

Multi-Pivot translation by system combination

Gregor Leusch, Hermann Ney

Aurélien Max, Josep Maria Crego, François Yvon

{leusch, ney}@i6.informatik.rwth-aachen.de,

{aurelien.max, jmcrego}@limsi.fr

International Workshop on Spoken Language Translation 2010
December 3, 2010

Lehrstuhl für Informatik 6
RWTH Aachen University, Germany

LIMSI-CNRS & Univ. Paris-Sud
Orsay, France

Outline

- 1. Introduction: Multilingual Machine Translation**
- 2. Multi Source Translation and System Combination**
- 3. Multi Pivot Translation**
- 4. Experimental setup**
- 5. Results**
- 6. Conclusion and Outlook**

Introduction: Multilingual Machine Translation

- ▶ “Classical” MT: Translate from one language (*source*) into one other language (*target*)
- ▶ We can only exploit knowledge from these two languages
- ▶ We need (for statistical MT) large amounts of parallel training data in these two languages
- ▶ For each new language pair, we need new data
- ▶ Good data is scarce

In a multilingual world, we have:

- ▶ Many possible source and target languages
- ▶ Languages with scarce resources
- ▶ Language pairs with scarce bilingual resources

Illustration: Matrix-style scenario

Assume we want to translate from any EU language to any other EU language.

Only direct systems:

| | bg | cs | da | de | el | en | es | et | fi | fr | ga | hu | it | ka | lt | lv | mt | nl | pl | pt | ro | sk | sl | sv |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| bg | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| cs | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| da | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| de | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| el | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| en | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| es | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| et | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| fi | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| fr | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| ga | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • |
| hu | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • |
| it | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • |
| ka | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • |
| lt | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • |
| lv | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • |
| mt | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • |
| nl | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • |
| pl | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • |
| pt | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • |
| ro | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • |
| sk | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • |
| sl | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • |
| sv | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |

► 506 MT engines

Multilingual MT / Multi Source MT

- ▶ **But: There are several scenarios where data in other languages available for exploitation, either for training, or from the source**
 - ▷ **Word sense disambiguation**
 - ▷ **anaphora resolution,**
 - ▷ **word order from more related languages**
 - ▷ **...**

“Documents translated into more than one language will likely be translated into many more languages” [Kay 00]

Multi Source:

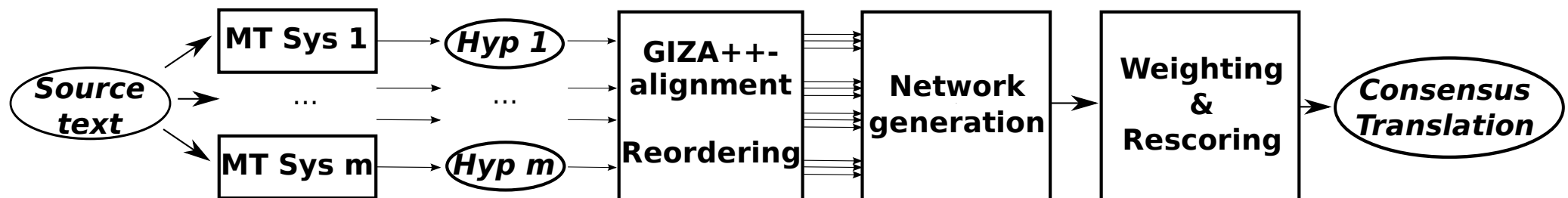
- ▶ **In some applications, documents are available in more than one language.**
- ▶ **Task here: Produce translation in a new language**
- ▶ **→ use multi-source instead of single-source information**

Multi Source Translation: Approaches

- ▶ **Sentence Selection**
 - ▷ Using translation scores [Och & Ney 01]
 - ▷ Using additional features ([Hildebrand & Vogel 08, Crego & Max⁺ 09])
- ▶ **Multi-Source Decoding**
 - ▷ Parallel decoding [Och & Ney 01]
 - ▷ Constrained decoding [Schwartz 08]
- ▶ **System Combination**
 - ▷ (Sentence selection) [Hildebrand & Vogel 08, Crego & Max⁺ 09]
 - ▷ **Confusion Network Consensus Translation**
[Matusov & Ueffing⁺ 06, Leusch & Popović⁺ 09]

Confusion Network based System Combination

- ▶ Basic idea from ASR: ROVER [Fiscus 97]
- ▶ Implementation at RWTH: [Matusov & Leusch⁺ 08]

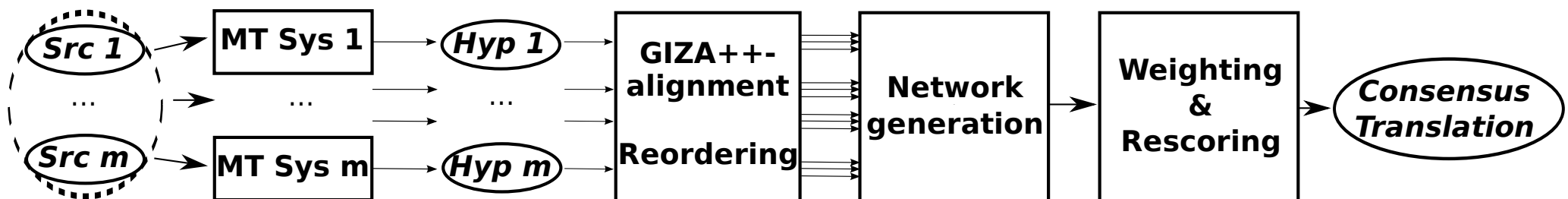


[Details]

System Combination as Multi-source translation

▶ Idea:

- ▶ Treat MT systems for different source language as different MT systems
- ▶ *Ignore that they do not have the same source language*
- ▶ Generate consensus translation from these systems



[Details]

Pivot Translation

- ▶ **Statistical MT needs large amount of bilingual training data**
- ▶ **For many language pairs, only scarce bilingual resources available**
- ▶ **For tasks with large number of potential source/target languages, hardly possible to have systems for all pairs, e.g.**
 - ▷ **EU: 23 official languages = 506 language pairs**
- ▶ **Idea: Use a different language as **pivot language** (or *bridge language*)**
- ▶ **E.g. to translate from Latvian to Irish use resources for the language pairs Latvian–English and English–Irish**
- ▶ **Needs rich resources/systems in Source–Pivot and Pivot–Target pair**

Pivot Translations: Approaches

Assume we want to translate from **Latvian** to **Irish** using **English** as pivot language.

Possible approaches: (see [Wu & Wang 09])

- ▶ **Via Generated training data:**
Create Latvian–Irish training data by translating Latvian–English or English–Irish training data using an MT system
- ▶ **Via Combined phrase tables:**
Create Latvian–Irish phrase table (etc) directly from their pivot counterparts
- ▶ **Via Dedicated intermediate translations:**
For each Latvian sentence to translate,
 - ▷ translate it into English using the first MT system.
 - ▷ translate this into Irish using the second system.

Multi Pivot Translations

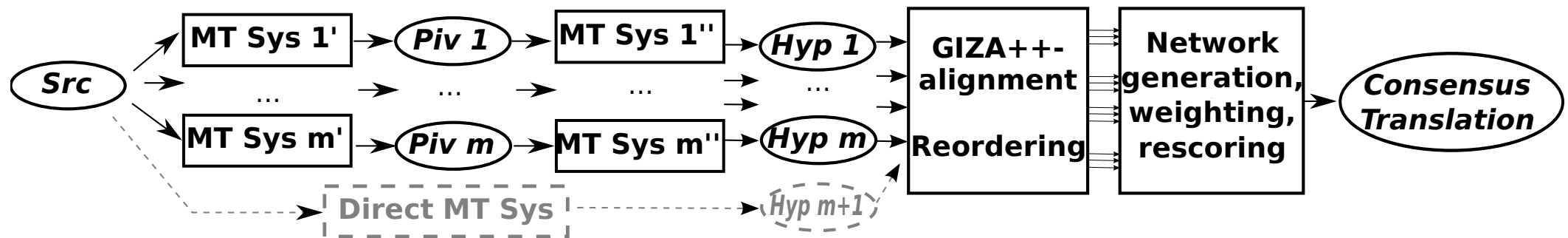
▶ Idea:

- ▶ Use intermediate-translation pivoting, but:
- ▶ Use multiple intermediate translations in different pivot languages
- ▶ Treat the second step as a **multi-source translation** problem

▶ Rationales:

- ▶ Smooth artefacts (correct errors) in phrase table
 - ▶ Exploit LMs in different languages to resolve ambiguities
 - ▶ On matrix scenario: Focus on few good systems
- ▶ Can we also use this to improve an existing “direct” (non-pivot) system?
[Koehn & Birch⁺ 09]
- ▶ [Crego & Max⁺ 09]: Hypothesis selection (more precisely: direct-system nbest rescoring using pivot translations)
- ▶ Here: CN-based Multi-Source MT / System Combination

Multi Pivot Translations: Architecture



Example: Matrix-style scenario

Assume we want to translate from any EU language to any other EU language.

Only direct systems:

| | bg | cs | da | de | el | en | es | et | fi | fr | ga | hu | it | ka | lt | lv | mt | nl | pl | pt | ro | sk | sl | sv |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| bg | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| cs | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| da | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| de | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| el | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| en | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| es | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| et | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| fi | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| fr | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| ga | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • |
| hu | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • |
| it | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • |
| ka | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • |
| lt | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • |
| lv | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • |
| mt | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • |
| nl | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • |
| pl | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • |
| pt | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • |
| ro | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • |
| sk | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • |
| sl | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • |
| sv | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |

► 506 MT engines

Example: Matrix-style scenario

Assume we want to translate from any EU language to any other EU language.

4 pivot languages (e.g., de, en, es, fr):

| | bg | cs | da | de | el | en | es | et | fi | fr | ga | hu | it | ka | lt | lv | mt | nl | pl | pt | ro | sk | sl | sv | | |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|
| bg | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| cs | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| da | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| de | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| el | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| en | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| es | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| et | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| fi | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| fr | • | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| ga | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| hu | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| it | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| ka | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| lt | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| lv | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| mt | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| nl | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| pl | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| pt | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| ro | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| sk | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| sl | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |
| sv | | | | • | | • | • | | | • | | | | | | | | | | | | | | | | |

► 164 MT engines

Pivot & direct system setup:

- ▶ **French → English, German → English, French → German**
- ▶ **Total: 11 languages from Europarl, incl Pivot**
- ▶ **19 systems built**
- ▶ **N-gram-based SMT systems [Crego & Marino 07]**
- ▶ **Training data parallel in all 11 languages**
 - ▷ **Same amount of data per system (320k lines)**
 - ▷ **Advantage: Consistency**
 - ▷ **Disadvantage: No “new” phrases possible**
- ▶ **Held out dev and test sets**

Corpus statistics

| | Train | | Dev | | | Test | | |
|-----------|-------|--------|-------|------|-----|-------|------|-----|
| | Words | Voc. | Words | Voc. | OOV | Words | Voc. | OOV |
| DA | 8.5M | 133.5k | 13.4k | 3.2k | 104 | 25.9k | 5.1k | 226 |
| DE | 8.5M | 145.3k | 13.5k | 3.5k | 120 | 26.0k | 5.5k | 245 |
| EN | 8.9M | 53.7k | 14.0k | 2.8k | 39 | 27.2k | 4.0k | 63 |
| ES | 9.3M | 85.3k | 14.6k | 3.3k | 56 | 28.6k | 5.0k | 88 |
| FI | 6.4M | 274.9k | 10.1k | 4.3k | 244 | 19.6k | 7.1k | 407 |
| FR | 10.3M | 67.8k | 16.1k | 3.2k | 47 | 31.5k | 4.8k | 87 |
| EL | 8.9M | 128.3k | 14.1k | 3.9k | 72 | 27.2k | 6.2k | 159 |
| IT | 9.0M | 78.9k | 14.3k | 3.4k | 61 | 28.1k | 5.1k | 99 |
| NL | 8.9M | 105.0k | 14.2k | 3.1k | 76 | 27.5k | 4.8k | 162 |
| PT | 9.2M | 87.3k | 14.5k | 3.4k | 49 | 28.3k | 5.2k | 118 |
| SV | 8.0M | 140.8k | 12.7k | 3.3k | 116 | 24.5k | 5.2k | 226 |

Experimental setup 2

System Combination setup:

- ▶ **CN-based system combination using all possible primaries**
- ▶ **No additional nbest rescoring**
- ▶ **All “training” only on pivot hyps, no additional training data (e.g. LM)**
- ▶ **Case-insensitive combination and scoring**

Experiments: Multi-Pivot

First experiment: *Can multi-pivot **replace** a direct system?*

- ▶ Do not include direct fr–en/de–en/fr–de systems
- ▶ Start with three pivot languages
- ▶ Add more (in *greedy* order)

Second experiment: *Can multi-pivot **improve** a direct system?*

- ▶ Include direct fr–en/de–en/fr–de systems
- ▶ Add pivot languages in same order as before

Results: DE-EN

| system | single | | pivot only | | direct + pivot | |
|--------|--------|------|------------|------|----------------|------|
| | BLEU | TER | BLEU | TER | BLEU | TER |
| direct | 24.8 | 58.7 | — | | | |
| via NL | 22.7 | 61.6 | | | | |
| via DA | 22.8 | 63.4 | | | 24.6 | 58.0 |
| via PT | 22.0 | 63.6 | 23.6 | 59.6 | 25.4 | 57.0 |
| via FR | 21.6 | 62.9 | 24.5 | 58.5 | 25.5 | 56.7 |
| via ES | 21.3 | 62.6 | 24.4 | 58.0 | 25.4 | 56.8 |
| via EL | 21.0 | 63.7 | 24.7 | 57.5 | 25.3 | 56.8 |
| via SV | 21.4 | 61.1 | 25.1 | 57.0 | 25.5 | 56.7 |
| via FI | 18.1 | 68.0 | 24.9 | 57.3 | 25.3 | 56.7 |
| via IT | 18.2 | 61.3 | 25.2 | 57.8 | 25.3 | 56.7 |

Results: FR-EN

| system | single | | pivot only | | direct + pivot | |
|--------|--------|------|------------|------|----------------|------|
| | BLEU | TER | BLEU | TER | BLEU | TER |
| direct | 29.6 | 54.7 | — | | | |
| via ES | 27.9 | 57.2 | | | | |
| via PT | 27.4 | 56.9 | | | 29.5 | 54.1 |
| via EL | 25.4 | 60.1 | 28.7 | 55.4 | 30.0 | 53.9 |
| via IT | 25.9 | 56.5 | 29.0 | 54.2 | 30.1 | 53.8 |
| via DA | 25.6 | 60.1 | 29.5 | 54.3 | 30.9 | 53.4 |
| via NL | 25.3 | 59.4 | 29.9 | 53.9 | 30.5 | 53.5 |
| via DE | 23.6 | 60.5 | 29.6 | 53.5 | 30.4 | 53.3 |
| via SV | 23.8 | 57.2 | 29.7 | 53.5 | 30.6 | 53.3 |
| via FI | 19.3 | 69.2 | 29.8 | 53.6 | 30.8 | 53.3 |

Results: FR-DE

| system | single | | pivot only | | direct + pivot | |
|--------|--------|------|------------|------|----------------|------|
| | BLEU | TER | BLEU | TER | BLEU | TER |
| direct | 18.2 | 68.7 | — | | | |
| via ES | 17.0 | 71.0 | | | | |
| via NL | 17.0 | 69.1 | | | 18.8 | 66.9 |
| via PT | 16.5 | 69.7 | 18.0 | 66.3 | 18.9 | 65.4 |
| via IT | 16.7 | 70.6 | 18.4 | 65.7 | 18.8 | 65.1 |
| via EN | 15.9 | 71.5 | 18.5 | 65.0 | 19.1 | 65.9 |
| via DA | 16.5 | 70.1 | 18.7 | 65.9 | 19.3 | 65.1 |
| via EL | 16.1 | 70.5 | 19.0 | 64.3 | 19.6 | 64.7 |
| via SV | 14.0 | 73.5 | 19.3 | 64.6 | 19.6 | 64.4 |
| via FI | 11.6 | 82.8 | 19.4 | 64.5 | 19.6 | 64.2 |

Example

Source

les réflexions étranges de ceux qui trouvent que ceux qui ne pratiquent pas d'enrichissement devraient recevoir des droits de plantation supplémentaires sont quand même complètement débiles!

Reference translation

and the strange idea some people have that wine growers not using enrichment should be given additional planting rights is simply crazy.

Direct translation fr-en

the strange ideas of those who find that those who do not practise should receive additional planting rights are still completely débiles!

Single pivot translation fr-(es)-en

the comments of those who are those who are not being enrichment should receive additional planting rights are completely mental anyway!

Multi-pivot translation fr-(es+pt+el+it+da+nl)-en

the strange of those who think that those who do not practise enrichment should receive additional planting rights are débiles!

Multi-pivot plus direct translation fr-(en+es+pt+el+it+da)-en

the strange ideas of those who think that those who do not practise enrichment should receive additional planting rights are completely débiles!

Conclusions & Future Work

In our training conditions (especially, same training corpus for all systems):

- ▶ **Combining multiple pivot translations improves translation quality over a single-pivot translation**
- ▶ **With about 5–6 pivot languages, translation quality reaches quality of direct system**
- ▶ **Even 2 additional pivot languages can improve an existing “direct” system; the more, the better**
- ▶ **Improvements of up to +1.3 BLEU / -2.0 TER possible**
- ▶ **Experiments: Try combination of different MT engines (e.g. (PBT+JANE) – (PBT+JANE))**
- ▶ **Investigate RARE–(FREQUENT+FREQUENT+FREQUENT)–RARE scenario (e.g. It-(en+fr+es)-ei)**
- ▶ **Regarding “matrix” scenario: Are the optimization parameters source-language independent?**

Thank you for your attention

Gregor Leusch

`leusch@i6.informatik.rwth-aachen.de`

`http://www-i6.informatik.rwth-aachen.de/`

References

- [Crego & Marino 07] Josep M. Crego, Jose B. Marino: Extending MARIE: an N-gram-based SMT decoder. In *ACL '07: Proceedings of the 45th Annual Meeting of the ACL on Interactive Poster and Demonstration Sessions*, pp. 213–216, Morristown, NJ, USA, 2007. Association for Computational Linguistics. 15
- [Crego & Max⁺ 09] Josep M. Crego, Aurélien Max, François Yvon: A case study in multi-lingual system combination. Improving SMT with SMT? Quaero WP4-WP5 Workshop, July 2009. 6, 11
- [Fiscus 97] J.G. Fiscus: A Post-Processing System to Yield Reduced Word Error Rates: Recognizer Output Voting Error Reduction (ROVER). In *IEEE Workshop on Automatic Speech Recognition and Understanding*, 1997. 7
- [Hildebrand & Vogel 08] Almut Silja Hildebrand, Stephan Vogel: Combination of Machine Translation Systems via Hypothesis Selection from Combined N-Best Lists. In *Proc. AMTA*, pp. 254–261, October 2008. 6
- [Kay 00] Martin Kay: Triangulation in translation, 2000. 5
- [Koehn & Birch⁺ 09] Philipp Koehn, Alexandra Birch, Ralf Steinberger: 462 Machine Translation Systems for Europe. pp. 65–72, August 2009. 11
- [Leusch & Popović⁺ 09] Gregor Leusch, Maja Popović, Evgeny Matusov, Hermann Ney: Multilingual System Combination as Multi-Source translation: RWTH's WMT 2009 submission. Quaero CTC Meeting, March 2009. 6

- [Matusov & Leusch⁺ 08]** Evgeny Matusov, Gregor Leusch, Rafael E. Banchs, Nicola Bertoldi, Daniel Dechelotte, Marcello Federico, Muntsin Kolss, Young-Suk Lee, Jose B. Marino, Matthias Paulik, Salim Roukos, Holger Schwenk, Hermann Ney: System Combination for Machine Translation of Spoken and Written Language. *IEEE Transactions on Audio, Speech and Language Processing*, Vol. 16, No. 7, pp. 1222–1237, Sept. 2008. 7
- [Matusov & Ueffing⁺ 06]** Evgeny Matusov, Nicola Ueffing, Hermann Ney: Computing Consensus Translation from Multiple Machine Translation Systems Using Enhanced Hypotheses Alignment. In *Conference of the European Chapter of the Association for Computational Linguistics (EACL)*, pp. 33–40, Trento, Italy, April 2006. 6
- [Och & Ney 01]** Franz Josef Och, Hermann Ney: Statistical Multi-Source Translation. In *Machine Translation Summit*, pp. 253–258, Santiago de Compostela, Spain, Sept. 2001. 6
- [Schwartz 08]** Lane Schwartz: Multi-Source Translation Methods. In *Proc. AMTA*, pp. 279–288, October 2008. 6
- [Wu & Wang 09]** Hua Wu, Haifeng Wang: Revisiting Pivot Language Approach for Machine Translation. In *Proceedings of the Joint Conference of the 47th Annual Meeting of the ACL and the 4th International Joint Conference on Natural Language Processing of the AFNLP*, pp. 154–162, Suntec, Singapore, August 2009. Association for Computational Linguistics. 10

System Combination: Steps

1. **Preprocessing: normalize true casing, frequent NE, ...**
2. **Generate hyp-LM**
3. **Alignment and reordering:**
 - ▶ **Initialize “monolingual lexicon” (synonyms) by full match, prefix match (\approx stemming)**
 - ▶ **“Train” alignment (gammas) using GIZA++**
 - ▶ **Align and reorder hyps to a primary (skeleton) hyp**
4. **Generate a confusion network**
 - ▶ **Along primary**
 - ▶ **Special treatment at insertions vs. the primary**
5. **Vote, “local determinize”, LM-rescore (hyp-LM)**
6. **Return best path (consensus translation)**

[\[Back to Syscombi Principle\]](#)

System Combination: Example

| | |
|---------------------------------|--|
| source sent. | préférez-vous du café ou du thé |
| pivot translations | préférez-vous du café ou du thé wilt u graag thee of koffie quiere café o té ich hätte Kaffee oder Tee, was wünschen Sie |
| system hypotheses | 0.25 would your like coffee or tea 0.35 have you tea or Coffee 0.10 would like your coffee or 0.30 I have some coffee tea would you like |
| alignment and reordering | have would you your \$ like Coffee coffee or or tea tea would would your your like like coffee coffee or or \$ tea I \$ would would you your like like have \$ some \$ coffee coffee \$ or tea tea |
| confusion network | \$ would your like \$ \$ coffee or tea \$ have you \$ \$ \$ Coffee or tea \$ would your like \$ \$ coffee or \$ I would you like have some coffee \$ tea |
| voting (normalized) | \$ would you \$ \$ \$ coffee or tea 0.7 0.65 0.65 0.35 0.7 0.7 0.5 0.7 0.9 I have your like have some Coffee \$ \$ 0.3 0.35 0.35 0.65 0.3 0.3 0.5 0.3 0.1 |
| consensus transl. | would you like coffee or tea |

[\[Back to Syscombi Principle\]](#) [\[Back to Multisource Principle\]](#)