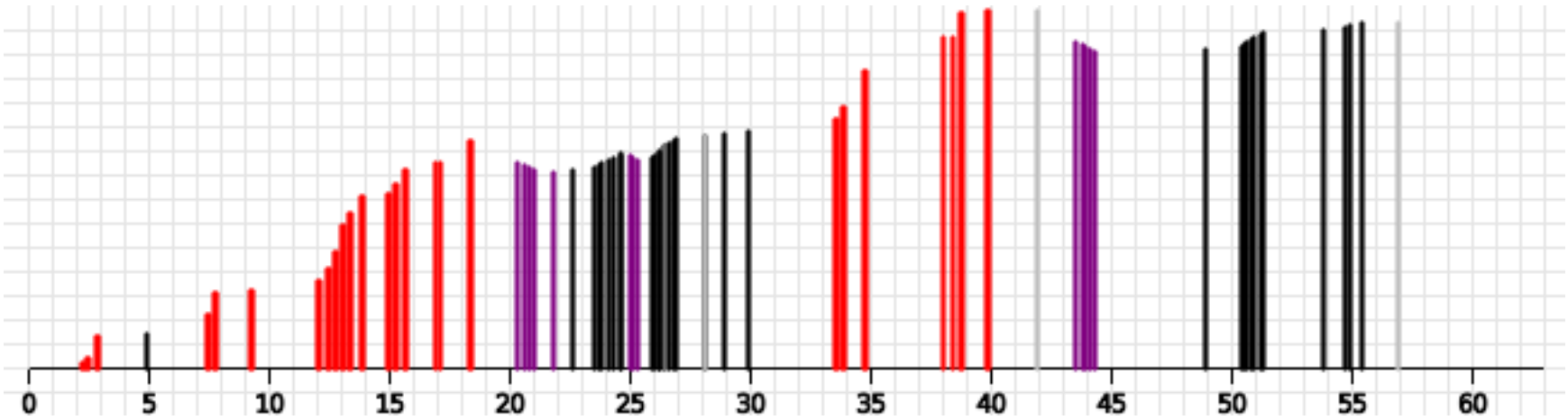


- Use the assistance sparingly or not at all, and see generally no gains
- The two best translators are in this group
- Postediting
  - mixed on quality (2 better, 1 worse, 1 same), but all faster
  - best translator (L2e, 68%) becomes much better (record 79%)

Further Analysis

- How does the assistance change translator behaviour?
- How do translators utilize assistance?
- How is the translation produced?

Keystroke Log



black: keystroke, purple: deletion, grey: cursor move

red: sentence completion accept

orange: click on translation option

Analysis: Segment into periods of activity: typing, tabbing, clicking, pauses

one second before and after a keystroke is part of typing interval

Activities: Native French User L1b

User: L1b	total	init-p	end-p	short-p	mid-p	big-p	key	click	tab
Unassisted	7.7s	1.3s	0.1s	0.3s	1.8s	1.9s	2.3s	-	-
Postedit	4.5s	1.5s	0.4s	0.1s	1.0s	0.4s	1.1s	-	-
Options	4.5s	0.6s	0.1s	0.4s	0.9s	0.7s	1.5s	0.4s	-
Prediction	2.7s	0.3s	0.3s	0.2s	0.7s	0.1s	0.6s	-	0.4s
Prediction+Options	4.8s	0.6s	0.4s	0.4s	1.3s	0.5s	0.9s	0.5s	0.2s

Activities: Native French User L1b

User: L1b	total	init-p	end-p	short-p	mid-p	big-p	key	click	tab
Unassisted	7.7s	1.3s	0.1s	0.3s	1.8s	1.9s	2.3s	-	-
Postedit	4.5s	1.5s	0.4s	0.1s	1.0s	0.4s	1.1s	-	-
Options	4.5s	0.6s	0.1s	0.4s	0.9s	0.7s	1.5s	0.4s	-
Prediction	2.7s	0.3s	0.3s	0.2s	0.7s	0.1s	0.6s	-	0.4s
Prediction+Options	4.8s	0.6s	0.4s	0.4s	1.3s	0.5s	0.9s	0.5s	0.2s

Slighly less time spent on typing

Activities: Native French User L1b

User: L1b	total	init-p	end-p	short-p	mid-p	big-p	key	click	tab
Unassisted	7.7s	1.3s	0.1s	0.3s	1.8s	1.9s	2.3s	-	-
Postedit	4.5s	1.5s	0.4s	0.1s	1.0s	0.4s	1.1s	-	-
Options	4.5s	0.6s	0.1s	0.4s	0.9s	0.7s	1.5s	0.4s	-
Prediction	2.7s	0.3s	0.3s	0.2s	0.7s	0.1s	0.6s	-	0.4s
Prediction+Options	4.8s	0.6s	0.4s	0.4s	1.3s	0.5s	0.9s	0.5s	0.2s

Less pausing

Slighly less time spent on typing

Activities: Native French User L1b

User: L1b	total	init-p	end-p	short-p	mid-p	big-p	key	click	tab
Unassisted	7.7s	1.3s	0.1s	0.3s	1.8s	1.9s	2.3s	-	-
Postedit	4.5s	1.5s	0.4s	0.1s	1.0s	0.4s	1.1s	-	-
Options	4.5s	0.6s	0.1s	0.4s	0.9s	0.7s	1.5s	0.4s	-
Prediction	2.7s	0.3s	0.3s	0.2s	0.7s	0.1s	0.6s	-	0.4s
Prediction+Options	4.8s	0.6s	0.4s	0.4s	1.3s	0.5s	0.9s	0.5s	0.2s

Less pausing

Especially less time in big pauses

Slighly less time spent on typing

Activities: Native English User L2e

User: L2e	total	init-p	end-p	short-p	mid-p	big-p	key	click	tab
Unassisted	2.8s	0.3s	0.2s	0.2s	0.3s	0.1s	1.9s	-	-
Postedit	2.6s	0.4s	0.3s	0.2s	1.0s	0.1s	0.7s	-	-
Options	3.5s	0.1s	0.3s	0.4s	0.6s	0.2s	1.7s	0.1s	-
Prediction	2.8s	0.1s	0.3s	0.3s	0.3s	-	1.4s	-	0.3s
Prediction+Options	3.0s	0.1s	0.3s	0.2s	0.5s	-	1.9s	-	-

Activities: Native English User L2e

User: L2e	total	init-p	end-p	short-p	mid-p	big-p	key	click	tab
Unassisted	2.8s	0.3s	0.2s	0.2s	0.3s	0.1s	1.9s	-	-
Postedit	2.6s	0.4s	0.3s	0.2s	1.0s	0.1s	0.7s	-	-
Options	3.5s	0.1s	0.3s	0.4s	0.6s	0.2s	1.7s	0.1s	-
Prediction	2.8s	0.1s	0.3s	0.3s	0.3s	-	1.4s	-	0.3s
Prediction+Options	3.0s	0.1s	0.3s	0.2s	0.5s	-	1.9s	-	-

Little time spent on assistance

Activities: Native English User L2e

User: L2e	total	init-p	end-p	short-p	mid-p	big-p	key	click	tab
Unassisted	2.8s	0.3s	0.2s	0.2s	0.3s	0.1s	1.9s	-	-
Postedit	2.6s	0.4s	0.3s	0.2s	1.0s	0.1s	0.7s	-	-
Options	3.5s	0.1s	0.3s	0.4s	0.6s	0.2s	1.7s	0.1s	-
Prediction	2.8s	0.1s	0.3s	0.3s	0.3s	-	1.4s	-	0.3s
Prediction+Options	3.0s	0.1s	0.3s	0.2s	0.5s	-	1.9s	-	-

Does not use both assistances, little overall change

Little time spent on assistance

Activities: Native English User L2e

User: L2e	total	init-p	end-p	short-p	mid-p	big-p	key	click	tab
Unassisted	2.8s	0.3s	0.2s	0.2s	0.3s	0.1s	1.9s	-	-
Postedit	2.6s	0.4s	0.3s	0.2s	1.0s	0.1s	0.7s	-	-
Options	3.5s	0.1s	0.3s	0.4s	0.6s	0.2s	1.7s	0.1s	-
Prediction	2.8s	0.1s	0.3s	0.3s	0.3s	-	1.4s	-	0.3s
Prediction+Options	3.0s	0.1s	0.3s	0.2s	0.5s	-	1.9s	-	-

Does not use both assistances, little overall change

Postediting: less typing (-1.2s) more medium pauses (+0.7s)

Little time spent on assistance

Origin of Characters: Native French L1b

User: L1b	key	click	tab	mt
Postedit	18%	-	-	81%
Options	59%	40%	-	-
Prediction	14%	-	85%	-
Prediction+Options	21%	44%	33%	-

Origin of Characters: Native French L1b

User: L1b	key	click	tab	mt
Postedit	18%	-	-	81%
Options	59%	40%	-	-
Prediction	14%	-	85%	-
Prediction+Options	21%	44%	33%	-

Translation comes to large degree from assistance

Origin of Characters: Native English L2e

User: L2e	key	click	tab	mt
Postedit	20%	-	-	79%
Options	77%	22%	-	-
Prediction	61%	-	38%	-
Prediction+Options	100%	-	-	-

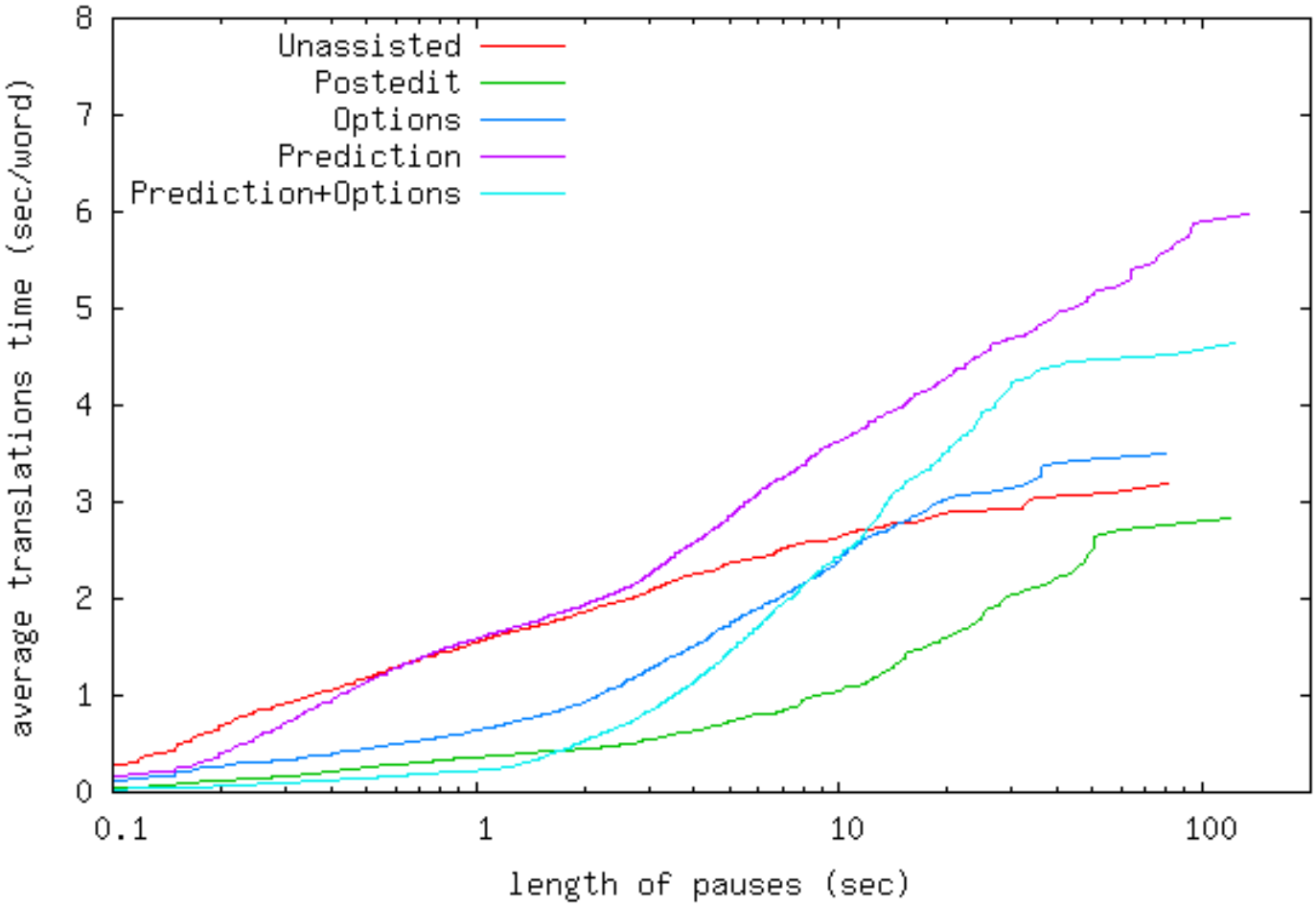
Origin of Characters: Native English L2e

User: L2e	key	click	tab	mt
Postedit	20%	-	-	79%
Options	77%	22%	-	-
Prediction	61%	-	38%	-
Prediction+Options	100%	-	-	-

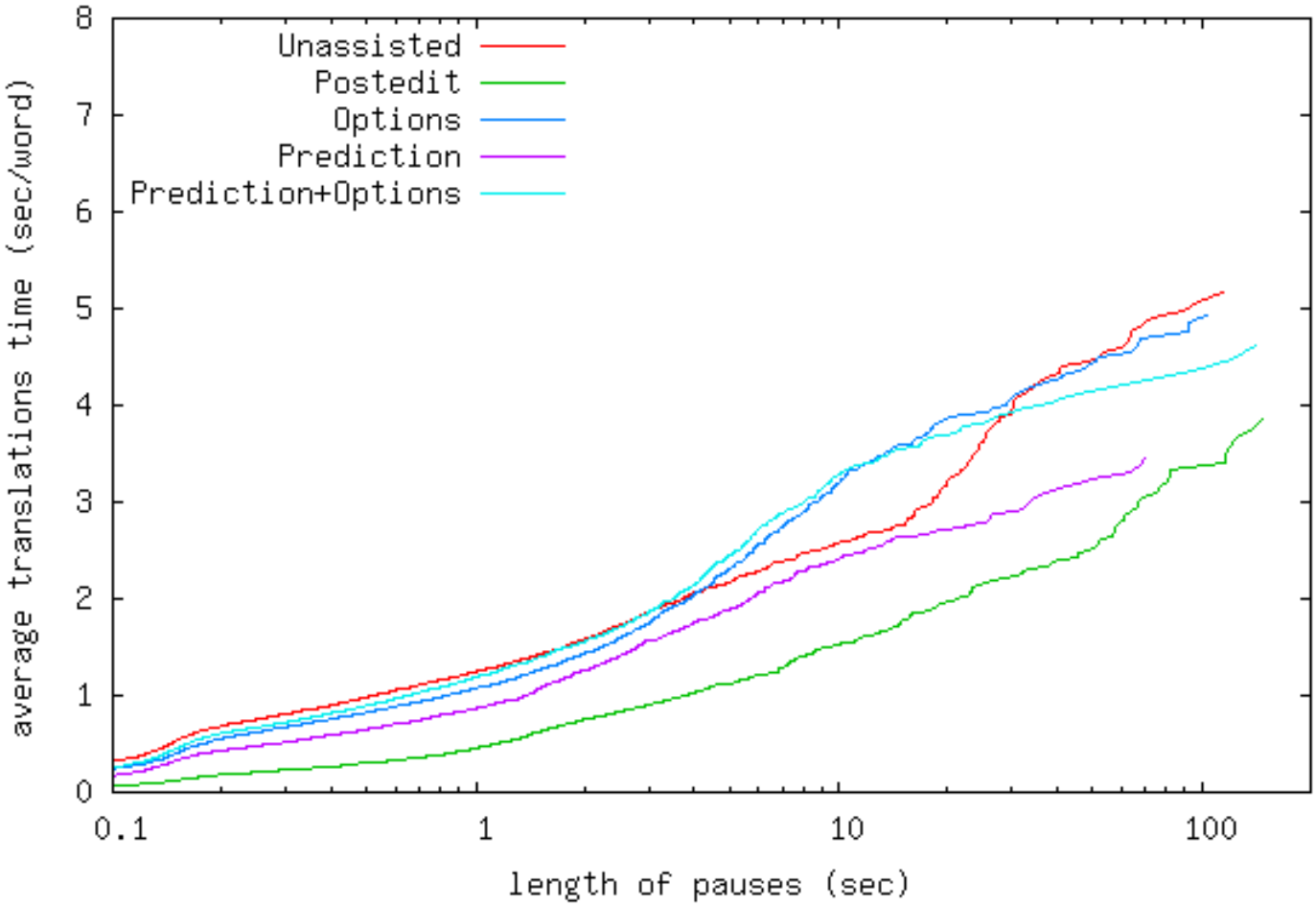
Although hardly any time spent on assistance,

fair amount of characters produced by it

Pauses: French-Native User L1b

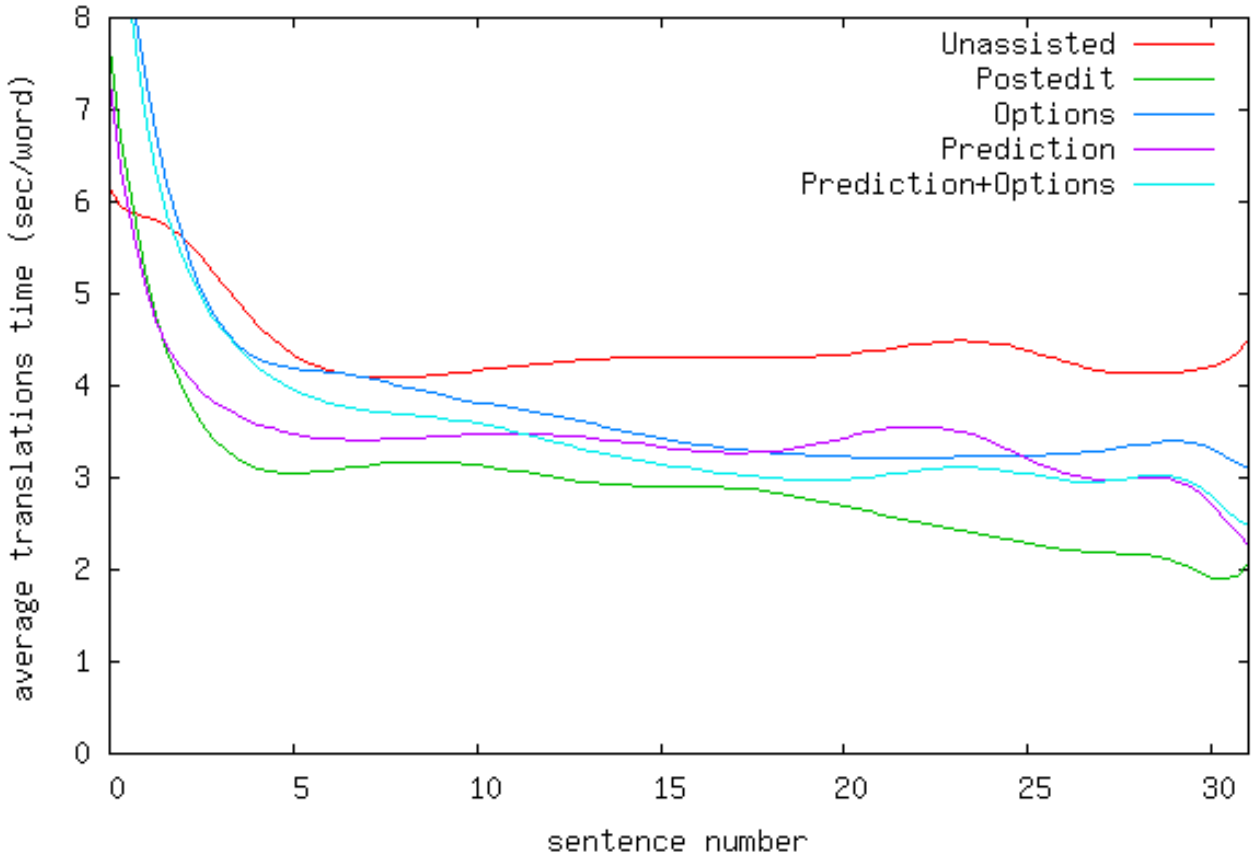


Pauses: English-Native User L2e



Learning Curve

users become better over time with assistance



User Feedback

- Q: In which of the five conditions did you think you were most accurate?
  - predictions+options: 5 users
  - options: 2 users
  - prediction: 1 user
  - postediting: 1 user
- Q: Rank the different types of assistance on a scale from 1 to 5, where1 indicates not at all and 5 indicates very helpful.
  - prediction+options: 4.6
  - prediction: 3.9
  - options: 3.7
  - postediting: 2.9

User Feedback

- Q: In which of the five conditions did you think you were most accurate?
  - predictions+options: 5 users
  - options: 2 users
  - prediction: 1 user
  - postediting: 1 user
- Q: Rank the different types of assistance on a scale from 1 to 5, where1 indicates not at all and 5 indicates very helpful.
  - prediction+options: 4.6
  - prediction: 3.9
  - options: 3.7
  - postediting: 2.9
- **Note:** does not match empirical results

Summary

- Assistance made translators faster
  - average speed improvement from 4.4s/word to 2.7-3.7s/word
  - reduction of big pauses
  - reduction of typing effort in post-editing
- Assistance made translators better
  - average judgment increased from 47% to 51-55% with help
  - even good translators get better with postediting
- Some good translators ignored the assistance
- Fastest and (barely) best with postediting, but did not like it

Outlook: More analysis

- What do translators think about when they are pausing?
- What are the hard problems?
  - unknown words
  - words without direct translation
  - syntactic re-arrangement
- What do translators change in post-editing?

⇒ We will investigate this in a new EU project

Related Work: Tools used by Translators

- Translators often use standard text editors and additional tools
- Bilingual dictionary
- Spell checker, grammar checker
- Monolingual concordancer
- Terminology database
- Web search to establish and verify meaning of terms

Bilingual Concordancer

Examples	Windkraft (noun, feminine) (also: Windenergie)	wind power (noun)	
	Zum Vergleich: **Windkraft** schafft fast sieben Mal mehr. German: www.goethe.de/wis/umw/thm/ntr/de92305.htm	By way of comparison, **wind power** generates almost seven times as much. English: www.goethe.de/wis/umw/thm/ntr/en92305.htm	
	Einführung von Windcube, einer neuen Generation von Wind Lidar für **Windkraft.** German: www.husumwindenergy.com/index.php?L...howUid]=1177	Introducing Windcube, a new generation of **wind** Lidar for **wind power.** English: www.husumwindenergy.com/index.php?L...howUid]=1177	
	Windkraft ist eine etablierte, wettbewerbsfähige Technologie mit hoher Zuverlässigkeit German: www.powergeneration.siemens.de/abou...ns-services/	**Wind power** is an established, competitive technology with high reliability English: www.powergeneration.siemens.com/abo...ns-services/	
Examples	Windkraft (noun, feminine) (also: Windenergie)	wind energy (noun)	
	Je mehr aber klimapolitische Sonntagsreden von der Politik auch in Taten umgesetzt werden, desto höher steigt dieser Preis und desto wettbewerbsfähiger werden saubere Energien wie die **Windkraft.** German: emagazine.credit-suisse.com/app/art...4382 (=DE	But as the focus of the climate change issue shifts increasingly from policy to action, this price will increase and cleaner **energy** sources like **wind** will become more competitive. English: emagazine.credit-suisse.com/app/art...4382 (=en	
	Nur wenige befürchten hingegen, dass dies auch bei erneuerbaren Energieträgern wie Biomasse oder **Windkraft** der Fall sein wird. German: www.eu2006.gv.at/de/News/Press_Rele...1proell.html	However, only a few fear that this will also be the case with renewable **energy** sources such as biomass or **wind energy.** English: www.eu2006.gv.at/en/News/Press_Rele...1proell.html	

show translations in context (www.linguee.com)

Overview

- Human Translation
- Assistance to Human Translators
- User Study
- **Assistance to Monolingual Translators**
- Integration of Translation Memory and MT

Enabling Monolingual Translators

- Monolingual translator
  - wants to understand a foreign document
  - has no knowledge of foreign language
  - uses a machine translation system

- Questions
  - Is current MT output sufficient for understanding?
  - What else could be provided by a MT system?

Good Enough

- An MT system might produce this:

  The girl entered into room.

- We know what is meant:

  The girl entered the room.

- We understood.

Process

- MT system translates foreign story
- Person A edits it
  - goal: fluent translation
    that represents the meaning (as it was understood)
  - without access to reference translation
- Person B checks if edited sentences are correct
  - with access to reference translation

Example

- MT system translates foreign sentence

  The girl goes the room.

- Person A edits it

  The girl goes into the room.

- Reference

  The girl enters the room.

- Person B checks edited sentence: CORRECT

Real Example

- MT system output:

  The study also found that one of the genes in the improvement in people with prostate cancer risk, it also reduces the risk of suffering from diabetes.

- What does this mean?

- Monolingual translator:

  The research also found that one of the genes increased people's risk of prostate cancer, but at the same time lowered people's risk of diabetes.

- Document context helps

Experiment

- Language pairs
  - Arabic–English
  - Chinese–English
- Machine translation systems
  - Edinburgh's 2009 GALE systems
  - Moses system with all available parallel data
- Stories taken from NIST 2008 test sets

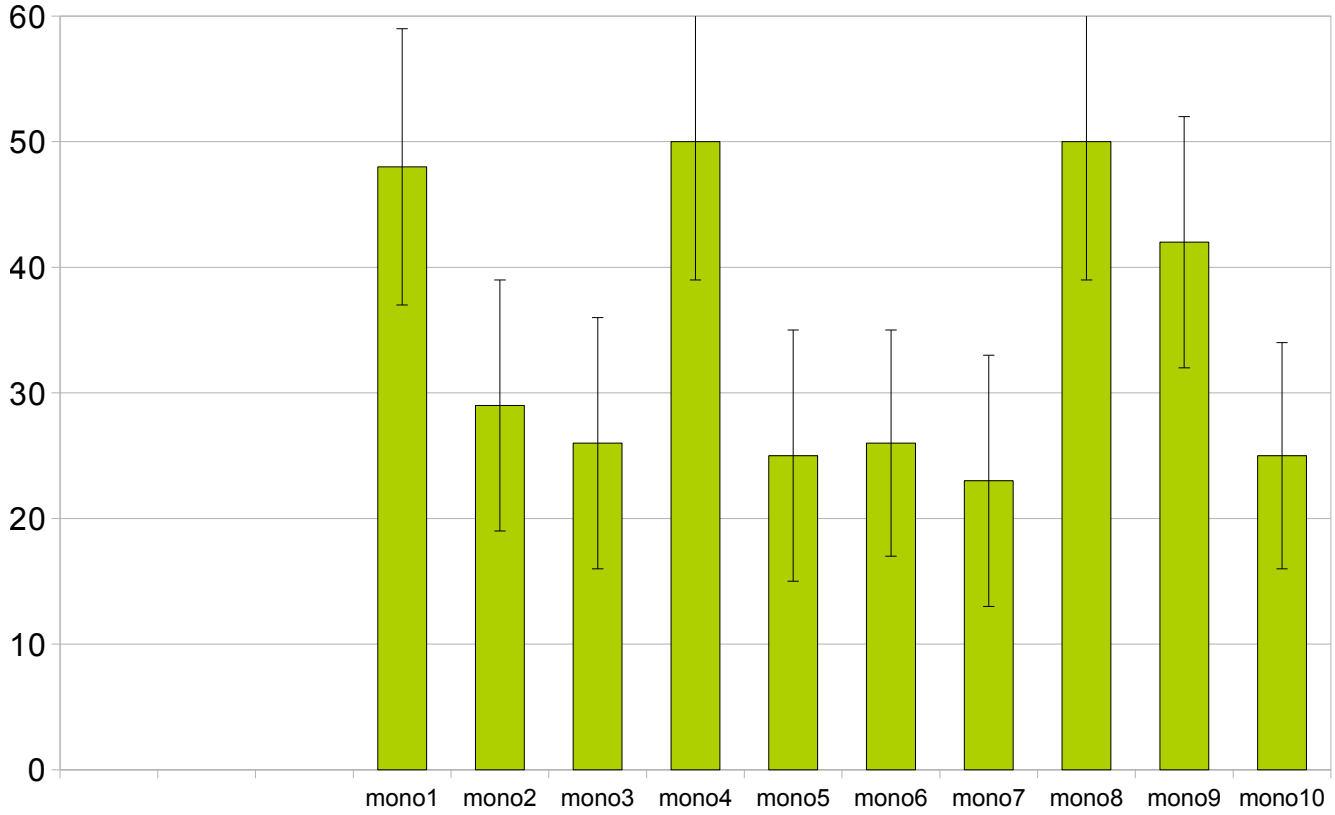
Stories

Story	Headline	Sent.	Words
1: chi	White House Pushes for Nuclear Inspectors to Be Sent as Soon as Possible to Monitor North Korea's Closure of Its Nuclear Reactors	6	207
2: chi	Torrential Rains Hit Western India, 43 People Dead	10	204
3: chi	Research Shows a Link between Arrhythmia and Two Forms of Genetic Variation	7	247
4: chi	Veteran US Goalkeeper Keller May Retire after America's Cup	10	367
5: ara	Britain: Arrests in Several Cities and Explosion of Suspicious Car	7	224
6: ara	Ban Ki-Moon Withdraws His Report on the Sahara after Controversy Surrounding Its Content	8	310
7: ara	Pakistani Opposition Leaders Call on Musharraf to Resign.	11	312
8: ara	Al-Maliki: Iraqi Forces Are Capable of Taking Over the Security Dossier Any Time They Want	8	255

Experiment

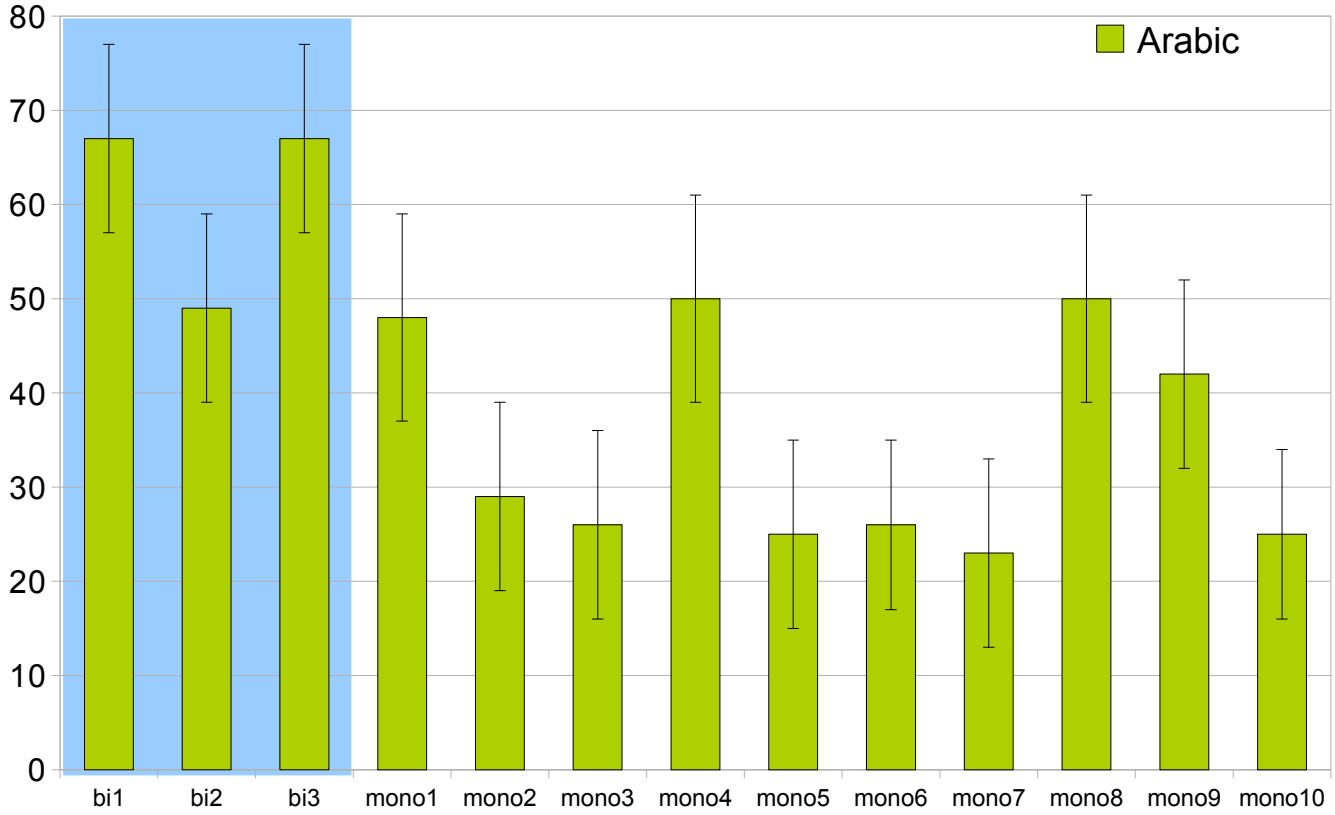
- Monolingual translators
  - 10 students/staff at the University of Edinburgh
  - none knew Arabic or Chinese
  - have access to full stories at a time, may correct prior sentences
- Bilingual translators
  - 3 of the 4 reference translations in NIST test set
- Remaining reference translation as truth

Results: Arabic



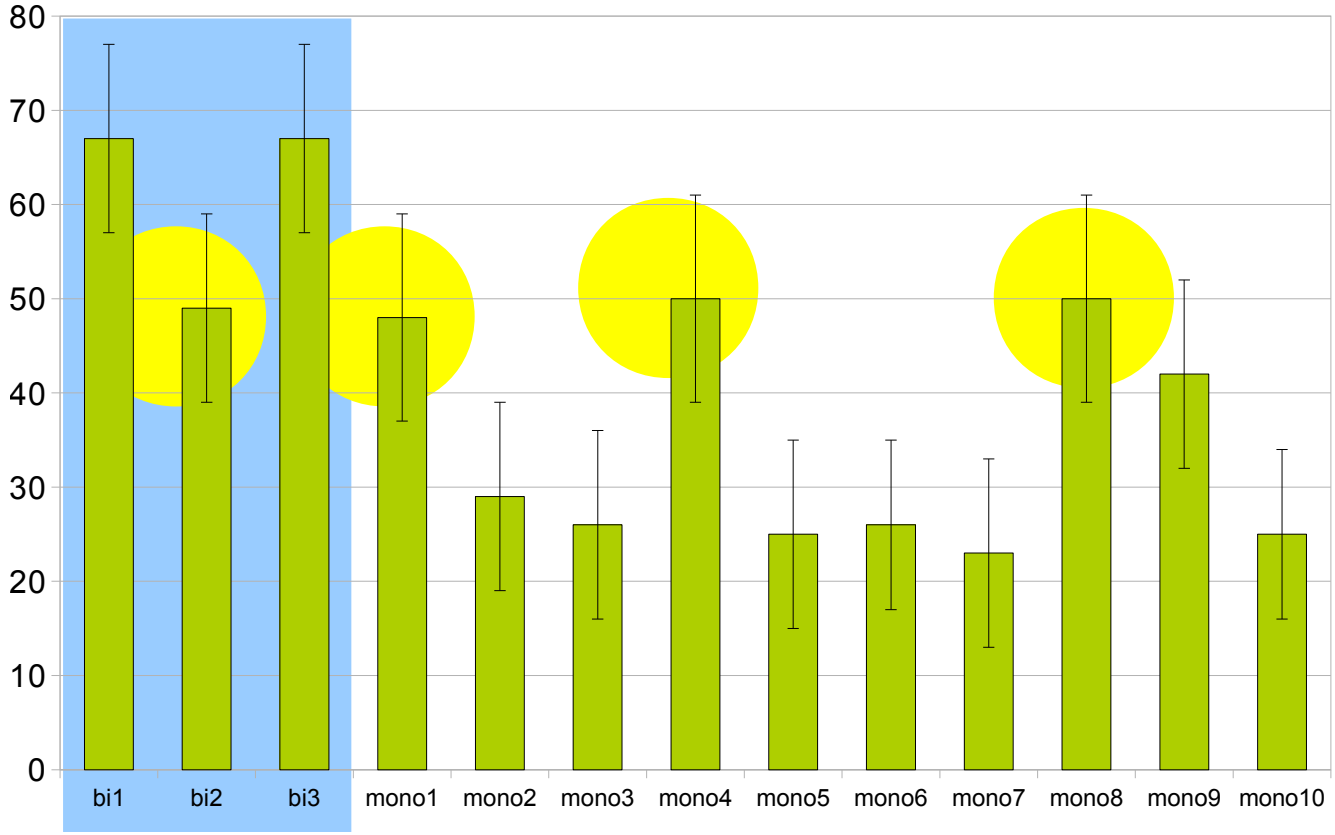
percentage of sentences judged as correct

Results: Arabic



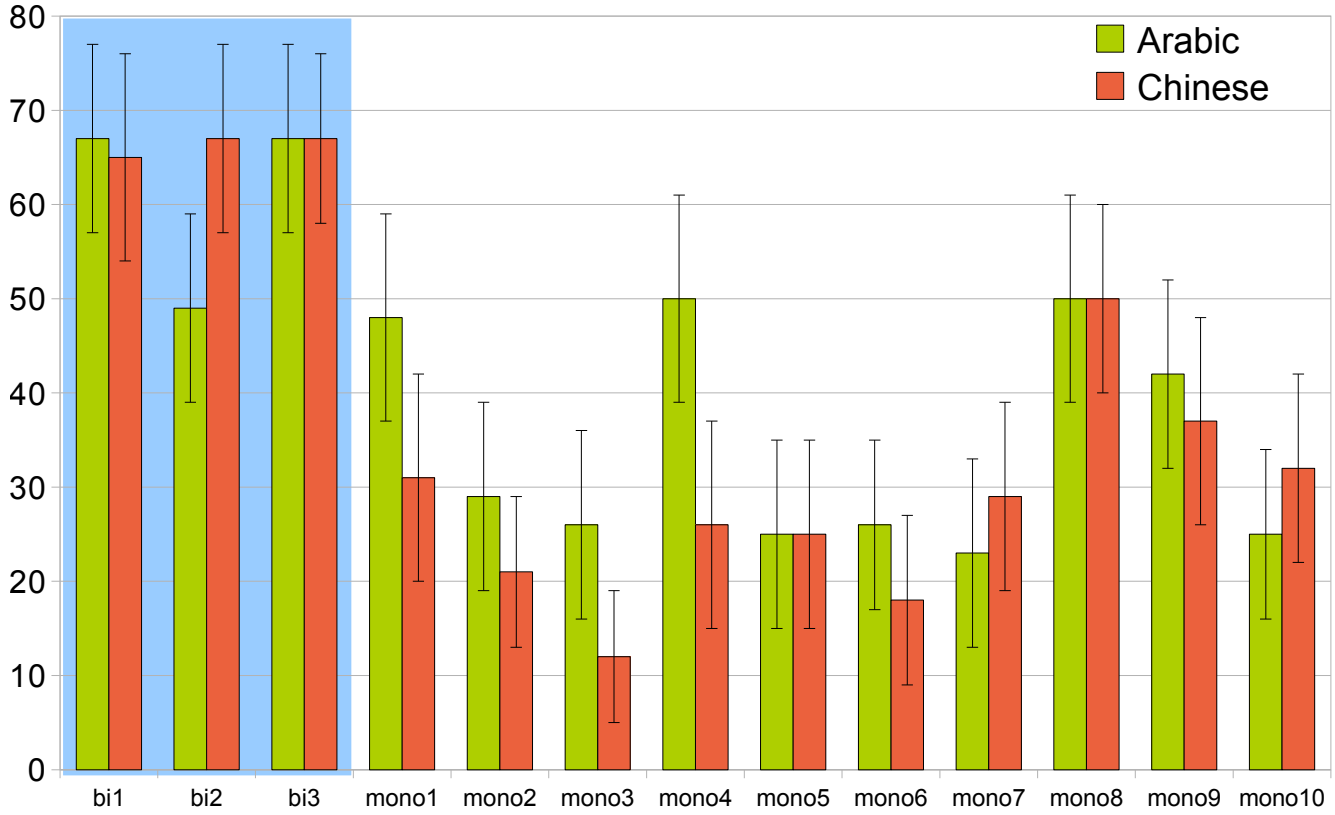
compared to bilingual translators

Results: Arabic



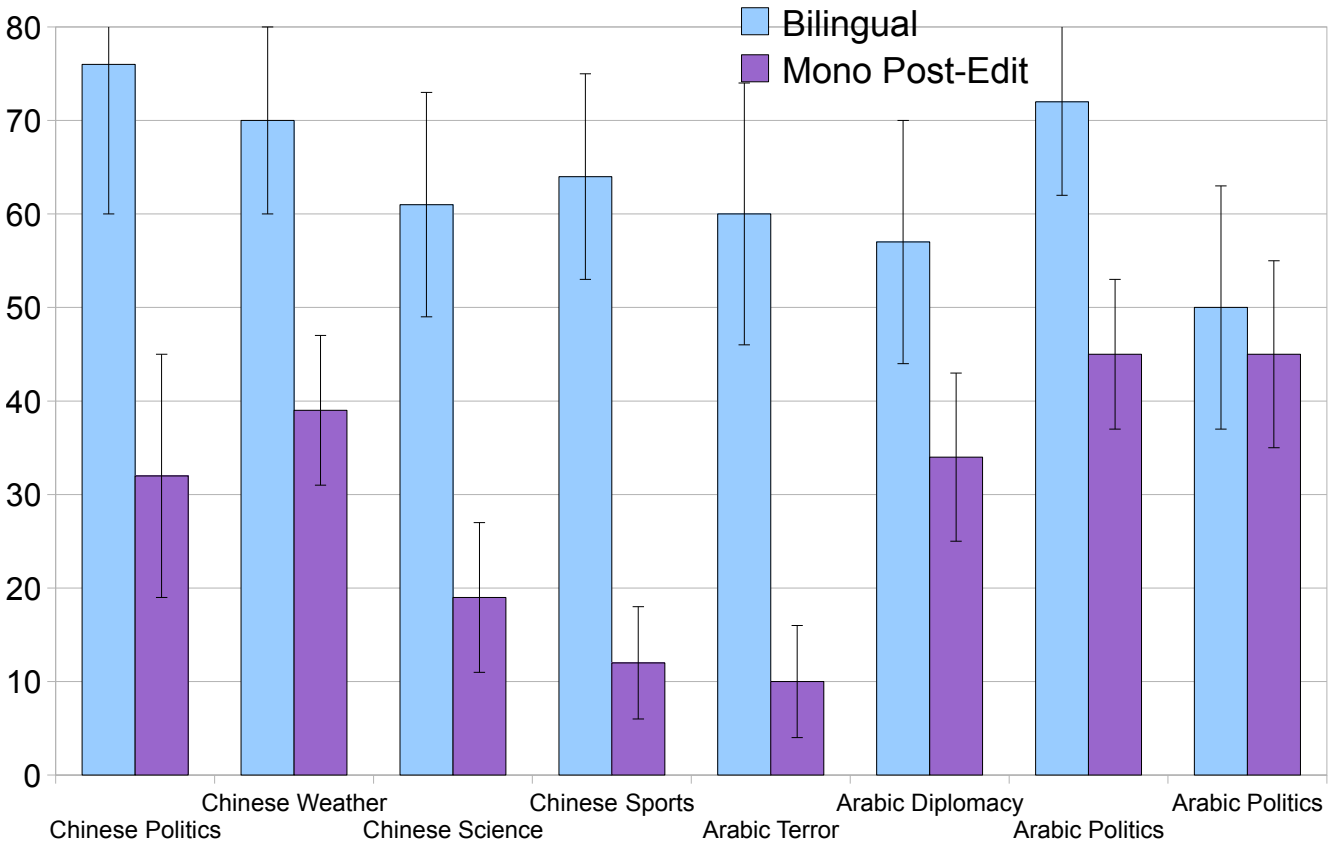
best monolinguals as good as worst bilingual

Results: Arabic and Chinese



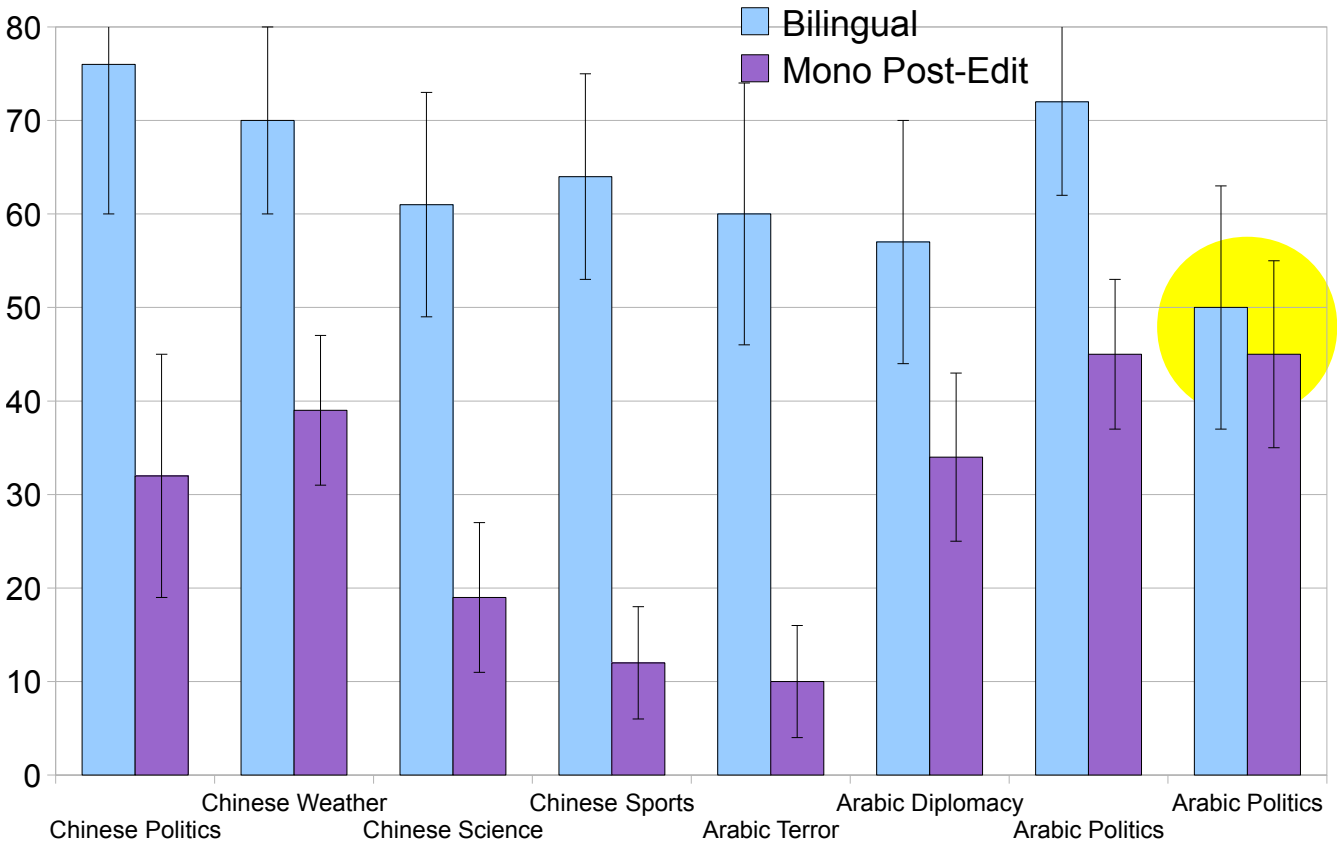
mostly worse performance for Chinese

Results per Story



performance differs widely per story

Results per Story



one story: monolinguals as good as bilinguals

Offering more assistance

- Progress in computer aided translation
- Interactive machine translation (TransType)
  - show prediction of sentence completion
  - recompute when user types own translation
- Alternative translations [Koehn and Haddow, 2009]
  - display translation options from translation model
  - ranked by translation score

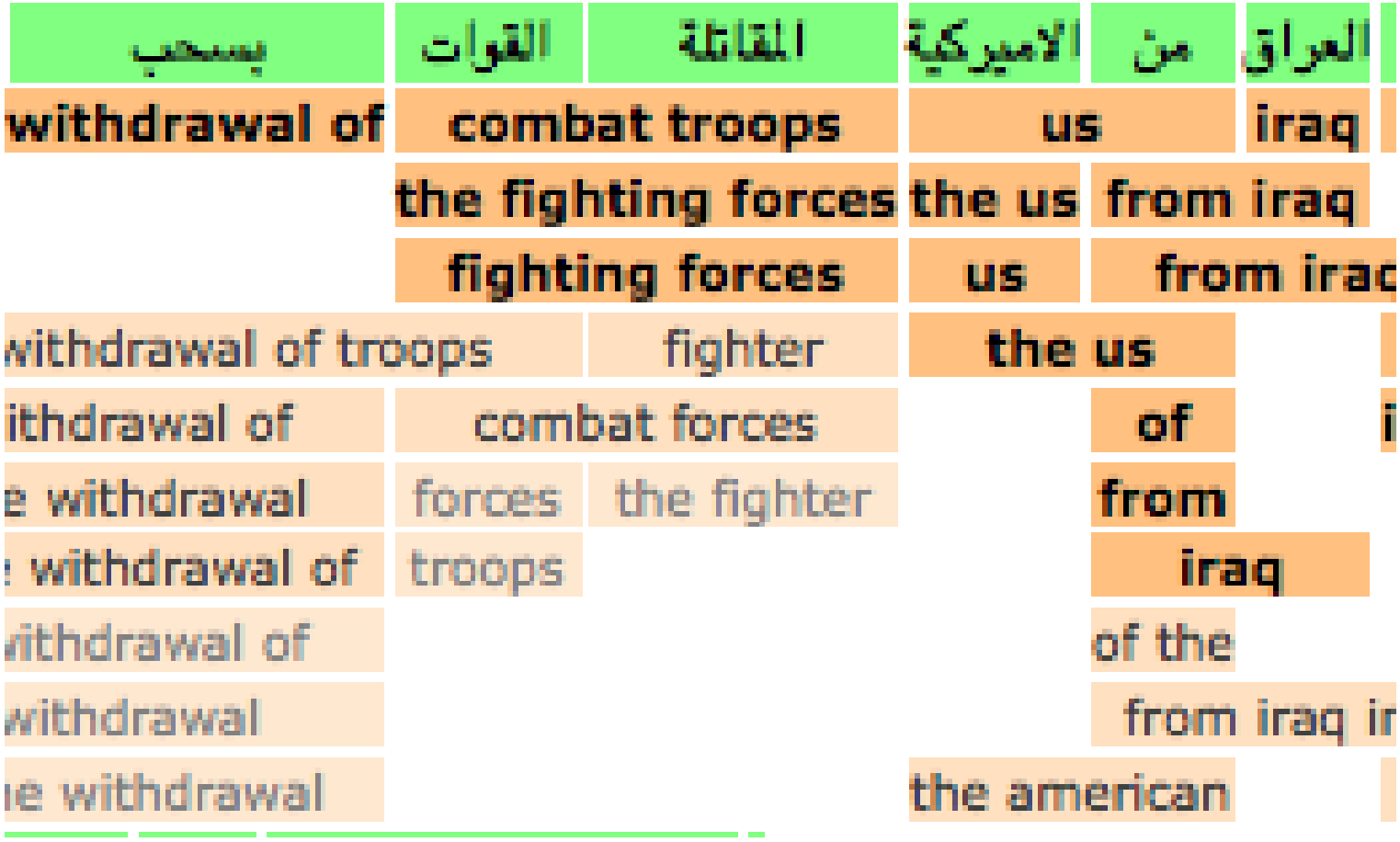
Translation Options

وكان	مجلس	النواب	الاميركى	اعتمد	الخميس	قانونا	يطالب	بسحب	القوات	المقاتلة	الاميركية	من	العراق	فى	موعد	اقصاه	الاول	من	نيسان	@/@	ابريل
the	**the us house of representatives**			**adopted**	**thursday**	**legally**	**calls for the withdrawal of**		**combat troops**		**us**		**iraq**	**in**	**no later than**		**the first**		**from april**		
the us house of representatives				the	thursday ,	law			**the fighting forces**		**the us**	**from iraq**			**the latest**		**the first of**		**april**		
the us house				adopted the	thu	the legally			**fighting forces**		**us**	**from iraq in**					i		april		
it was	us house of representatives			was adopted	thursday , the	the law	demands withdrawal of troops			fighter	**the us**			**no later than**			first		on april		
he was	the us house			adopted by	thursday 's	a law	calls for withdrawal of		combat forces			**of**		**in the**	not later than		first of				
he	us house			adopted by the	on thursday	a legally	calls for the withdrawal		forces	the fighter		**from**									
earlier ,			us	adopted a	on thursday ,	by law	demands the withdrawal of		troops			**iraq**									
was				, was adopted	thursday the	legally ,	demands withdrawal of					of the									
it was the				adopted ,	thu ,	the legal	calls for withdrawal					from iraq in the									
earlier , the				adopted , the	thursday , a	legally @-@	demands the withdrawal				the american			by the first of							

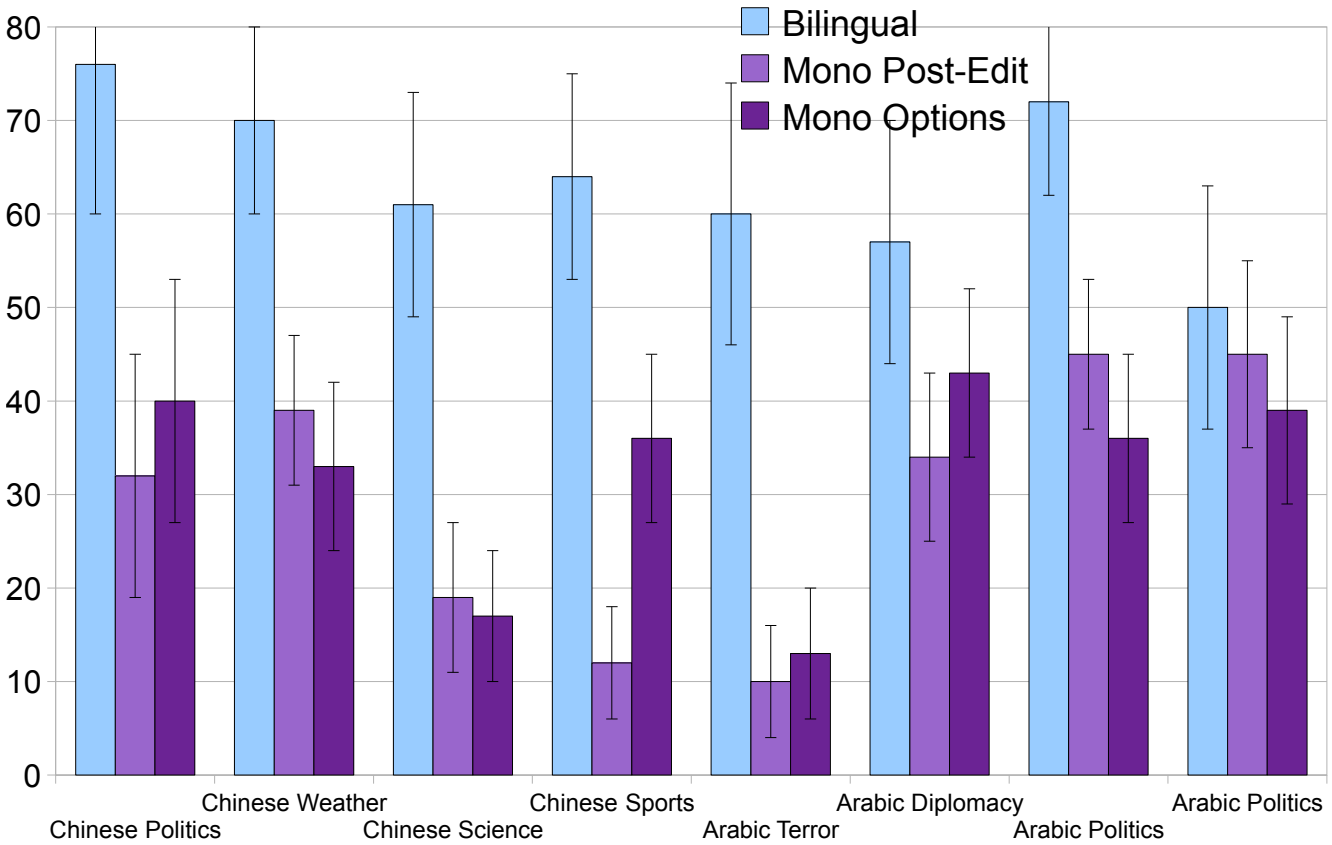
2008	,	متحديا	مرة	جديدة	الرئيس	جورج	بوش	الذى	يعارض	تحديد	اى	موعد	.
2008	**,**	**defying**	**once**	**new**	**president george w. bush**			**, which opposes the**		**no date has been set for the**			**.**
the 2008		**defiant**	**once again**		president george bush			**who opposes**		no date has been set for			
2008		challenging	again	the new				**, which opposes**		no date has been set			
		a defiant	the first					**, who opposes the**				a date .	
		in defiance of	once again ,					**, who opposes**				date .	
		, challenging	once again the		president george bush , who				opposed to setting any			the date of the	
	,	in defiance	for the first time	a new	president george w. bush 's			which opposes				no date	
in 2008 ,		defying the	again		us president george w. bush				opposed to		any	the date of	
		challenging the	time					who opposes the				date of	
		, defying	once again , the						opposes			date	

up to 10 translations for each word / phrase

Translation Options



Results with Options



no big difference — once significantly better

Error Analysis
(a) Critical Judges

- Reference

  Torrential Rains Hit Western India, 43 People Dead

- Bilingual translator

  Heavy Rains Plague Western India Leaving 43 Dead

Error Analysis

(b) Mistakes by the professional translators

- Reference

  Over just two days on the 29th and 30th, rainfall in Mumbai reached 243 mm.

- Bilingual translator

  The rainfall in Mumbai had reached 243 cm over the two days of the 29th and 30th alone.

Error Analysis

(b2) Domain knowledge vs. language skills

- Bilingual translator

  With Munchen-Gladbach falling to the German Bundesliga 2, ...

- Monolingual translator

  The Mönchengladbach team fell into the second German league, ...

Error Analysis
(c) Bad English by monolingual translators

- Monolingual translator

  The western region of india heavy rain killed 43 people.

Error Analysis

(d) Mistranslated / untranslated name

- Reference

  Johndroe said that the two leaders ...

- Machine translation

  Strong zhuo, pointing out that the two presidents ...

- Monolingual translator

  Qiang Zhuo pointed out that the two presidents ...

Error Analysis

(e) Wrong relationship between entities

- Machine translation

  The colombian team for the match, and it is very likely that the united states and kai in the americas cup final performance.

- Monolingual translator 6

  The Colombian team and the United States are very likely to end up in the Americas Cup as the final performance.

- Monolingual translator 8

  The next match against Colombia is likely to be the United States' and Keller's final performance in the current Copa America.

Error Analysis

(f) Badly muddled machine translation

- Reference

  In the current America's cup, he has, just as before, been given an important job to do by head coach Bradley, but he clearly cannot win the match singlehanded. The US team, made up of "young guards,"...

- Machine translation

  He is still being head coach bradley appointed to important, it's even a fist ", four young guards at the beginning of the ", the united states is...

Conclusions

- Main findings
  - monolingual translators may be as good as bilinguals
  - widely different performance by translator / story
  - named entity translation critically important
- Various human factors important
  - domain knowledge
  - language skills
  - effort

Overview

- Human Translation
- Assistance to Human Translators
- User Study
- Assistance to Monolingual Translators
- **Integration of Translation Memory and MT**

Progress in Translation Automation

- **Translation Memory** (TM)
  - translators store past translation in database
  - when translating new text, consult database for similar segments
  - fuzzy match score defines similarity

  widely used by translation agencies

- **Statistical Machine Translation** (SMT)
  - collect large quantities of translated text
  - extract automatically probabilistic translation rules
  - when translating new text, find most probable translation given rules

  wide use of free web-based services
  not yet used by many translation agencies

TM	vs.	SMT
used by human translator		used by target language information seeker
restricted domain (e.g. product manual)		open domain translation (e.g. news)
very repetitive content		huge diversity (esp. web)
corpus size: 1 million words		corpus size: 100-1000 million words
commercial developers (e.g., SDL Trados)		academic/commercial research (e.g., Google)

Our Goal

Better TM

using SMT methods

Main Idea

- Input

The second paragraph of Article 21 is deleted .

- Fuzzy match in translation memory

The second paragraph of Article 5 is deleted .

⇒ **Part of the translation from TM fuzzy match**

Part of the translation with SMT

The second paragraph of Article	21	is deleted .

Related Work

- Work inspired by EBMT

  [Smith and Clark, 2009]
  [Zhechev and van Genabith, 2010]

  – uses syntactic information in alignment
  – lower performance than reported here

- Encode fuzzy match as rule with gaps

  [Biçici and Dymetman, 2008]

  – similar to our second method
  – impressive improvements, but weak baseline SMT

Two Solutions

- XML frames

- Very large hierarchical rules

Example

- Input sentence:

The second paragraph of Article 21 is deleted .

Example

- Input sentence:

The second paragraph of Article 21 is deleted .

- Fuzzy match in translation memory:

The second paragraph of Article 5 is deleted .

=

À l' article 5 , le texte du deuxiéme alinéa est supprimé .

Example

- Input sentence:

The second paragraph of Article 21 is deleted .

- Fuzzy match in translation memory:

The second paragraph of Article 5 is deleted .

=

À l' article 5 , le texte du deuxiéme alinéa est supprimé .

- Detect mismatch (string edit distance)

Example

- Input sentence:

The second paragraph of Article 21 is deleted .

- Fuzzy match in translation memory:

The second paragraph of Article 5 is deleted .

=

À l' article 5 , le texte du deuxiéme alinéa est supprimé .

- Detect mismatch (string edit distance)

- Align mismatch (using word alignment from GIZA++)

Example

- Input sentence:

The second paragraph of Article 21 is deleted .

- Fuzzy match in translation memory:

The second paragraph of Article 5 is deleted .

=

À l' article 5 , le texte du deuxiéme alinéa est supprimé .

Output word(s) taken from the target TM

Example

- Input sentence:

The second paragraph of Article 21 is deleted .

- Fuzzy match in translation memory:

The second paragraph of Article 5 is deleted .

=

À l' article 5 , le texte du deuxiéme alinéa est supprimé .

Output word(s) taken from the target TM

Input word(s) that still need to be translated by SMT

Example

- Input sentence:

The second paragraph of Article 21 is deleted .

- Fuzzy match in translation memory:

The second paragraph of Article 5 is deleted .

=

À l' article 5 , le texte du deuxiéme alinéa est supprimé .

- XML frame (input to Moses)

<xml translation=" À l' article "/> 21

<xml translation=" , le texte du deuxiéme alinéa est supprimé . "/>

Example

- Input sentence:

The second paragraph of Article 21 is deleted .

- Fuzzy match in translation memory:

The second paragraph of Article 5 is deleted .

=

À l' article 5 , le texte du deuxiéme alinéa est supprimé .

- More compact formalism for the purposes of this presentation:

< À l' article > 21 < , le texte du deuxiéme alinéa est supprimé . >

Steps

- Fuzzy matching
  - based on string edit distance on words

$$\text{FMS} = 1 - \frac{\text{edit-distance}(\text{source}, \text{tm-source})}{\max(|\text{source}|, |\text{tm-source}|)}$$

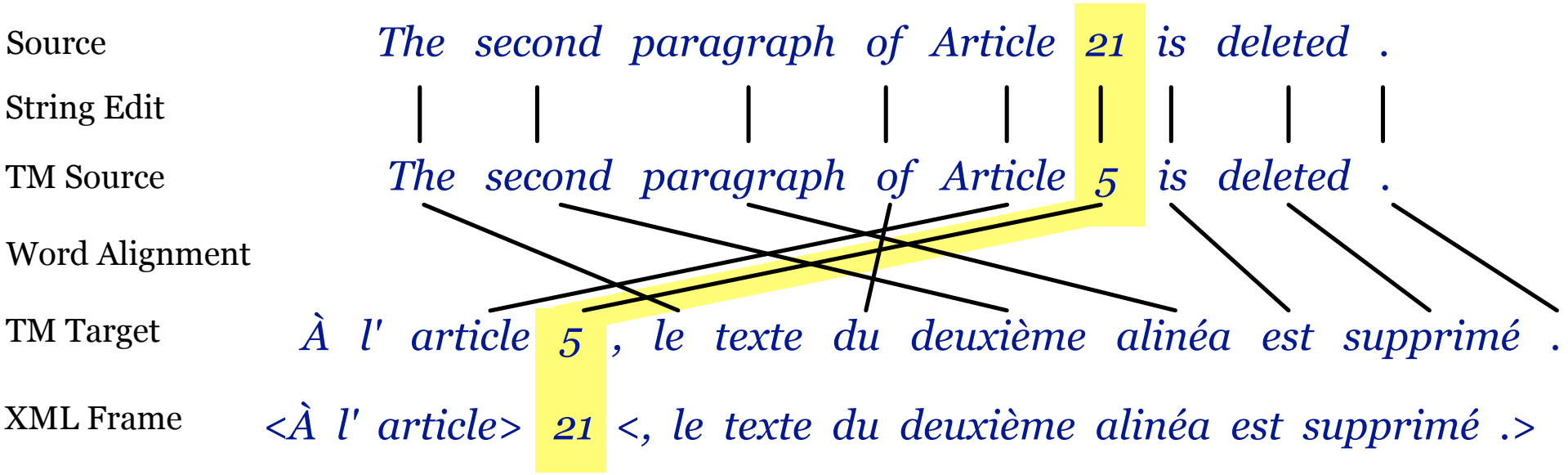
  - string edit distance on letters as tie breaker
  - details see [Koehn and Senellart, AMTA 2010] straight-forward
- Word alignment of TM source and target standard method
- Construction of XML frame
  = linking mismatch(input, TM source) to TM target can be tricky

Construction of XML Frame

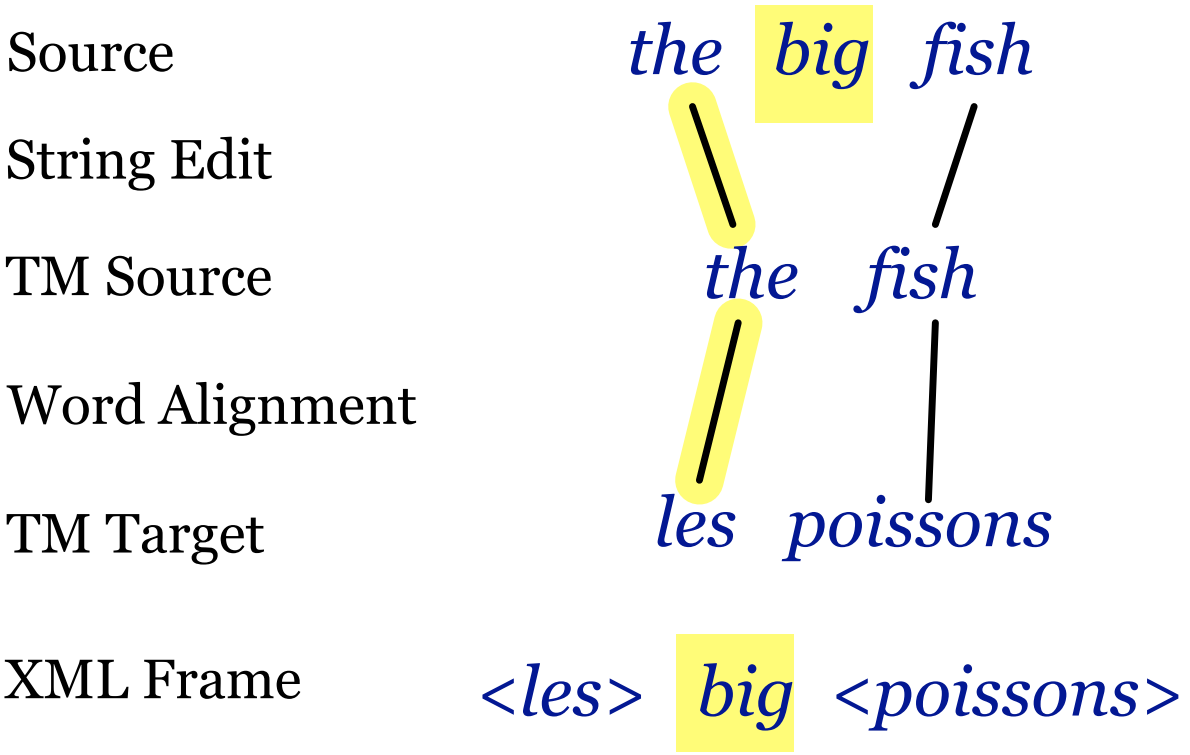
- Basic principles
  - start with fully specified XML frame
  - all mismatched source words have to be translated by SMT
  - all TM target words aligned to mismatched TM source words are removed
  - if the alignment to the TM target words fails
    $\rightarrow$ go to the previous TM source word and follow its alignment

- See paper for algorithm

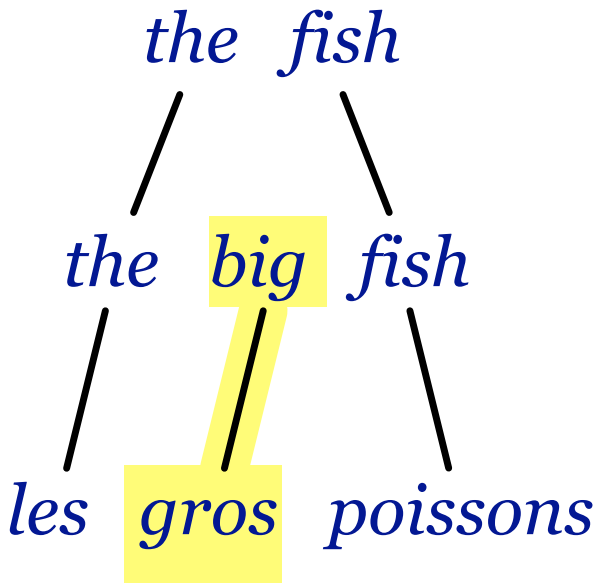
Example


Source
The second paragraph of Article 21 is deleted .
String Edit
TM Source
The second paragraph of Article 5 is deleted .
Word Alignment
TM Target
À l' article 5 , le texte du deuxième alinéa est supprimé .
XML Frame
<À l' article> 21 <, le texte du deuxième alinéa est supprimé .>

Special Case: Insertion

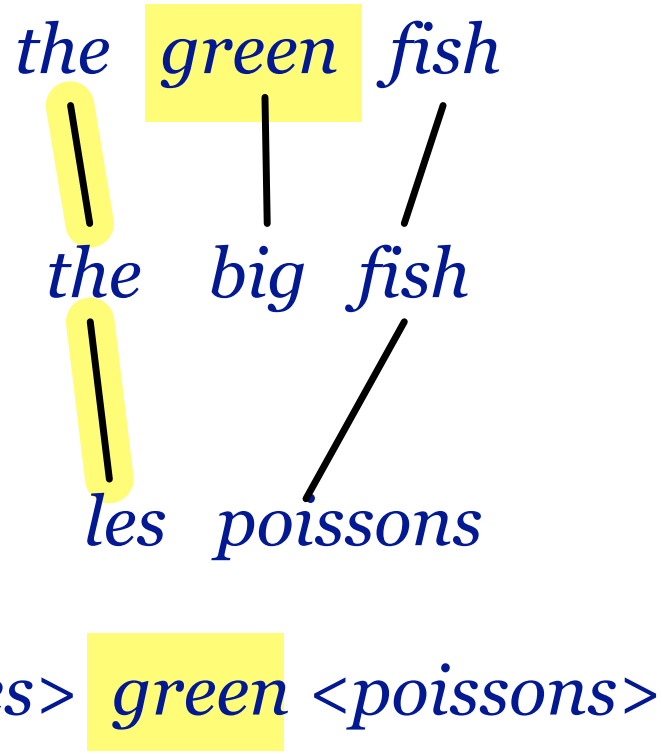


Special Case: Deletion

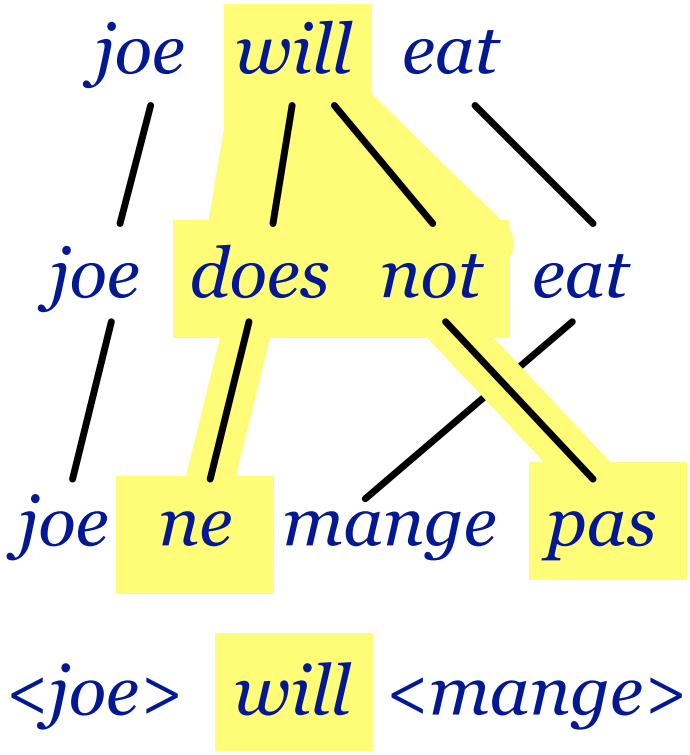


<les> <poissons>

Special Case: Unaligned Mismatch



Special Case: Disconnected Alignments



Experiments

- Baseline 1: Unmodified TM matches
- Baseline 2: SMT system trained on TM data
- Our XML frame method

Corpora: Size

Acquis

	Corpus	Test
segments	1,165,867	4,107
English words	24,069,452	129,261
French words	25,533,259	135,224

Product

	Corpus	Test
segments	83,461	2,000
English words	1,038,762	24,643
French words	1,110,284	26,248

Corpora: Fuzzy Matches

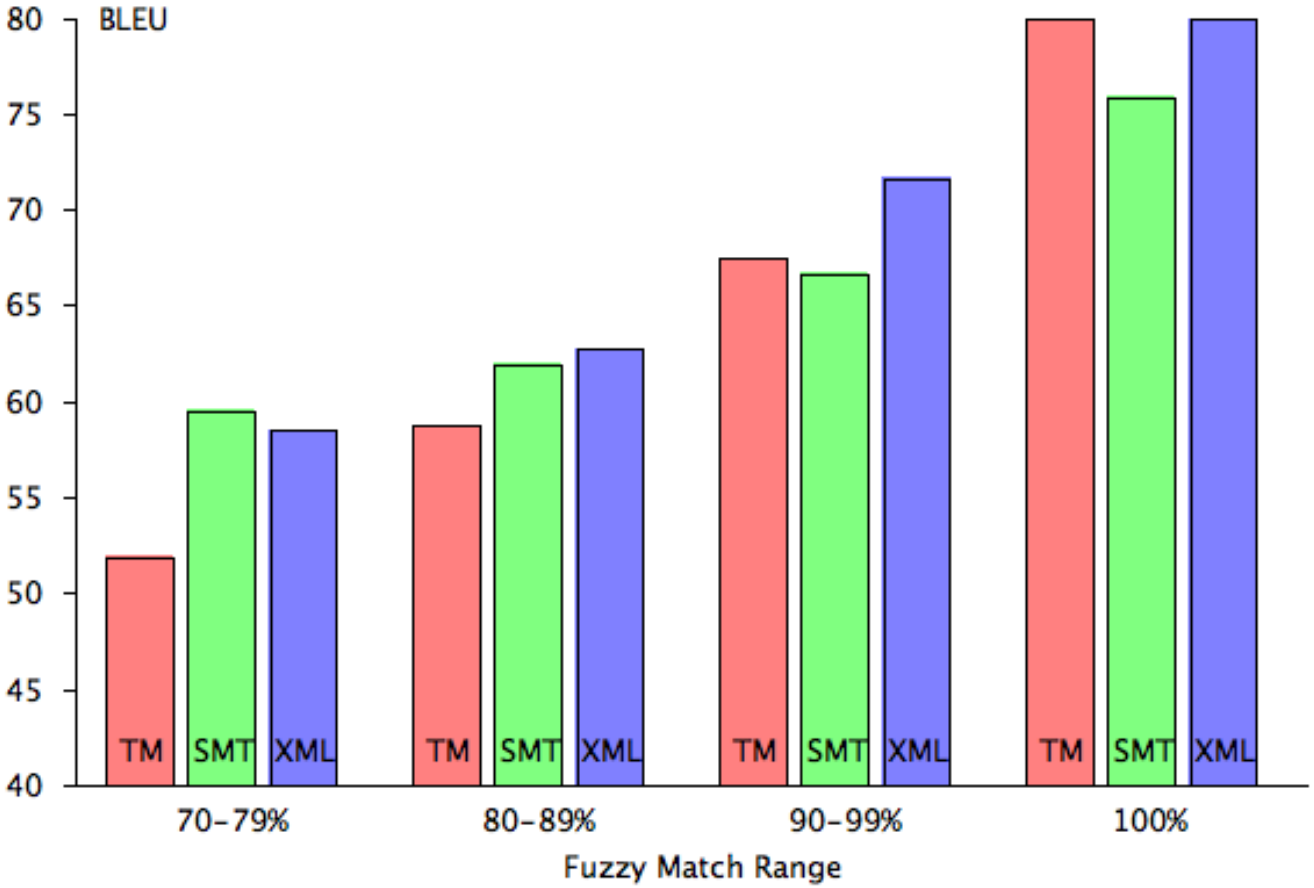
Acquis

	Sentences	Words	W/S
100%	1395	14,559	10.4
90-99%	433	12,775	29.5
80-89%	154	5,347	34.7
70-79%	250	6,767	27.1

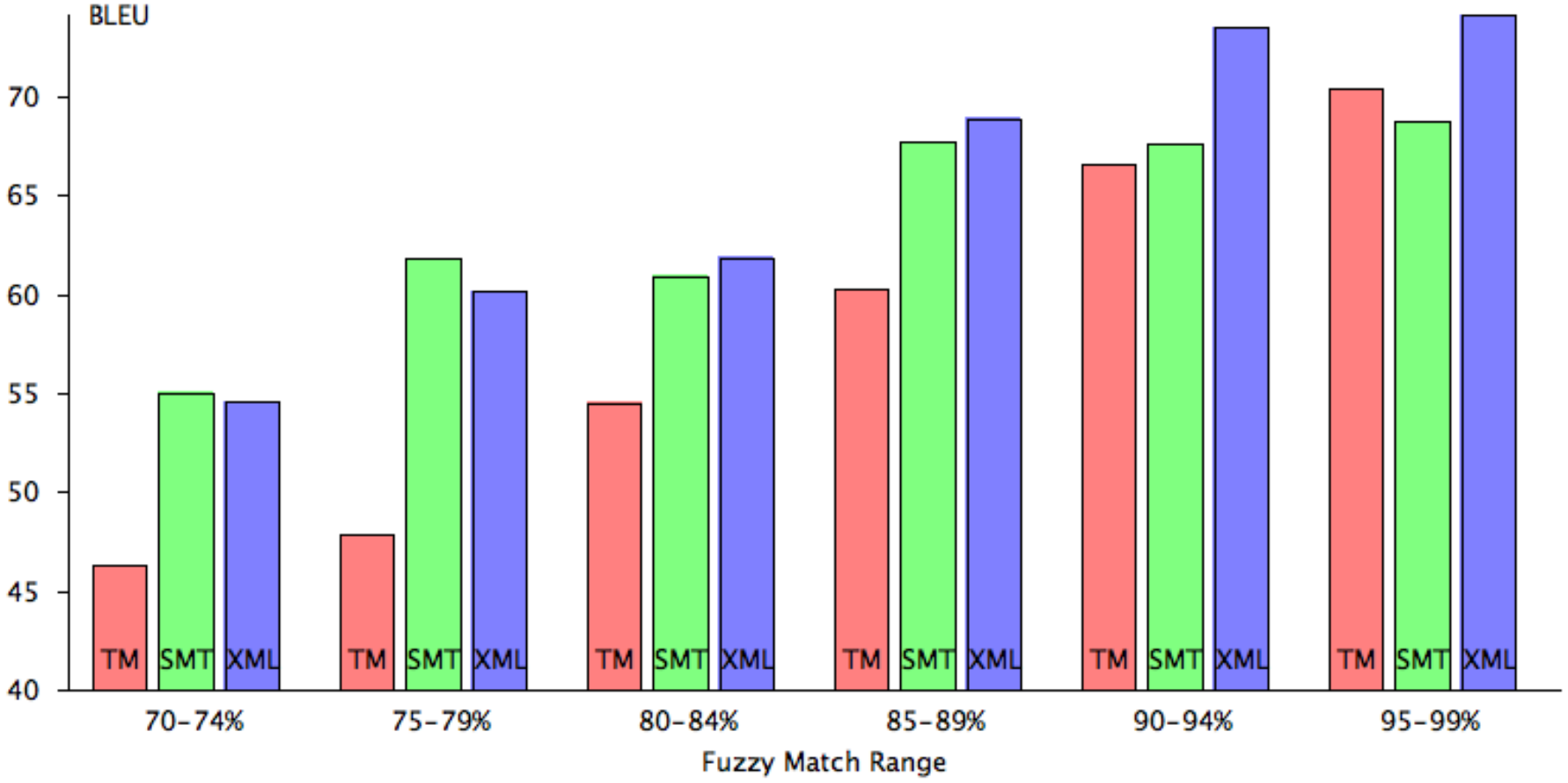
Product

	Sentences	Words	W/S
95-99%	230	3,006	13.1
90-94%	225	2,968	13.2
85-89%	177	2,000	11.3
80-84%	185	1,950	10.5
75-79%	152	1,350	8.9
70-74%	98	987	10.1

Results: Acquis



Results: Product



Recap

- TM provides fuzzy matches
- SMT translates mismatched words
- TM match encoded in XML frame

... but is that not just a very large translation rule?

Background: Hierarchical Phrase Rules

- Given: sentence pair with monotone 1-to-1 alignment

  the big fish = les gros poissons

- Phrase translation rules

  (the ; les)
  (the big ; les gros)
  (the big fish ; les gros poissons)
  (big ; gros)
  (big fish ; gros poissons)
  (fish ; poissons)

- Hierarchical phrase-based rule are constructed by subtraction
  - large rule: (the big fish ; les gros poissons)
  - small rule: (big ; gros) (contained in large rule)

  → hierarchical rule: (the X fish ; les X poissons)

XML Frame as Very Large Rule

- XML frame

  <À l' article> 21 <, le texte du deuxiéme alinéa est supprimé .>

  for input

  The second paragraph of Article 21 is deleted .

- Very large rule

  (The second paragraph of Article x is deleted .
  ; À l' article x , le texte du deuxiéme alinéa est supprimé .)

Very Large Rules in SMT

- Rule size limited in SMT
  - maximum number of words, e.g. 5
  - maximum number of non-terminals (X), e.g. 2
- ... but only due to storage limitations for large rule rule tables
- Rules may be generated on the fly [Lopez, 2007]

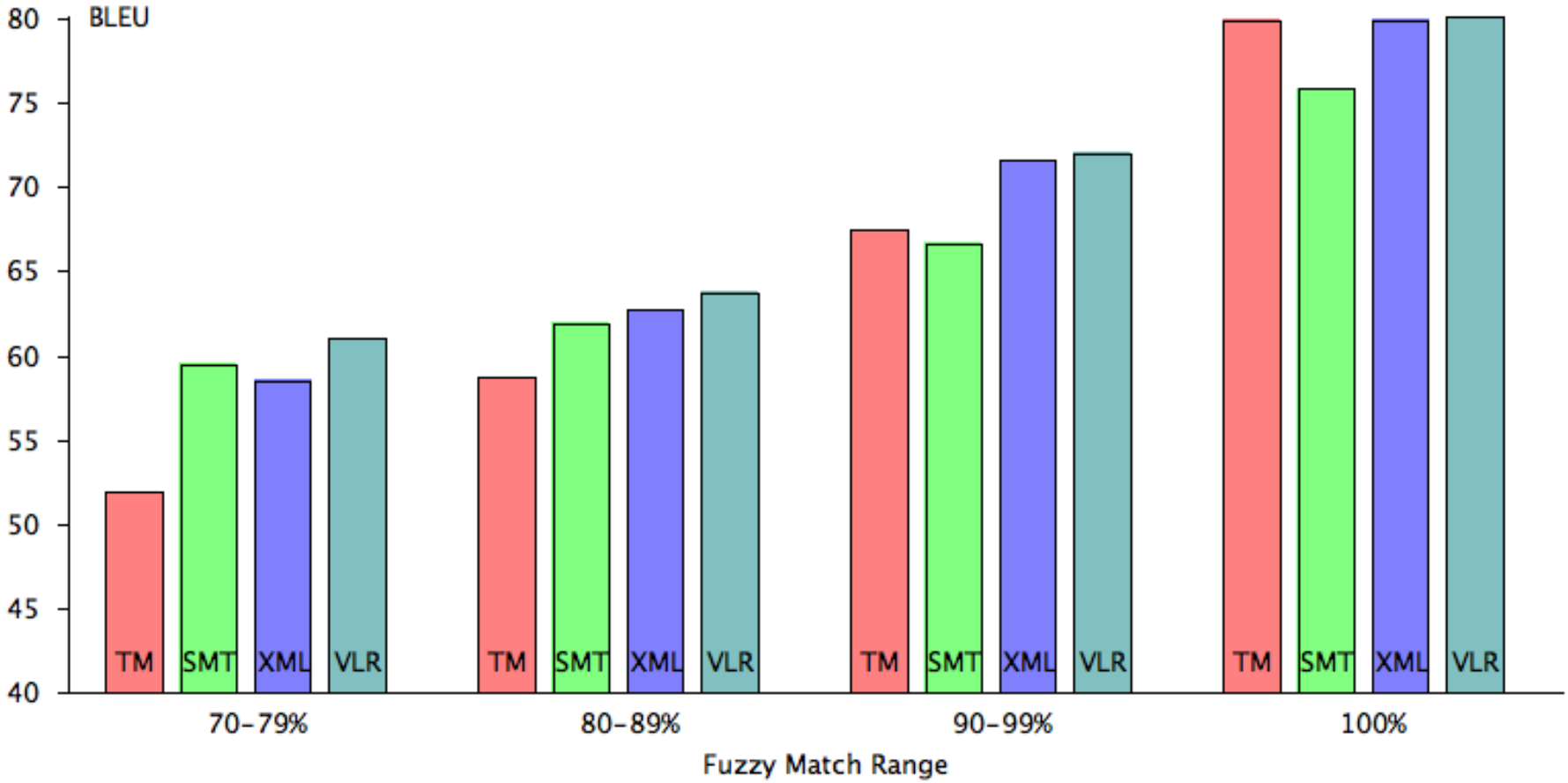
Advantage over XML Method

- Choices
  1. multiple fuzzy matches in TM with same score
  2. same TM source with multiple translations
  3. multiple SMT translations

- Decisions in XML frame method
  1. randomly chosen
  2. most frequent
  3. highest model score (tried others, see paper)

- Decisions for very large rules
  1. all
  2. all
  3. integrated scoring of VLR rules and basic translation rules (tunable)

Result: Acquis



Future Work: User Studies

- Significant increases in BLEU
- To do: validation in user studies
- Additional benefit: possible to highlight mismatch in translation
  - input

    The second paragraph of Article 21 is deleted .
  - suggested translation

    À l' article 21 , le texte du deuxiéme alinéa est supprimé .

Thank You

questions?