Analysing Soft Syntax Features and Heuristics for Hierarchical Phrase Based Machine Translation

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1 Introduction

- Hierarchical phrase-based models: Generalization of phrase-based-models
  - Allow for “gaps” in the phrases
  - Integration of reordering in the translation model
- Study the effect of extraction heuristics
- Extension with inclusion of (soft) syntactic features
Outline

1 Introduction
2 Hierarchical Phrases
3 Heuristic Features
4 Syntactical Features
5 Experimental Results
6 Conclusions
2 Hierarchical Phrases

► Formalization as a synchronous CFG
► Rules of the form $X \rightarrow \langle \gamma, \alpha, \sim \rangle$, where:
  ▶ $X$ is a non-terminal
  ▶ $\gamma$ and $\alpha$ are strings of terminals and non-terminals
  ▶ $\sim$ is a one-to-one correspondence between the non-terminals of $\alpha$ and $\gamma$
► Example:

\[
X \rightarrow \langle \text{中 中 中 那个 X}^1, \text{It's the X}^1 \text{ in the X}^0 \rangle \\
X \rightarrow \langle \text{也 要 X}^0 \text{ 一些 X}^1, \text{like to X}^0 \text{ some X}^1 \text{ too} \rangle
\]

► Additionally: Glue rules

\[
S \rightarrow \langle S^0 X^1, S^0 X^1 \rangle \\
S \rightarrow \langle X^0, X^0 \rangle
\]
Illustration

meal • • • ■ • • • •
toddler • • • • • ■ •
a • • ■ • • • • •
order • ■ • • • • • •
you ■ • • • • • • • •
did ■ • • • • • • • •
ha
ordinato
un
piatto
per
bambini
Alignment
Illustration

meal • • • □ □ • •
toddler • • • • □ □ □
a • • □ • • • •
order □ • • • • •
you □ • • • • •
did □ • • • • •
ha ha ordinato un piatto per bambini

Standard phrases
Example rule
3 Heuristic Features

Following features were tested:

- **Paste rule**  Binary feature for rules of the form

  \[ X \rightarrow \langle X^0 \alpha, X^0 \beta \rangle \text{ or } X \rightarrow \langle \alpha X^0, \beta X^0 \rangle \]

- **Hierarchical penalty**  Binary feature for hierarchical rules

- **Number of non-terminals**  Two binary features indicating if the rule has one or two non-terminals.

- **Extended glue rule**  added rule of the form

  \[ X \rightarrow \langle X^0 X^1, X^0 X^1 \rangle \]
4 Syntactical Features

Goal: include linguistic information from a deep syntactic parser

Idea: introduce additional soft syntactic features

This can be done during the extraction of the phrases:
- No additional computational costs during decoding
- Can be done both on source and target side
- Rules are not filtered out
“Valid” syntactical phrases

- A phrase is valid when a node exists that completely covers all positions
- In order to obtain a normalized score, we add up all the counts and divide by the number of occurrences of the phrase pair

Extracted rule: $X \sim 0$ 在 哪 里 # Where is $X \sim 0$
Scoring variants

\[ m(i, j) = \text{minimum number of words to be deleted or added to a phrase, so that it fits the yield of a node} \]

Source Phrases:

- public toilet
- is the
Scoring variants

\[ m(i, j) = \text{minimum number of words to be deleted or added to a phrase, so that it fits the yield of a node} \]

Source Phrases:

- public toilet \( m(i, j) = 1 \)
- is the
Scoring variants

\[ m(i, j) = \text{minimum number of words to be deleted or added to a phrase, so that it fits the yield of a node} \]

Source Phrases:
- **public toilet** \( m(i, j) = 1 \)
- **is the** \( m(i, j) = 1 \)
Four count ("smoothing") variants:

\[ c(i, j|t) := \begin{cases} 
\delta (m(i, j), 0) & \text{binary} \\
\frac{1}{m(i, j) + 1} & \text{linear} \\
\frac{1}{\exp(m(i, j))} & \text{exponentional} \\
\frac{j - i}{(j - i) + m(i, j)} & \text{relative}
\end{cases} \]
5 Experimental Results

- IWSLT BTEC Data (Tourist and Travel domain)

<table>
<thead>
<tr>
<th></th>
<th>Sentences</th>
<th>Running words</th>
<th>Vocabulary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chinese</strong></td>
<td>23,940</td>
<td>181,486</td>
<td>9,041</td>
</tr>
<tr>
<td><strong>English</strong></td>
<td>232,746</td>
<td>232,746</td>
<td>10,350</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Sentences</th>
<th>Running words</th>
<th>OOVs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test 2004 Data</strong></td>
<td>500</td>
<td>7,543</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10,718</td>
<td>154</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
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<th>Running words</th>
<th>OOVs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test 2005 Data</strong></td>
<td>506</td>
<td>8,052</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10,828</td>
<td>164</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th></th>
<th>Sentences</th>
<th>Running words</th>
<th>OOVs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test 2008 Data</strong></td>
<td>507</td>
<td>6,325</td>
<td>87</td>
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</table>
# Results

<table>
<thead>
<tr>
<th></th>
<th>test04</th>
<th>test05</th>
<th>test08</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BLEU</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>baseline</strong></td>
<td>47.3</td>
<td>50.9</td>
<td>39.6</td>
</tr>
<tr>
<td><strong>non-syntactic information</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>hierarch</strong></td>
<td>48.4</td>
<td>51.4</td>
<td>39.6</td>
</tr>
<tr>
<td><strong>paste</strong></td>
<td>49.1</td>
<td>51.1</td>
<td>40.8</td>
</tr>
<tr>
<td><strong>glue2</strong></td>
<td>48.2</td>
<td>51.2</td>
<td>39.7</td>
</tr>
<tr>
<td><strong>1NT2NT</strong></td>
<td>48.4</td>
<td>51.8</td>
<td>39.8</td>
</tr>
<tr>
<td><strong>syntactic information</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>binary</strong></td>
<td>47.8</td>
<td>51.7</td>
<td>40.3</td>
</tr>
<tr>
<td><strong>linear</strong></td>
<td>47.6</td>
<td>51.2</td>
<td>40.6</td>
</tr>
<tr>
<td><strong>exponential</strong></td>
<td>47.9</td>
<td>51.6</td>
<td>40.3</td>
</tr>
<tr>
<td><strong>relative</strong></td>
<td>47.3</td>
<td>51.5</td>
<td>40.2</td>
</tr>
</tbody>
</table>
## Results

<table>
<thead>
<tr>
<th></th>
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<th>test05</th>
<th>test08</th>
</tr>
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<tbody>
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<td></td>
<td>BLEU</td>
<td>TER</td>
<td>BLEU</td>
</tr>
<tr>
<td><strong>baseline</strong></td>
<td>47.3</td>
<td>42.6</td>
<td>50.9</td>
</tr>
<tr>
<td><strong>non-syntactic information</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hierarch + paste</td>
<td>48.5</td>
<td>42.0</td>
<td>51.9</td>
</tr>
<tr>
<td>hierarch + paste + glue2</td>
<td>49.2</td>
<td>42.5</td>
<td>50.8</td>
</tr>
<tr>
<td>hierarch + paste + glue2 + 1NT2NT</td>
<td>48.6</td>
<td>41.6</td>
<td>51.0</td>
</tr>
<tr>
<td><strong>combination of both syntactic and non-syntactic information (all features)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>binary</td>
<td>46.9</td>
<td>42.5</td>
<td>50.6</td>
</tr>
<tr>
<td>linear</td>
<td>48.0</td>
<td>42.3</td>
<td>51.2</td>
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<tr>
<td>exponential</td>
<td>47.7</td>
<td>42.3</td>
<td>51.0</td>
</tr>
<tr>
<td>relative</td>
<td>47.8</td>
<td>42.3</td>
<td>51.0</td>
</tr>
</tbody>
</table>
### Example Translations

<table>
<thead>
<tr>
<th>Reference</th>
<th>Baseline</th>
<th>Syntactical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where is the exchange counter?</td>
<td>The currency exchange office is</td>
<td>Where is the currency exchange office?</td>
</tr>
<tr>
<td>Could you exchange it for a new one?</td>
<td>You can buy a new one?</td>
<td>Could you change it for a new one?</td>
</tr>
<tr>
<td>You can take our airport shuttle bus to pick up the car.</td>
<td>You can take our airport shuttle bus with me.</td>
<td>You can take our the airport shuttle bus come to pick it up.</td>
</tr>
</tbody>
</table>
6 Conclusions

▶ Analyzed heuristics for phrase extraction
▶ Introduced soft syntactic constraints
  ▶ Use of source- and target-side information
  ▶ No additional search effort
▶ High variability of results
  ▶ Test on bigger corpora
▶ Bigger improvements when dealing with speech input
  (system talk tomorrow!)
▶ Applicable also to phrase-based systems
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