Reordering Rules for Phrase-based SMT

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Outline

- Introduction
- Definition of Reordering Rule
- Application of Reordering Rules
- Experiments
- Conclusions
Introduction

- An important aspect of SMT is **word reordering**

- Reordering occurs when translation changes relative position of words

- In SMT, word reordering is faced by
  1. Constraints
     - by limiting the number of possible reorderings
  2. Modeling
     - by assigning scores/probabilities to possible reordering

- We propose a linguistically motivated reordering model based on automatically extracted reordering rules
Reordering Rules

- At the level of:
  - Unit
  - Block (ngram) of units

- A unit can be:
  - POS (POS based rules)
  - Word (lexicalized rules)
Block

Definition of Block:

- a sequence of source units
- all occurrences of the sequence are aligned to consecutive positions
  - experimentally, this check is relaxed a bit
  - singletons are filtered out

Note that a single unit is also a block.

In the example, the sequence “a b c” is a block, while “d b” is not.
Reordering Rule

- Unit reordering rule:
  - lhs: block of units
  - rhs: normalized intra-alignment

- Block reordering rule:
  - lhs: two blocks
  - rhs: relative position of blocks

- Rules are weighted, according to statistics extracted from aligned training data.

- Rules are used in the rescoring of N-best lists as two additional feature functions.
## Application of Reordering Rules

1. list all possible rules that match the input source sentence.

<table>
<thead>
<tr>
<th>Test sentence:</th>
<th>我/rr</th>
<th>要/vmodal</th>
<th>送/v</th>
<th>餐/ng</th>
<th>服务/v</th>
<th>/wfullstop</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) UnitREORDER</td>
<td>/rr</td>
<td>/vmodal</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b) UnitREORDER</td>
<td>/rr</td>
<td>/vmodal</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Application of Reordering Rules (Cont.)

2. for each N-best entry, check if the rule is applied
   a. for each rule’s lhs, extract its actual alignment
      – /rr /vmodal # 1 1
   b. match the alignment with the rule’s reordering suggestion
      – alignment is over phrases, but rules involve the position of single units.
      – accept any rule which is “compatible” with the alignment.
      – Eg: for the rule pattern “/rr /vmodal”, any reordering rule is compatible.
3. compute the score

\[ h_{\text{rules}}(\tilde{e}, f, a) = \frac{1}{K} \left( \sum_{i=1}^{K} \log P(r_{(i)}^{n} | p_{(i)}^{n}) \right) \]  

(1)

K is the number of the reordering patterns matching the given source/target pair.
Translation Tasks and Data

- **Translation Tasks:** BTEC data, Open data Track
- **Language pairs:**
  - Chinese-to-English (POS based rules and Lexicalized rules)
  - Japanese-to-English (Lexicalized rules)
  - Arabic-to-English (Lexicalized rules)
- **Test sets:** IWSLT04, IWSLT05, Devset4
- **Dev set:** CSTAR03
- **BLEU%:** no-case
- **Non-monotone search:** IBM S4 reordering constraints

  - Chinese-to-English: MVD=6 MVN=6
  - Japanese-to-English: MVD=8 MVN=8
  - Arabic-to-English: MVD=4 MVN=4
Statistics of Rules

- Statistics of extracted and applied rules for Chinese-to-English

<table>
<thead>
<tr>
<th></th>
<th>Chi-POS</th>
<th></th>
<th>Chi-LEX</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unit</td>
<td>Block</td>
<td>Unit</td>
<td>Block</td>
</tr>
<tr>
<td>Extracted</td>
<td>86K</td>
<td>1,743K</td>
<td>77K</td>
<td>3,002K</td>
</tr>
<tr>
<td>Matches</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IWSLT’04</td>
<td>18,121</td>
<td>149,446</td>
<td>6,870</td>
<td>10,439</td>
</tr>
<tr>
<td>IWSLT’05</td>
<td>19,259</td>
<td>162,873</td>
<td>8,046</td>
<td>12,451</td>
</tr>
<tr>
<td>Devset4</td>
<td>19,245</td>
<td>272,364</td>
<td>6,987</td>
<td>7,375</td>
</tr>
</tbody>
</table>
Experimental Results

- **BLEU% scores on test sets**

<table>
<thead>
<tr>
<th></th>
<th>Chi-POS</th>
<th>Chinese</th>
<th>Japanese</th>
<th>Arabic</th>
</tr>
</thead>
<tbody>
<tr>
<td>IWSLT</td>
<td>baseline</td>
<td>48.63</td>
<td>48.79</td>
<td>48.88</td>
</tr>
<tr>
<td>2004</td>
<td>unit+block</td>
<td>49.16</td>
<td>49.42</td>
<td>49.41</td>
</tr>
<tr>
<td>IWSLT</td>
<td>baseline</td>
<td>55.58</td>
<td>57.30</td>
<td>50.65</td>
</tr>
<tr>
<td>2005</td>
<td>unit+block</td>
<td>56.04</td>
<td>57.82</td>
<td>51.32</td>
</tr>
<tr>
<td>Devset4</td>
<td>baseline</td>
<td>16.45</td>
<td>17.05</td>
<td>16.24</td>
</tr>
<tr>
<td></td>
<td>unit+block</td>
<td>17.36</td>
<td>17.44</td>
<td>16.61</td>
</tr>
</tbody>
</table>

- Absolute improvement of the BLEU score: 0.4-0.9
- BLEU score are obtained without penalizing the NIST score.
<table>
<thead>
<tr>
<th>Translation examples for the Chinese-to-English task with POS rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>baseline</td>
</tr>
<tr>
<td>rescored</td>
</tr>
<tr>
<td>reference</td>
</tr>
<tr>
<td>baseline</td>
</tr>
<tr>
<td>rescored</td>
</tr>
<tr>
<td>reference</td>
</tr>
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</tr>
<tr>
<td>rescored</td>
</tr>
<tr>
<td>reference</td>
</tr>
</tbody>
</table>
Conclusions

- Proposed a new word reordering method for SMT based on probabilistic rules:
  - automatically extracted from training data
  - suggesting movements of words or blocks
  - matching either word or POS pattern
- Rules are applied in the N-best rescoring stage
- Consistent improvements were obtained
The End ... Thank You!