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:

$X \rightarrow \langle \text{中 中 中} X \sim^0 \text{那个} X \sim^1, \text{It’s the } X \sim^1 \text{ in the } X \sim^0 \rangle$

$X \rightarrow \langle \text{也 要} X \sim^0 \text{ 一些} X \sim^1, \text{like to } X \sim^0 \text{ some} X \sim^1 \text{ too} \rangle$

▶ Additionally: Glue rules

$S \rightarrow \langle S \sim^0 X \sim^1, S \sim^0 X \sim^1 \rangle$

$S \rightarrow \langle X \sim^0, X \sim^0 \rangle$
Illustration

meal • • • ■ • • •
toddler • • • • • ■ ■
a • • ■ • • • •
order • ■ • • • • •
you ■ • • • • • •
did ■ • • • • • •

Alignment

toddler
meal
a
order
you

bambini
piatto
per
un
ordinato
ha
Illustration

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

Standard phrases
Illustration

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:

\[ c(i, j \mid t) := \begin{cases} 
\delta(m(i, j), 0) & \text{binary} \\
\frac{1}{m(i, j) + 1} & \text{linear} \\
\frac{1}{\exp(m(i, j))} & \text{exponential} \\
\frac{j - i}{(j - i) + m(i, j)} & \text{relative}
\end{cases} \]
## 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>
<th>Sentences</th>
<th>Running words</th>
<th>OOVs</th>
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</thead>
<tbody>
<tr>
<td><strong>Training data</strong></td>
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<td></td>
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<td></td>
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<tr>
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<td>181 486</td>
<td>9 041</td>
<td>English</td>
<td>232 746</td>
<td>10 350</td>
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<tr>
<td>Sentences</td>
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<td>7 543</td>
<td>96</td>
<td>OOVs</td>
<td>10 718</td>
<td>154</td>
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<td><strong>Test 2005 Data</strong></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Sentences</td>
<td>506</td>
<td>8 052</td>
<td>101</td>
<td>OOVs</td>
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<tr>
<td>Sentences</td>
<td>507</td>
<td>6325</td>
<td>87</td>
<td></td>
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## Results

<table>
<thead>
<tr>
<th></th>
<th>test04</th>
<th>test05</th>
<th>test08</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>BLEU</td>
<td>TER</td>
<td>BLEU</td>
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<tr>
<td>baseline</td>
<td>47.3</td>
<td>42.6</td>
<td>50.9</td>
</tr>
<tr>
<td>non-syntactic information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hierarch</td>
<td>48.4</td>
<td>41.9</td>
<td>51.4</td>
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<tr>
<td>paste</td>
<td>49.1</td>
<td>41.6</td>
<td>51.1</td>
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<tr>
<td>glue2</td>
<td>48.2</td>
<td>41.8</td>
<td>51.2</td>
</tr>
<tr>
<td>1NT2NT</td>
<td>48.4</td>
<td>42.2</td>
<td>51.8</td>
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<tr>
<td>syntactic information</td>
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<td></td>
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<tr>
<td>binary</td>
<td>47.8</td>
<td>41.7</td>
<td>51.7</td>
</tr>
<tr>
<td>linear</td>
<td>47.6</td>
<td>41.9</td>
<td>51.2</td>
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<tr>
<td>exponential</td>
<td>47.9</td>
<td>41.7</td>
<td>51.6</td>
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<tr>
<td>relative</td>
<td>47.3</td>
<td>42.4</td>
<td>51.5</td>
</tr>
</tbody>
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## Results

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<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>
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<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>Where is the exchange counter?</th>
</tr>
</thead>
<tbody>
<tr>
<td>baseline</td>
<td>The currency exchange office is</td>
</tr>
<tr>
<td>syntactical</td>
<td>Where is the currency exchange office?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>reference</th>
<th>Could you exchange it for a new one?</th>
</tr>
</thead>
<tbody>
<tr>
<td>baseline</td>
<td>You can buy a new one?</td>
</tr>
<tr>
<td>syntactical</td>
<td>Could you change it for a new one?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>reference</th>
<th>You can take our airport shuttle bus to pick up the car.</th>
</tr>
</thead>
<tbody>
<tr>
<td>baseline</td>
<td>You can take our airport shuttle bus with me.</td>
</tr>
<tr>
<td>syntactical</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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