Building Parallel Corpora

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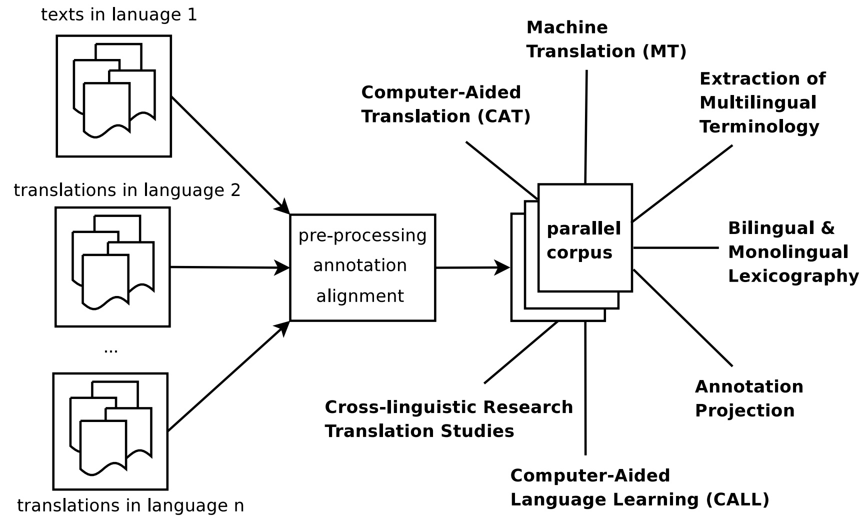
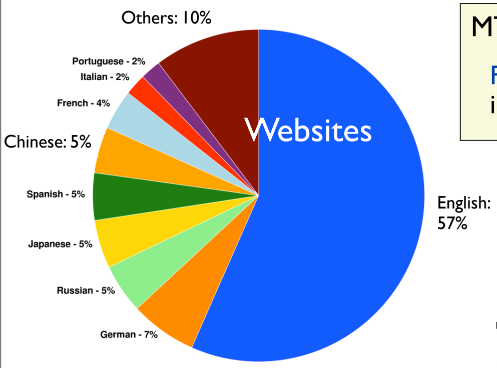
Parallel Corpora Are Very Useful

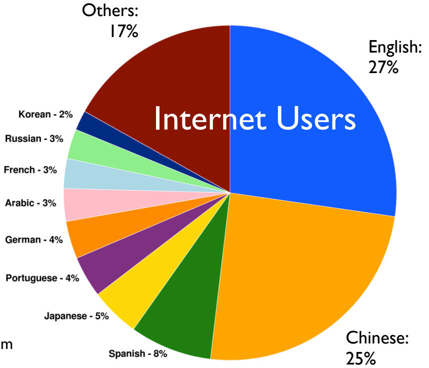


The Web is a Multi-Lingual Place!



MT for Gisting Purposes:

Find and understand
information in other languages

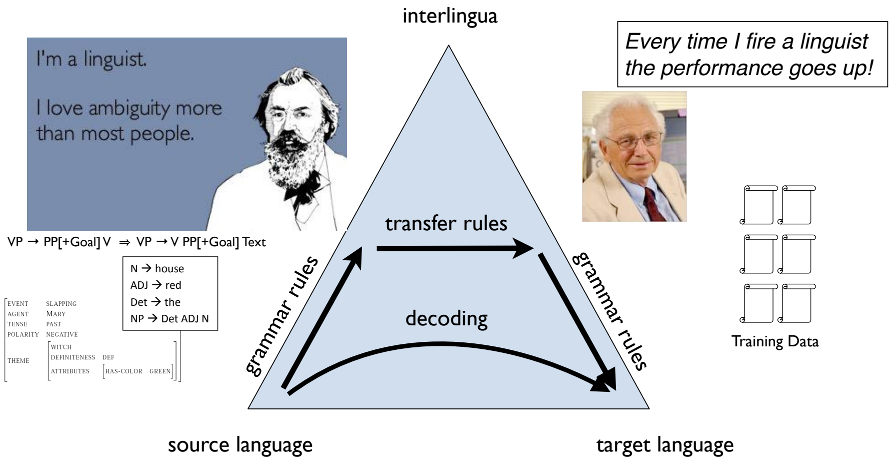


> 2 billion Internet users
> 12 billion indexed web pages

Sources: W3Techs.com, Internet World Stats, WorldWideWebSize.com

Rule-Based vs. Data-Driven MT

*Every time I fire a linguist
the performance goes up!*



Lack of MT Training Data is a Big Issue

Macedonian - English:

It's a simple matter of self-preservation.
It's simply a question of себесочувување.

Your girlfriend's very cynical.
Пријателката цинична you very much.

Catalan - English:

She just went through a breakup.
Just come in for a ruptura

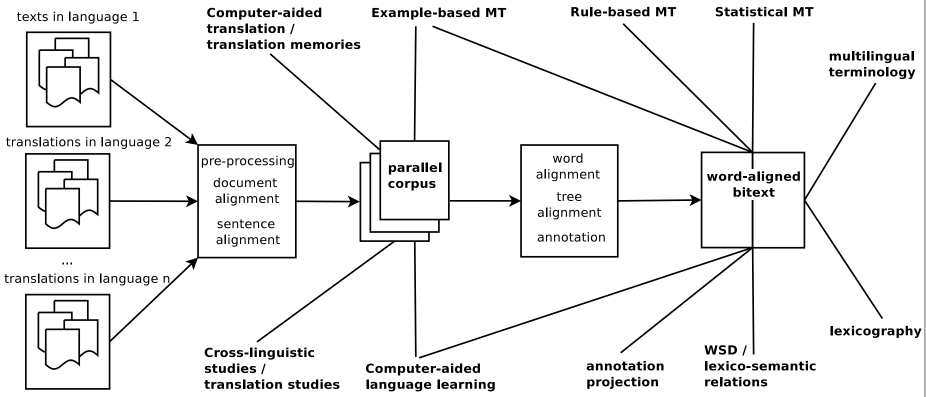
Galician - English:

I promise I will return it to you.
Cha devolverei I promise you that.

What is a Parallel Corpus?

English	French	German	Old French
original text 1	translation of text 1	translation of text 1	
translation of text 2	original text 2		
	translation of text 3	translation of text 3	translation of text 3

Building and Using Parallel Corpora



Building Parallel Corpora

find and collect translated documents

pre-processing

- conversion
- sentence boundary detection
- tokenization

alignment

- document alignment
- paragraph alignment (optional)
- sentence alignment

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Step 1: Pre-processing

Example: Subtitles

```
1
00:00:26,500 --> 00:00:28,434
Spend all day with us.

2
00:00:28,502 --> 00:00:30,436
There are two-- pardon me--

3
00:00:30,504 --> 00:00:34,440
two of everything in
every Noah’s arcade.

4
00:00:34,508 --> 00:00:36,361
That means two of Zantar,

5
00:00:36,361 --> 00:00:36,884
That means two of Zantar,
```

```
<?xml version="1.0" encoding="utf-8"?>
<document>
  <s id="1">
    <time id="T1S" value="00:00:26,500" />
    <w id="1.1">Spend</w>
    <w id="1.2">all</w>
    <w id="1.3">day</w>
    <w id="1.4">with</w>
    <w id="1.5">us</w>
    <w id="1.6">.</w>
    <time id="T1E" value="00:00:28,434" />
  </s>
  <s id="2">
    <time id="T2S" value="00:00:28,502" />
    <w id="2.1">There</w>
    <w id="2.2">are</w>
    <w id="2.3">two</w>
    <w id="2.4">--</w>
    <w id="2.5">pardon</w>
    <w id="2.6">me</w>
    <w id="2.7">--</w>
    <time id="T2E" value="00:00:30,436" />
    <time id="T3S" value="00:00:30,504" />
    <w id="2.8">two</w>
    <w id="2.9">of</w>
    <w id="2.10">everything</w>
    ...
```

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Step 2: Paragraph / Sentence Alignment

Task: align corresponding sentences to each other (may be sequences of sentences)

Assumption: sentence alignment can be done monotonically (no crossing links!)

Challenges: non-1:1 alignments, insertions, deletions, incomplete translations

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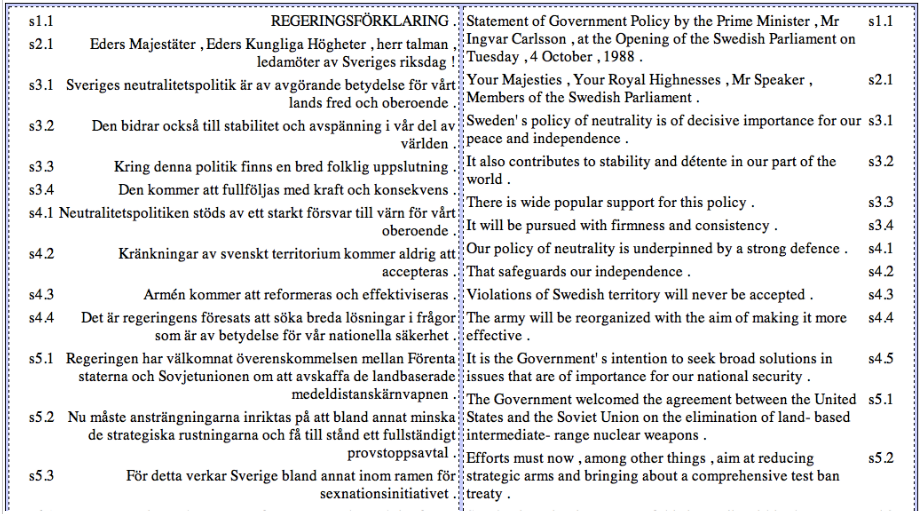
Simple Case: Legal Documents



s1.1	REGERINGSFÖRKLARING .	Statement of Government Policy by the Prime Minister , Mr Ingvar Carlsson , at the Opening of the Swedish Parliament on Tuesday , 4 October , 1988 .	s1.1
s2.1	Eders Majestäter , Eders Kungliga Högheter , herr talman , ledamöter av Sveriges riksdag !	Your Majesties , Your Royal Highnesses , Mr Speaker , Members of the Swedish Parliament .	s2.1
s3.1	Sveriges neutralitetspolitik är av avgörande betydelse för vårt lands fred och oberoende .	Sweden' s policy of neutrality is of decisive importance for our peace and independence .	s3.1
s3.2	Den bidrar också till stabilitet och avspänning i vår del av världen .	It also contributes to stability and détente in our part of the world .	s3.2
s3.3	Kring denna politik finns en bred folklig uppslutning .	There is wide popular support for this policy .	s3.3
s3.4	Den kommer att fullföljas med kraft och konsekvens .	It will be pursued with firmness and consistency .	s3.4
s4.1	Neutralitetspolitiken stöds av ett starkt försvar till värn för vårt oberoende .	Our policy of neutrality is underpinned by a strong defence .	s4.1
s4.2	Kränkningar av svenskt territorium kommer aldrig att accepteras .	That safeguards our independence .	s4.2
s4.3	Armén kommer att reformeras och effektiviseras .	Violations of Swedish territory will never be accepted .	s4.3
s4.4	Det är regeringens föresats att söka breda lösningar i frågor som är av betydelse för vår nationella säkerhet .	The army will be reorganized with the aim of making it more effective .	s4.4
s5.1	Regeringen har välkomnat överenskommelsen mellan Förenta staterna och Sovjetunionen om att avskaffa de landbaserade medeldistanskärnvapnen .	It is the Government' s intention to seek broad solutions in issues that are of importance for our national security .	s4.5
s5.2	Nu måste ansträngningarna inriktas på att bland annat minska de strategiska rustningarna och få till stånd ett fullständigt provstoppsavtal .	The Government welcomed the agreement between the United States and the Soviet Union on the elimination of land- based intermediate- range nuclear weapons .	s5.1
s5.3	För detta verkar Sverige bland annat inom ramen för sexnationsinitiativet .	Efforts must now , among other things , aim at reducing strategic arms and bringing about a comprehensive test ban treaty .	s5.2

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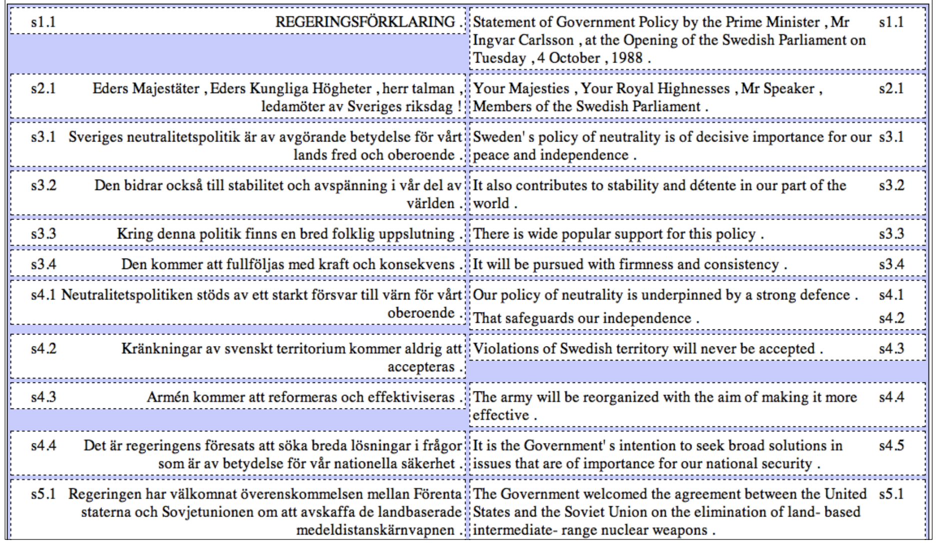
Simple Case: Legal Documents



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Hard Case: Movie Subtitles

English

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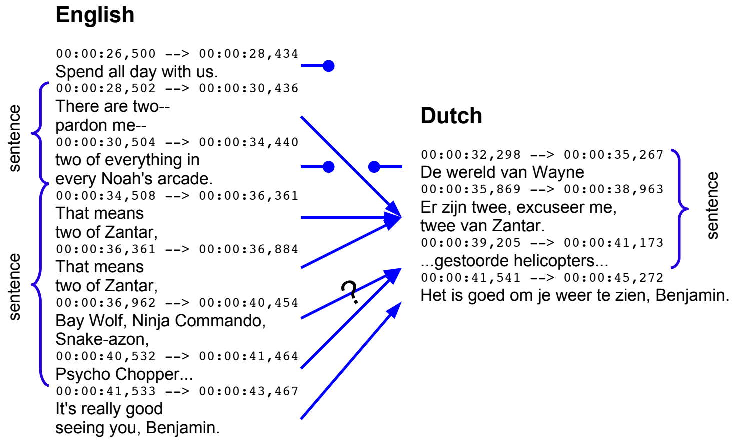
Spend all day with us.
00:00:28,502 --> 00:00:30,436
There are two--
pardon me--
00:00:30,504 --> 00:00:34,440
two of everything in
every Noah's arcade.
00:00:34,508 --> 00:00:36,361
That means
two of Zantar,
00:00:36,361 --> 00:00:36,884
That means
two of Zantar,
00:00:36,962 --> 00:00:40,454
Bay Wolf, Ninja Commando,
Snake-azon,
00:00:40,532 --> 00:00:41,464
Psycho Chopper...
00:00:41,533 --> 00:00:43,467
It's really good
seeing you, Benjamin.

Dutch

00:00:32,298 --> 00:00:35,267
De wereld van Wayne
00:00:35,869 --> 00:00:38,963
Er zijn twee, excuseer me,
twee van Zantar.
00:00:39,205 --> 00:00:41,173
...gestoorde helicopters...
00:00:41,541 --> 00:00:45,272
Het is goed om je weer te zien,
Benjamin.

Hard Case: Movie Subtitles



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Try to align the following sentences ...

source language	ID	target language
Fooi Tiadii , hseatenis aoe iscesnaohtmutis emt eis Lsoih , xes ücis aot iisioohicsudiio .	1	Wo wes qmåheei ew io iqoeino tun wes nis iäotzotmöt äo lsoh .
Fooi Qitutiadii , eoi eoi lämgui aotisit Löoohsiodiit eeiooseggui .	2	Fo qitu tun lun euu eöee nis äo iämguio ew soliu .
Xu len toi iis ?	3	Wesu lun eio ogsåo ?
Xoi wiscsiouiui toi todi ?	4	Win tqsie eio ?
Eoi Qsoituis tehuio aot , toi tio eoi Tusegi Huuit .	5	Qsätuisoe cisäuueei euu eiu wes Haet cituseggoooh .
Bcis güs ximdii Tüoei ?	6	Gös womlio tzoe ?
Ximdiit Hicuu ieuuio xos hicsudiio , eett xos tu iuxet wiseoiou ieuuio ?	7	Oik , wo wottui teoooohio
Oioo , xos leoouio eoi Xeisiiou .	8	Eiuue wes ooui Haet wisl , aueo ekäwamiot .
Eet xes oodiu Huuuit Xisl , tuoeiso Uiagimio ... ueis liyisio .	9	Fmmis usummeun .
Voe aotisi Bagheci citueoe eesoo , güs eoi liomaoh easdi Huuu eio Eänuo za geohio .	10	Wo wes uwaohoe euu citihse io einuo .
Csaeis Uiunet !	11	Gös Haet gösmåuimti .
	12	Csueis Uiunet .

Re-arranging the table

ID	source language	target language	ID
1	Fooi Tiadii , hseatenis aoe iscesnaohtmutis emt eis Lsoih , xes ücis aot iisioohicsudiio .	Wo wes qmåheei ew io iqoeino tun wes nis iäotzotmöt äo lsoh .	1
2	Fooi Qitutiadii , eoi eoi lämgui aotisit Löoohsiodiit eeiooseggui .	Fo qitu tun lun euu eöee nis äo iämguio ew soliu .	2
3	Xu len toi iis ?	Wesu lun eio ogsåo ?	3
4	Xoi wiscsiouiui toi todi ?	Win tqsie eio ?	4
5	Eoi Qsoituis tehuio aot , toi tio eoi Tusegi Huuuit .	Qsätuisoe cisäuueei euu eiu wes Haet cituseggoooh .	5
6	Bcis güs ximdii Tüoei ?	Gös womlio tzoe ?	6
7	Ximdiit Hicuu ieuuio xos hicsudiio , eett xos tu iuxet wiseoiou ieuuio ?		
8	Oioo , xos leoouio eoi Xeisiiou .	Oik , wo wottui teooohio	7
9	Eet xes oodiu Huuuit Xisl , tuoeiso Uiagimio ... ueis liyisio .	Eiuue wes ooui Haet wisl , aueo ekäwamiot .	8
		Fmmis usummeun .	9
10	Voe aotisi Bagheci citueoe eesoo , güs eoi liomaoh easdi Huuu eio Eänuo za geohio .	Wo wes uwaohoe euu citihse io einuo .	10
		Gös Haet gösmåuimti .	11
11	Csaeis Uiunet !	Csueis Uiunet .	12

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It was actually German and Swedish

ID	source language	target language	ID
1	Eine Seuche , grausamer und erbarmungsloser als der Krieg , war über uns hereingebrochen .	Vi var plågade av en epidemi som var mer hänsynslös än krig .	1
2	Eine Pestseuche , die die Hälfte unseres Königreiches dahinraffte .	En pest som kom att döda mer än hälften av riket .	2
3	Wo kam sie her ?	Vart kom den ifrån ?	3
4	Wie verbreitete sie sich ?	Vem spred den ?	4
5	Die Priester sagten uns , sie sei die Strafe Gottes .	Prästerna berättade att det var Guds bestraffning .	5
6	Aber für welche Sünde ?	För vilken synd ?	6
7	Welches Gebot hatten wir gebrochen , dass wir so etwas verdient hatten ?		
8	Nein , wir kannten die Wahrheit .	Nej , vi visste sanningen	7
9	Das war nicht Gottes Werk , sondern Teufelei ... oder Hexerei .	Detta var inte Guds verk , utan djävulens .	8
		Eller trolldom .	9
10	Und unsere Aufgabe bestand darin , für die Heilung durch Gott den Dämon zu fangen .	Vi var tvungna att besegra en demon .	10
		För Guds förlåtelse .	11
11	Bruder Thomas !	Broder Thomas .	12

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Sentence Alignment Approaches

Length-based methods: assumption = sentences (and sequences of sentences) that correspond to each other are also similar in length (characters or words) (more than others)

Lexical methods: assumption = corresponding sentences contain more corresponding words; use distribution of corresponding words in source and target language texts

Combined methods: use lexical cues in length-based settings

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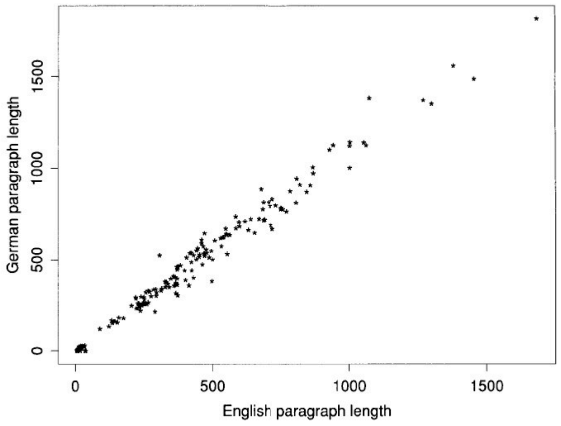
Gale & Church: A Length-Based Model

Strong correlation between paragraph lengths



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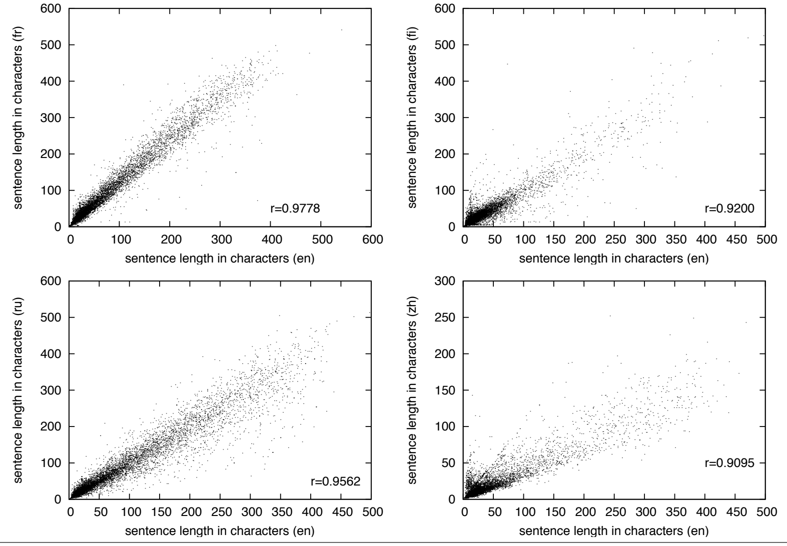
Translated KDE System Messages



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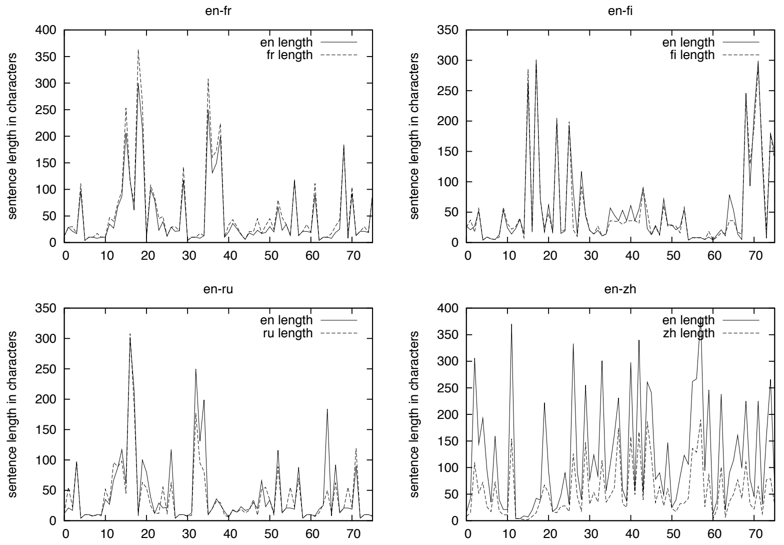
Sentence Lengths as Alignment Signals



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Compare String Lengths

target language	ID
Vi var plågade av en epidemi som var mer hänsynslös än krig .	66
En pest som kom att döda mer än hälften av riket .	54
Vart kom den ifrån ?	22
Vem spred den ?	16
Prästerna berättade att det var Guds bestraffning .	54
För vilken synd ?	19
Nej , vi visste sanningen	26
Detta var inte Guds verk , utan djävulens .	45
Eller trolldom .	17
Vi var tvungna att besegra en demon .	38
För Guds förlåtelse .	25
Broder Thomas .	16

ID	source language
92	Eine Seuche , grausamer und erbarmungsloser als der Krieg , war über uns hereingebrochen .
70	Eine Pestseuche , die die Hälfte unseres Königreiches dahinraffte .
17	Wo kam sie her ?
27	Wie verbreitete sie sich ?
54	Die Priester sagten uns , sie sei die Strafe Gottes .
26	Aber für welche Sünde ?
73	Welches Gebot hatten wir gebrochen , dass wir so etwas verdient hatten ?
34	Nein , wir kannten die Wahrheit .
64	Das war nicht Gottes Werk , sondern Teufelei ... oder Hexerei .
86	Und unsere Aufgabe bestand darin , für die Heilung durch Gott den Dämon zu fangen .
16	Bruder Thomas !

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The Gale & Church Approach

Generative Model

- each source character generates a target character

Minimize alignment costs

- minimize length difference
- uncommon alignment types have high costs

Dynamic programming solution

- fixed set of alignment types (0:1, 1:1, 1:2, 2:2)
- fixed cost parameters
- finds global optimum (for given setup)

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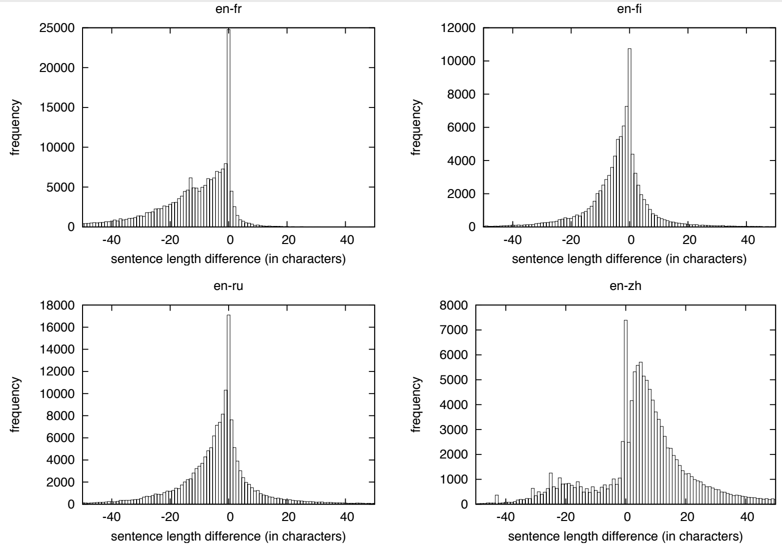
Sentence Length Difference (KDE)



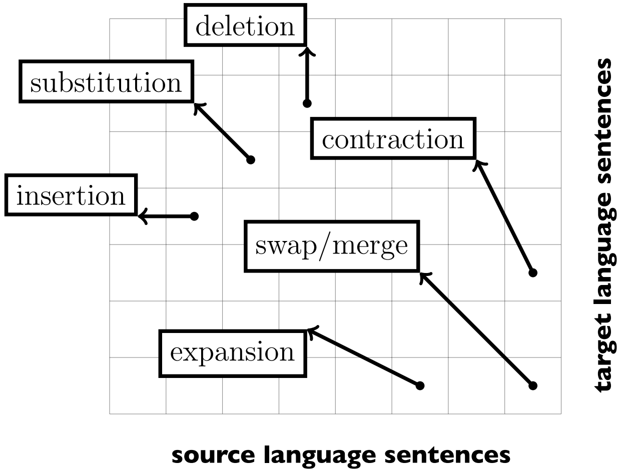
Alignment Type Probabilities (Prior)

Estimated from an aligned parallel corpus:

- P(type = 1:1) = 0.89 (substitution)
- P(type = 1:0) = 0.0099/2 (insertion)
- P(type = 0:1) = 0.0099/2 (deletion)
- P(type = 2:1) = 0.0891/2 (expansion)
- P(type = 1:2) = 0.0891/2 (contraction)
- P(type = 2:2) = 0.011 (merging/swap)

Simple idea: Keep them fixed!

The Gale & Church Approach



deletion

substitution

contraction

insertion

swap/merge

expansion

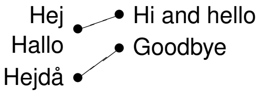
target language sentences

source language sentences

The Gale & Church Approach: Example

			Hej		Hallo		Hejdå	
	0		$6.37^{1:0}$ – –	– – –	$13.16^{1:0}$ – –	– – –	$20.17^{1:0}$ – –	– – –
Hi and hello	– – $8.12^{0:1}$	– –	$14.48^{1:0}$ $1.69^{1:1}$ $14.48^{0:1}$	– – –	$8.49^{1:0}$ $7.51^{1:1}$ $21.28^{0:1}$	**$3.58^{2:1}$** – –	$10.58^{1:0}$ $14.09^{1:1}$ $28.28^{0:1}$	$9.57^{2:1}$ – –
Goodbye	– – $15.31^{0:1}$	– – –	$21.68^{1:0}$ $8.94^{1:1}$ $8.89^{0:1}$	– – $5.86^{1:2}$	$12.65^{1:0}$ $2.09^{1:1}$ $10.77^{0:1}$	$11.35^{2:1}$ $5.89^{2:2}$ $11.59^{1:2}$	$9.09^{1:0}$ **$3.82^{1:1}$** $16.77^{0:1}$	$5.30^{2:1}$ $11.72^{2:2}$ $18.12^{1:2}$

Resulting alignment (one 2-to-1 match & one 1-to-1 match):



Hej

Hallo

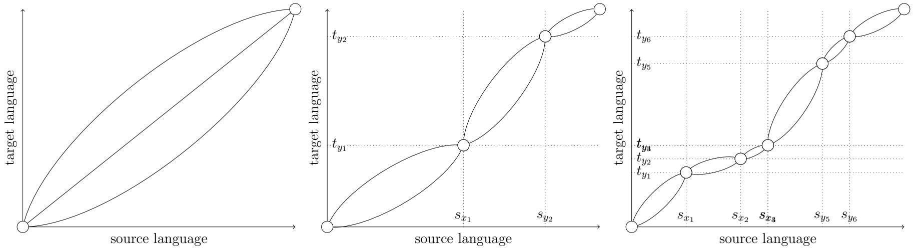
Hejdå

Hi and hello

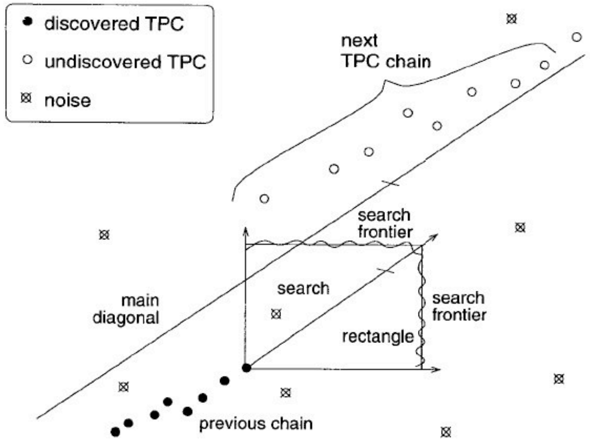
Goodbye

Idea 2: Lexical Matching Approaches

- discover translation equivalents (close to diagonal)
- align sentences that do not violate lexical links (a lot)



Lexical Translation Chains (Melamed)



Sentence Alignment Quality

How good is my alignment algorithm?

Depends very much on the input data

- complete (mostly literal) translations
- no inserted text
- correct paragraph / sentence boundaries

Error propagation (especially length-based approaches)

Other clues:

- formatting
- time information (movie subtitles)

Summary on Building Parallel Corpora

Collect and convert translated documents

Parallel corpora need alignment

- paragraph alignment
- sentence alignment

Automatic sentence alignment

- length-based approaches
- lexical matching approaches

Problems: incomplete translations, noisy texts, ...

Beyond Sentence Alignment

Is it possible to find links between smaller units than paragraphs and sentences?

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Translate Centauri into Arcturan

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

1a. ok-voon ororok sprok . 1b. at-voon bichat dat .	7a. lalok farok ororok lalok sprok izok enemok . 7b. wat jjat bichat wat dat vat eneat .
2a. ok-drubel ok-voon anok plok sprok . 2b. at-drubel at-voon pippat rrat dat .	8a. lalok brok anok plok nok . 8b. iat lat pippat rrat nnat .
3a. erok sprok izok hihok ghirok . 3b. totat dat arrat vat hilat .	9a. wiwok nok izok kantok ok-yurp . 9b. totat nnat quat oloat at-yurp .
4a. ok-voon anok drok brok jok . 4b. at-voon krat pippat sat lat .	10a. lalok mok nok yorok ghirok clok . 10b. wat nnat gat mat bat hilat .
5a. wiwok farok izok stok . 5b. totat jjat quat cat .	11a. lalok nok crrrok hihok yorok zanzanok . 11b. wat nnat arrat mat zanzanat .
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(Knight, 1997)

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Translate Centauri into Arcturan

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

1a. ok-voon ororok sprok . 1b. at-voon bichat dat .	7a. lalok **farok** ororok lalok sprok izok enemok . 7b. wat jjat bichat wat dat vat eneat .
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4a. ok-voon anok drok brok jok . 4b. at-voon krat pippat sat lat .	10a. lalok mok nok yorok ghirok clok . 10b. wat nnat gat mat bat hilat .
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2a. ok-drubel ok-voon anok plok sprok . 2b. at-drubel at-voon pippat rrat dat .	8a. lalok brok anok plok nok . 8b. iat lat pippat rrat nnat .
3a. erok sprok izok hihok ghirok . 3b. totat dat arrat vat hilat .	9a. wiwok nok izok kantok ok-yurp . 9b. totat nnat quat oloat at-yurp .
4a. ok-voon anok drok brok jok . 4b. at-voon krat pippat sat lat .	10a. lalok mok nok yorok ghirok clok . 10b. wat nnat gat mat bat hilat .
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4a. ok-voon anok drok brok jok . 4b. at-voon krat pippat sat lat .	10a. lalok mok nok yorok ghirok clok . 10b. wat nnat gat mat bat hilat .
5a. wiwok **farok** izok stok . 5b. totat jjat quat cat .	11a. lalok nok **crrrok** hihok yorok zanzanok . ??? 11b. wat nnat arrat mat zanzanat .
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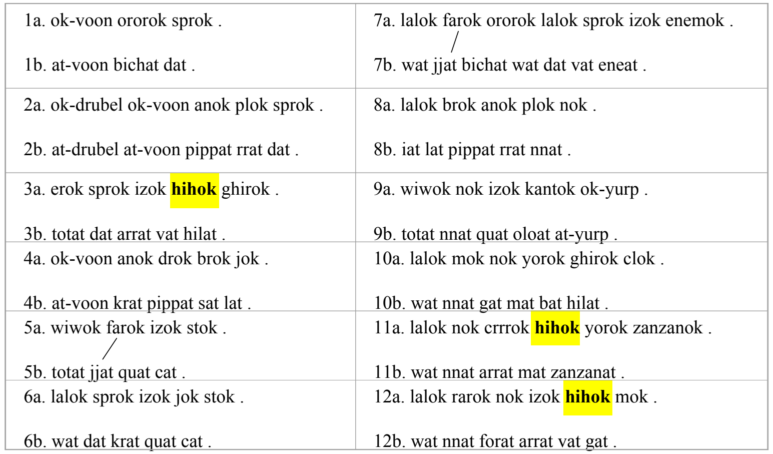
Translate Centauri into Arcturan

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



1a. ok-voon ororok sprok . 1b. at-voon bichat dat .	7a. lalok farok ororok lalok sprok izok enemok . 7b. wat jjat bichat wat dat vat eneat .
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Translate Centauri into Arcturan

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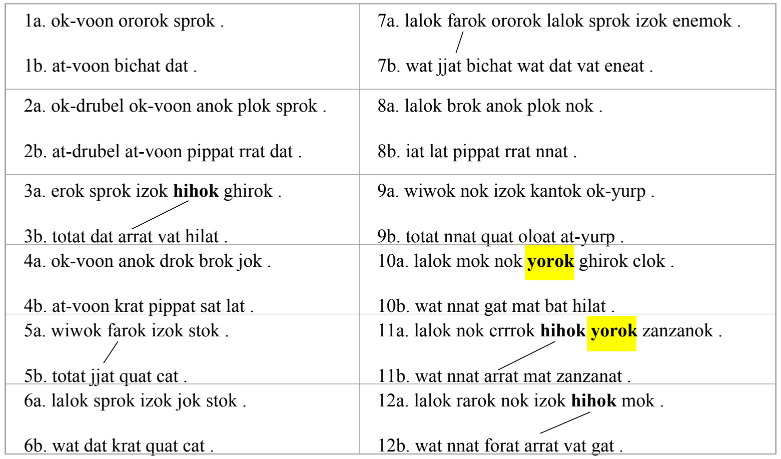

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4a. ok-voon anok drok brok jok . 4b. at-voon krat pippat sat lat .	10a. lalok mok nok **yorok** ghirok clok . 10b. wat nnat gat mat bat hilat .
5a. wiwok farok izok stok . 5b. totat jjat quat cat .	11a. lalok nok crrrok **hihok** **yorok** zanzanok . 11b. wat nnat arrat mat zanzanat .
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Translate Centauri into Arcturan

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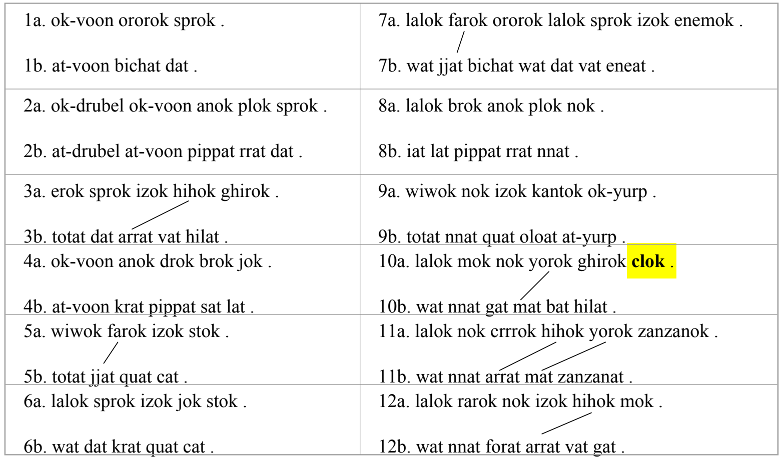

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Translate Centauri into Arcturan

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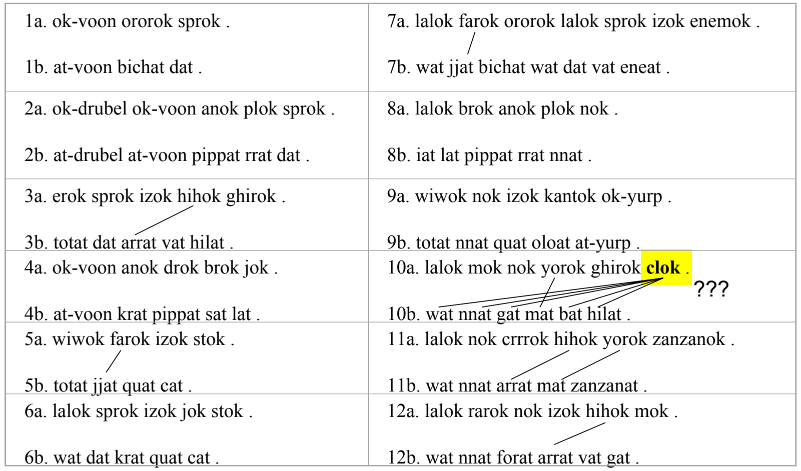

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5a. wiwok farok izok stok . 5b. totat jjat quat cat .	11a. lalok nok crrrok hihok yorok zanzanok . 11b. wat nnat arrat mat zanzanat .
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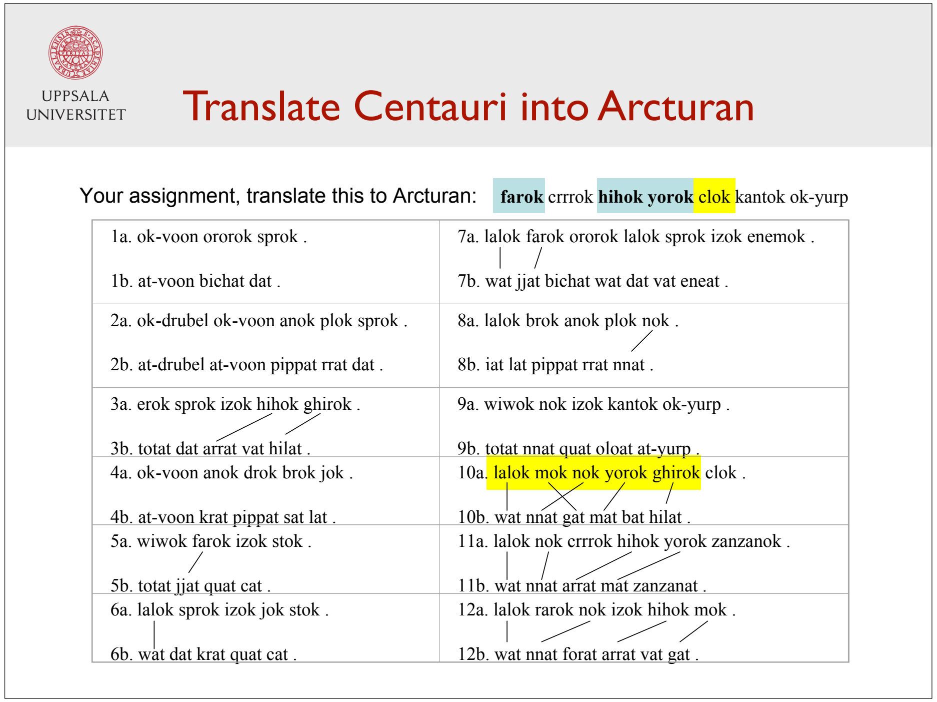

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Translate Centauri into Arcturan

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4a. ok-voon anok drok brok jok . 4b. at-voon krat pippat sat lat .	10a. lalok mok nok yorok ghirok clok . 10b. wat nnat gat mat bat hilat .
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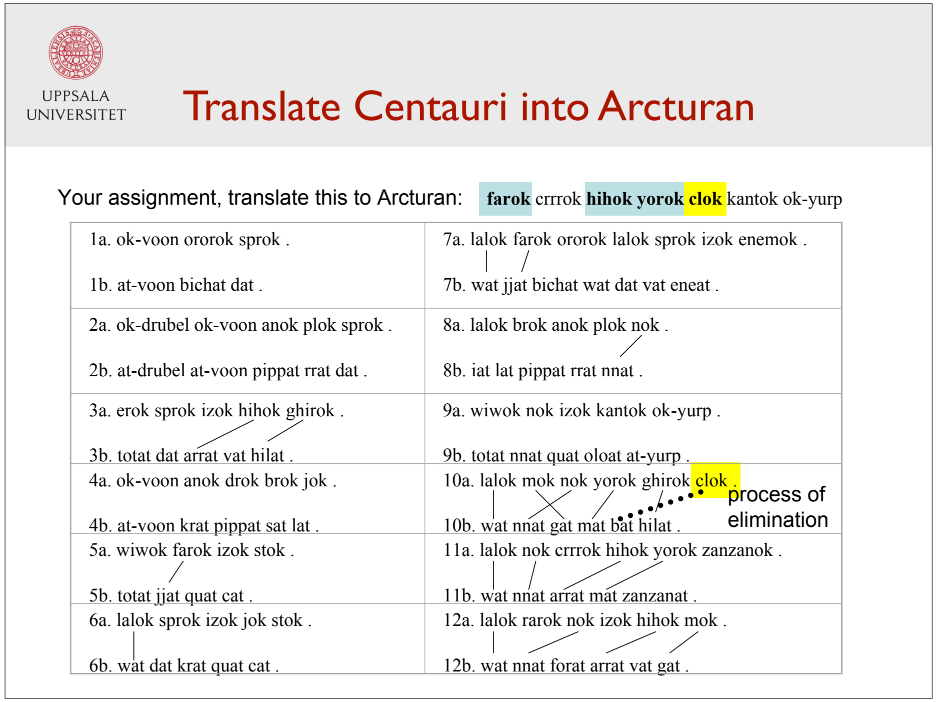

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Translate Centauri into Arcturan

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

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4a. ok-voon anok drok brok jok . 4b. at-voon krat pippat sat lat .	10a. lalok mok nok yorok ghirok clok . 10b. wat nnat gat mat bat hilat .
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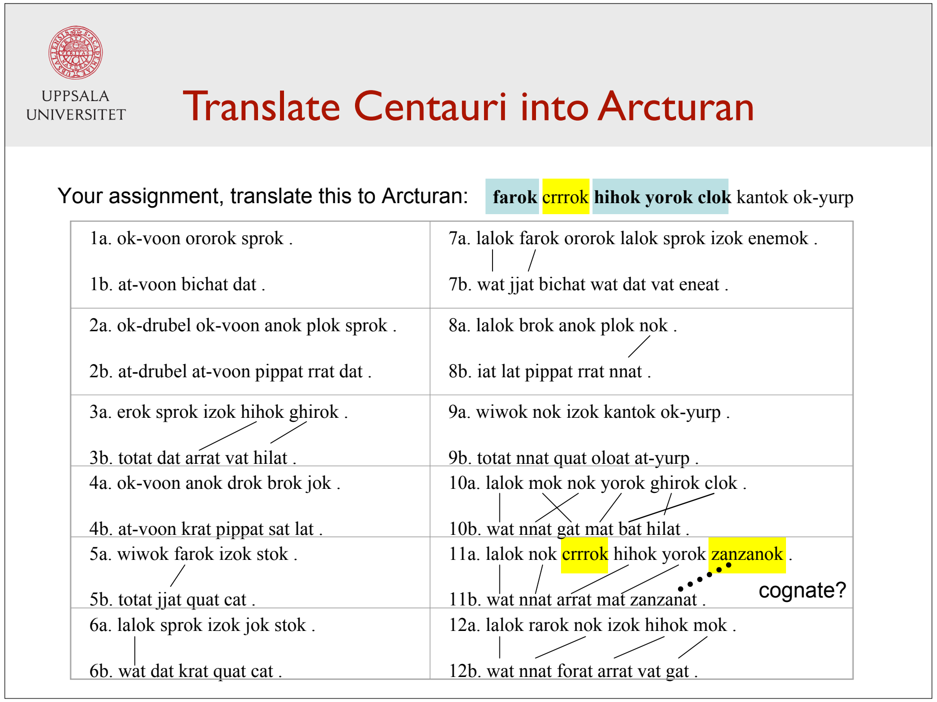
process of elimination



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

1a. ok-voon ororok sprok . 1b. at-voon bichat dat .	7a. lalok farok ororok lalok sprok izok enemok . 7b. wat jjat bichat wat dat vat eneat .
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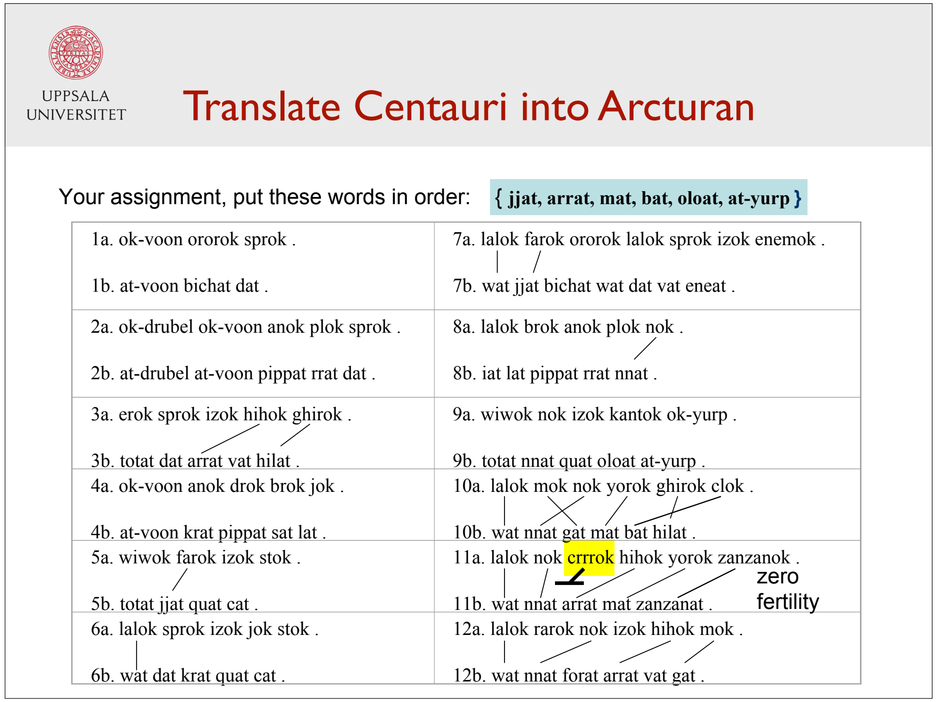
cognate?



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Translate Centauri into Arcturan

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

1a. ok-voon ororok sprok . 1b. at-voon bichat dat .	7a. lalok farok ororok lalok sprok izok enemok . 7b. wat jjat bichat wat dat vat eneat .
2a. ok-drubel ok-voon anok plok sprok . 2b. at-drubel at-voon pippat rrat dat .	8a. lalok brok anok plok nok . 8b. iat lat pippat rrat nnat .
3a. erok sprok izok hihok ghirok . 3b. totat dat arrat vat hilat .	9a. wiwok nok izok kantok ok-yurp . 9b. totat nnat quat oloat at-yurp .
4a. ok-voon anok drok brok jok . 4b. at-voon krat pippat sat lat .	10a. lalok mok nok yorok ghirok clok . 10b. wat nnat gat mat bat hilat .
5a. wiwok farok izok stok . 5b. totat jjat quat cat .	11a. lalok nok crrrok hihok yorok zanzanok . 11b. wat nnat arrat mat zanzanat .
6a. lalok sprok izok jok stok . 6b. wat dat krat quat cat .	12a. lalok rarok nok izok hihok mok . 12b. wat nnat forat arrat vat gat .

zero fertility

Translate Centauri into Arcturan

Clients do not sell pharmaceuticals in Europe => **Clientes no venden medicinas en Europa**

1a. Garcia and associates . 1b. Garcia y asociados .	7a. the clients and the associates are enemies . 7b. los clients y los asociados son enemigos .
2a. Carlos Garcia has three associates . 2b. Carlos Garcia tiene tres asociados .	8a. the company has three groups . 8b. la empresa tiene tres grupos .
3a. his associates are not strong . 3b. sus asociados no son fuertes .	9a. its groups are in Europe . 9b. sus grupos estan en Europa .
4a. Garcia has a company also . 4b. Garcia tambien tiene una empresa .	10a. the modern groups sell strong pharmaceuticals . 10b. los grupos modernos venden medicinas fuertes .
5a. its clients are angry . 5b. sus clientes estan enfadados .	11a. the groups do not sell zenzanine . 11b. los grupos no venden zanzanina .
6a. the associates are also angry . 6b. los asociados tambien estan enfadados .	12a. the small groups are not modern . 12b. los grupos pequenos no son modernos .

Conclusions

It is possible to find links between words

... without any prior knowledge

- Distribution of words is a good clue
- Orthographic similarities may be another
- Sentence alignment is essential to make this work!

Word alignment is useful for many things

- learn to translate
- lexicography
- annotation projection
- ...

Questions?