Projection of Trees across Parallel Texts

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- Rebecca Hwa, Philip Resnik, Amy Weinberg, Clara Cabezas, Okan Kolak (2004). Bootstrapping Parsers via Syntactic Projection across Parallel Texts

- Source: English
- Target: Spanish, Chinese
- Dependency trees (not phrase structure)
Projection System Architecture

- Bilingual Corpus
  - English
  - Non-English
- English Dependency Parser
- Word Alignment Model
- Projected Non-English Dependency Treebank
- Dependency Parser
- New Non-English Sentences
- Dependency Trees for New Sentences
- Projection
- Transformation
- Filtering
Direct Projection

Given sentence pair \((E, F)\) and a set of syntactic relations for \(E\), where \(E = e_1, ..., e_n\) is an English sentence and \(F = f_1, ..., f_m\) is its non-English parallel, syntactic relations \(R(x, y)\) are projected from English as follows:

- **one-to-one** – \(e_i\) aligned with a unique \(f_x\) and \(e_j\) aligned with a unique \(f_y\) – then
  \[ R(e_i, e_j) \Rightarrow R(f_x, f_y) \]

- **one-to-many** – \(e_i\) aligned with \(f_x, ..., f_y\) – then create new empty \(f_z\), parent of \(f_x, ..., f_y\), and set \(e_i\) to align to \(f_z\) instead

- **many-to-one** – \(e_i, ..., e_j\) uniquely aligned to \(f_x\) – then keep the head of \(e_i, ..., e_j\) aligned to \(f_x\), and delete other alignments

- **many-to-many** – decompose: first one-to-many, then many-to-one

- **unaligned foreign** – leave them out of the projected tree
Given sentence pair $(E, F)$ and a set of syntactic relations for $E$, where $E = e_1, ..., e_n$ is an English sentence and $F = f_1, ..., f_m$ is its non-English parallel, syntactic relations $R(x, y)$ are projected from English as follows:

- **one-to-one** – $e_i$ aligned with a unique $f_x$ and $e_j$ aligned with a unique $f_y$ – then $R(e_i, e_j) \Rightarrow R(f_x, f_y)$

- **unaligned English** – $e_j$ not aligned with any word in $F$ – create new empty word $f_y$ so that for any $e_i$ aligned with a unique $f_x$, $R(e_i, e_j) \Rightarrow R(f_x, f_y)$ and $R(e_j, e_i) \Rightarrow R(f_y, f_x)$
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He took a picture of my daughter.

Vyfotil si

moji dceru
Direct Projection Example

He took a picture of my daughter

Vyfotil si moji dceru

Projection of Trees across Parallel Texts
He took a picture of my daughter.
He took a picture of my daughter.
He took a picture of my daughter Vyfotil.
He took a picture of my daughter.
He took a picture of my daughter.
He took a picture of my daughter Vyfotil si moji dceru.
He took a picture of my daughter Vyfotil si moji dceru.
He took a picture of my daughter.
He took a picture of my daughter.
Many-to-One Assumption: 
\( e_i, ..., e_j \) Is a Phrase with One Head
Many-to-One Assumption: $e_i, \ldots, e_j$ is a phrase with one head. What if not?
Experiments with Direct Projection

- 100 gold trees projected from English to Spanish
- 88 gold trees projected from English to Chinese
- Word alignments are gold-standard too!
  - The goal is just to check the direct correspondence assumption.
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- Word alignments are gold-standard too!
  - The goal is just to check the direct correspondence assumption.

- Compared with target gold-standard trees
  - Spanish unlabeled F-score = 37%
  - Chinese unlabeled F-score = 38%
Many-to-one deletes alignments ⇒ tree is not connected
Possible solution: transitive closure?

He took a picture of my daughter

Projection of Trees across Parallel Texts
Many-to-one deletes alignments ⇒ tree is not connected
  ▶ Possible solution: transitive closure?

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$f_1$ Vyfotil $f_6$ moji dceru
Problems

- Many-to-one deletes alignments $\Rightarrow$ tree is not connected
  - Possible solution: transitive closure?

- Unaligned foreign words remain unattached
  - Possible solution: postprocessing with target language knowledge
Postprocessing Rules

- A few dozen rules, less than a month work

- Spanish example
  - A reflexive clitic should modify the verb to its left.

- Chinese example
  - An aspectual marker should modify the verb to its left.
100 gold trees projected from English to Spanish

88 gold trees projected from English to Chinese

Word alignments are gold-standard too!

Compared with target gold-standard trees

- Spanish unlabeled F-score = 70%
- Chinese unlabeled F-score = 67%
Real-World Setting

- Collins Model2 (1997) English parser trained on Penn Treebank / WSJ
- Converted to dependencies (Magerman 1994, Xia and Palmer 2001)

- Word alignments computed with GIZA++ (Och and Ney 2003)
  - 100K en-es sentence pairs (Bible, Federal Broadcasting Information Service, United Nations Parallel Corpus)
  - 240K en-zh sentence pairs (Federal Broadcasting Information Service)

- Project trees using direct correspondence + postprocessing
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- Aggressive filtering: discard projected trees of poor quality
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- Project trees using direct correspondence + postprocessing
- Aggressive filtering: discard projected trees of poor quality
- Train Collins dependency parser (1999) on remaining trees
- Apply the parser to unseen target-language sentences
Pruning Criteria

Based on tuning on development set, discard if...

- > 20% of the English words have no Spanish counterpart
**Pruning Criteria**

- Based on tuning on development set, discard if...
  - > 20% of the English words have no Spanish counterpart
  - > 30% of the Spanish words have no English counterpart

Additional criteria for English-Chinese:
- Crossing dependencies
- Number of unattached nodes after postprocessing
- Number of words with unknown POS category

20K projected Spanish trees after filtering
50K projected Chinese trees after filtering
Pruning Criteria

Based on tuning on development set, discard if...

- > 20% of the English words have no Spanish counterpart
- > 30% of the Spanish words have no English counterpart
- > 4 Spanish words were aligned to the same English word

Additional criteria for English-Chinese:
- Crossing dependencies
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- Number of words with unknown POS category
- 20K projected Spanish trees after filtering
- 50K projected Chinese trees after filtering
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- 20K projected Spanish trees after filtering
- 50K projected Chinese trees after filtering
Experiments

- Spanish
  - Baseline (left-to-right) unl F-score = 33.8%
  - Parser on unfiltered data (98K) F = 67.3%
  - Parser on filtered data (20K) F = 72.1%
  - Commercial parser F = 69.2%
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- **Chinese**
  - Baseline (left-to-right) F = 35.1%
  - Baseline + postprocessing F = 44.3%
  - Parser on filtered data (50K) F = 53.9%
  - Parser on PennChineseTB (10K) F = 64.3%
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- Learning curve: projected parser = about 2K manual sentences