The TÜBİTAK-UEKAE Statistical Machine Translation System for IWSLT 2007

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Outline

• System Description
• Training
  – Phrase table augmentation
• Decoding
  – Out of Vocabulary Words (OOV)
• Results
• Conclusion and Future Work
System Description

• Participated in translation tasks
  – Arabic-to-English
  – Japanese-to-English

• Built on phrase-based SMT software Moses

• Used only supplied data and Buckwalter Arabic Morphological Analyzer (BAMA)
System Description

Preprocess Input (tokenize) → Punctuated

Yes (Clean) → OOV Process → Decode

No (ASR) → Punctuation Restore → OOV Process

Postprocess (case restore)
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Training

• Devset1-3 are included in the training with all 16 reference segments
• Train and Devset1-3 are given equal weight
• Language models
  – 3-gram for AR-EN
  – 4-gram for JP-EN
  – Trained with modified Kneser-Ney discounting and interpolation
Training

- Multi-sentence segments are split

<table>
<thead>
<tr>
<th></th>
<th>Before splitting</th>
<th>After splitting</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR-EN</td>
<td>44,164 *</td>
<td>49,318</td>
</tr>
<tr>
<td>JP-EN</td>
<td>64,145 *</td>
<td>71,435</td>
</tr>
</tbody>
</table>

* train segments + 16 * dev1-3 segments
• Parameter tuning
  – Manually tested different set of parameters
  – Different data favored different parameters
  – Instead of selecting argmax, selected *mode* in a *desirable interval* to select a robust set of parameters
Phrase Table Augmentation

• Translation model is represented in a phrase table
• Bi-directional alignment and phrase extraction with $grow$-$diag$-$final$-$and$ heuristics
• Source-language words without a one-word entry in phrase table are listed
• The words, which are in the list and have a lexical translation probability above a threshold in GIZA++ word alignment, are added to phrase list
## Phrase Table Augmentation

<table>
<thead>
<tr>
<th>Corpus</th>
<th>AR-EN</th>
<th>JP-EN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source vocabulary size</td>
<td>18,751</td>
<td>12,699</td>
</tr>
<tr>
<td>Number of entries in the original phrase table</td>
<td>408,052</td>
<td>606,432</td>
</tr>
<tr>
<td>Number of source vocabulary words without a one-word entry in the original phrase table</td>
<td>8,035</td>
<td>6,302</td>
</tr>
<tr>
<td>Number of one-word bi-phrases added to the phrase table</td>
<td>21,439</td>
<td>23,396</td>
</tr>
<tr>
<td>Number of entries in the augmented phrase-table</td>
<td>429,491</td>
<td>629,828</td>
</tr>
</tbody>
</table>
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Decoding

- Decoding is done on tokenized and punctuated data
  - Source-side punctuation insertion (for ASR data)
  - Target-side case restoration
- SRILM tools used for punctuation restoration
Decoding

- Merged 10 sentences to train punctuation restorer with more internal sentence boundaries

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Devset4</th>
<th>Devset5</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR-EN</td>
<td>1</td>
<td>24.32</td>
<td>20.23</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>24.95</td>
<td>20.66</td>
</tr>
<tr>
<td>JP-EN</td>
<td>1</td>
<td>15.59</td>
<td>14.26</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>17.82</td>
<td>16.12</td>
</tr>
</tbody>
</table>
Out of Vocabulary Words

• Lexical Approximation
  – Find a set of candidate approximations
  – Select the candidate with least edit distance
  – In case of a tie, more frequently used candidate is chosen
Out of Vocabulary Words

• Arabic lexical approximation (2 pass)
  – Morphological root(s) of the word found by feature function using BAMA
  – If not, skeletonized version of the word is found by feature function

• Japanese lexical approximation (1 pass)
  – Right-truncations of the word is found by feature function
## Out of Vocabulary Words

- **Run-time Lexical Approximation**

<table>
<thead>
<tr>
<th></th>
<th>Devset4</th>
<th>Devset5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of OOVs</td>
<td>BLEU</td>
</tr>
<tr>
<td><strong>AR-EN</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Original</td>
<td>661</td>
<td>24.91</td>
</tr>
<tr>
<td>After LA#1</td>
<td>185</td>
<td>25.33</td>
</tr>
<tr>
<td>After LA#2</td>
<td>149</td>
<td>25.56</td>
</tr>
<tr>
<td><strong>JP-EN</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Original</td>
<td>119</td>
<td>23.68</td>
</tr>
<tr>
<td>After LA</td>
<td>10</td>
<td>23.84</td>
</tr>
</tbody>
</table>
Out of Vocabulary Words

Without lexical approximation

hl hw mjAny~ ?  ➔  Is it mjAny~ ?

mjAny~ is OOV
Out of Vocabulary Words

• Lexical approximation finds candidates
  – mjAnyP, mjAnY, mjAnA, kjm, mjAny, mjAnAF
• mjAny has an edit distance of 1, so it’s selected
Out of Vocabulary Words

After lexical approximation

hl hw mjAny ?

Is it free ?
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<table>
<thead>
<tr>
<th>Language Pair</th>
<th>Clean Transcript</th>
<th>ASR Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR-EN</td>
<td>49.23</td>
<td>36.79</td>
</tr>
<tr>
<td>JP-EN</td>
<td>48.41</td>
<td>42.69</td>
</tr>
</tbody>
</table>
Clean vs. ASR

• Possible causes of performance drop in ASR condition
  – Recognition errors of ASR
  – Punctuation restorer performance
  – Parameter tuning for clean transcript but not for ASR output
• Possible causes of higher performance drop in AR-EN than JP-EN
  – Lower accuracy of Arabic ASR data than Japanese data
  – Higher difficulty of punctuation insertion due to higher number of punctuation types
  – Less reliable punctuation insertion caused by higher recognition error rate
AR-EN vs. JP-EN

- Lexical approximation is sensitive to recognition errors

<table>
<thead>
<tr>
<th></th>
<th>Clean transcript</th>
<th>ASR output</th>
<th>Clean-to-ASR degradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original source</td>
<td>38.48</td>
<td>31.82</td>
<td>17.3%</td>
</tr>
<tr>
<td>After LA</td>
<td>49.23</td>
<td>36.79</td>
<td>25.3%</td>
</tr>
</tbody>
</table>
Devset4-5 vs. Evaluation Set

- There is a dramatic variation in the improvement obtained with the lexical approximation technique on the evaluation and development sets.
## Devset4-5 vs. Evaluation Set

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
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<tr>
<td>After LA#1</td>
<td>25.33</td>
<td>21.22</td>
</tr>
<tr>
<td>After LA#2</td>
<td>25.56</td>
<td>21.51</td>
</tr>
<tr>
<td>Improvement</td>
<td>2.6%</td>
<td>4.5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Evaluation set clean transcript</th>
<th>Evaluation set ASR output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original source</td>
<td>38.48</td>
<td>31.82</td>
</tr>
<tr>
<td>After LA</td>
<td>49.23</td>
<td>36.79</td>
</tr>
<tr>
<td>Improvement</td>
<td>27.9%</td>
<td>15.6%</td>
</tr>
</tbody>
</table>
Devset4-5 vs. Evaluation Set

• 167 of 489 evaluation set segments have at least one reference which is a perfect match with a training segment
• Only 19 of 167 have the source segment exactly the same as in the training set
• Remaining 148 segments represents a potential to obtain a perfect match
<table>
<thead>
<tr>
<th>Number of segments</th>
<th>Devset4</th>
<th>Devset5</th>
<th>Evaluation set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exact match of at least one reference with a segment in the training set</td>
<td>12</td>
<td>4</td>
<td>167</td>
</tr>
<tr>
<td>Exact math of the source with a segment in the training set</td>
<td>1</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>489</td>
<td>500</td>
<td>489</td>
</tr>
</tbody>
</table>
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Conclusion and Future Work

• Make the system more robust to ASR output. For this goal:
  – Using n-best/lattice ASR output
  – Tuning system for ASR output
  – Better punctuation performance
Thank you for your attention!