Rule-Based Preordering on Multiple Syntactic Levels in Statistical Machine Translation

Ge Wu, Yuqi Zhang

Institute for Anthropomatics
Karlsruhe Institute of Technoloy, Germany

utcur@student.kit.edu, yuqi.zhang@kit.edu

Abstract

We propose a novel data-driven rule-based preordering approach, which uses the information of syntax tree and word alignment to reorder the words in source sentences before decoding in a phrase-based SMT system between English and Chinese. The preorering algorithm extracts reordering patterns from multiple levels of the syntax trees of the training data and applies the rules on the source sentences in a similar manner. We've conducted experiments in English-to-Chinese and Chinese-to-English translation directions. Our results show that the approach has led to improved translation quality both when it was applied separately on the baseline or when it was combined with some other reordering approaches. We report an improvement of 0.43 in BLEU score when our preordering approach was used in addition to the short rule [1], long rule[2] and tree rule [3] based preordering approaches in the English-to-Chinese translation direction. There's also an improvement of 0.3 in BLEU score when our preordering approach was used in addition to the aforementioned preordering approaches in the Chinese-to-English translation direction. Through the translation examples, we've also found improvements in syntactic structure with our preordering approach.

1. Introduction

Word order is a general issue when we want to translate text from one language to the other. Different languages normally have different word orders and the difference could be very huge. Among all the languages, Chinese is one language which is very different from English, because they belong to different language families and have long period of separately development. Both languages have a Subject-Verb-Object order, but they also have a lot of differences in word order. Especially sentences in both languages can sometimes have completely different syntactic structures. The differences may involve long-distance or unstructured position changes.

Most state-of-the-art phrase-based SMT systems use language model, phrase table or decoder to adjust the word order. Or an additional reordering model is used in the log-linear model for word reordering. However, these methods may have some disadvantages, such as some don't handle long-distance reordering, some don't handle unstructured reordering and some are rather time consuming.

Encouraged by the results from the paper [1], [2] and [3], we further propose a new data-driven, rule-based preordering method, which extracts and applies reordering rules based on syntax tree. The method is called Multi-Level-Tree (MLT) reordering, which orders the constituents on multiple levels of the syntax tree all together. This preordering method rearranges the words in source language into a similar order as they are supposed to be in the target language before translation. With the appropriate word order, better translation quality can be achieved. Especially, our preordering method is very suitable for translation between language pairs like English and Chinese, which have very different word orders. Besides, the method can also be combined with the above mentioned rule-based reordering methods to achieve better translation quality.

2. Related Work

Word reordering is an important problem for statistical machine translation, which has long been addressed.

In a phrase-based SMT system, there are several possibilities to change the word orders. Words can be reordered during the decoding phase by setting a window, which allows the decoder to choose the next word for translation. Reordering could also be influenced by the language model, because the language model give probability of how a certain word is likely to follow. Different language model may give different probability, which further influences the decision made by log-linear model. Other ways to change the word orders include using distance based reordering models or lexicalized reordering models [4, 5]. The lexicalized reordering model reorders the phrases by using information of how the neighboring phrases change orientations.

The hierarchical phrase-based translation model [6] is especially suitable for Chinese translation, and provide very good translation results. It extracts hierarchical rules by using information of the syntactic structure. Phrases from different hierarchies, or so-called phrases of phrases, are reordered during the decoding.

The idea of phrases on different hierarchies has inspired us to create this preordering method based on multiple levels of the syntax tree. Besides, we also hope to detach the reordering from decoding phase and do it separately in a preprocess before decoding, in order to reduce the time for translation. This kind of preordering approaches use linguistic information to modify the word orders.

Reordering approaches can also be rule-based, which extracts different types of reordering rules by observing reordering patterns from the training data and apply the rules to the sentences to be translated. Depends on how the rules are defined, different information may be used such as word alignments, POS tags, syntax trees, etc.

Some early approaches use manually defined reordering rules based on the linguistic information for particular languages [7, 8, 9]. Especially [10] is based on Chinese and has analyzed the reordering cases between English and Chinese based on syntactic structure. Later come the data-driven methods [11, 12], which learn the reordering rules automatically.

[1] introduced the idea of extracting reordering rules from the POS tag sequences of training data and use them for reordering. [2] went further, and developed a method for long-distance word reordering, which works good on German-English translation task due to the long-distance shift of verbs. The method extracts discontinuous reordering rules in addition to the continuous ones, which contains a placeholder to match several words and enables the word to shift cross long distance.

Afterwards, [3] introduced a novel approach to reorder the words based on syntax tree, which leads to further improvements on translation quality. The algorithm takes syntactic structure of the sentences into account and extract the rules from the syntax tree by detecting the reordering of child sequences. It also has the variant based only on part of the child sequences which is suitable for language with flat syntactic structure such as German.

Recently, [13] introduced a novel classified preordering approach. Unlike existing preordering models, it trains feature-rich discriminative classifiers that directly predict the target side word order. It reorders the children in subtrees in a similar manner as the syntax tree based method, but trains different classifiers for nodes with different number of children.

However, these approaches which are bases on POS tag sequences or syntax trees are mostly designed for German and are not especially adapted for Chinese translation. As Chinese has very different word orders, a reordering approach, which can further explore the syntactic structure of Chinese and utilize this information for reordering, is desirable.

Oracle reordering has also shown values for evaluating the potential of preordering. [14] introduced the permutation distance metrics which can be used to measure reordering quality. And [15] described how we can construct permutations from the word alignment as oracle reordering.

3. Motivation

4. Multi-Level-Tree Reordering

5. Results

6. Conclusion

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All figures must be centered on the column (or page, if the figure spans both columns). Figure captions should follow each figure and have the format given in Fig. 1.

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An example of a table is shown as Table 1. Somewhat different styles are allowed according to the type and purpose of the table. The caption text may be above or below the table.

Table 1: *This is an example of a table.*

ratio	decibels
1/1	0
2/1	≈ 6
3.16	10
10/1	20
1/10	-20

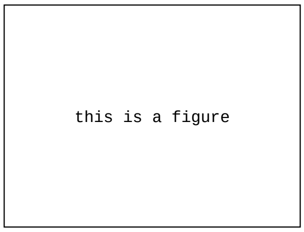

Figure 1: *Schematic diagram of speech production.*

6.6. Equations

Equations should be placed on separate lines and numbered. Examples of equations are given below. Particularly,

$$x(t) = s(f_\omega(t)) \tag{1}$$

where $f_\omega(t)$ is a special warping function

$$f_\omega(t) = \frac{1}{2\pi j} \oint_C \frac{\nu^{-1k} d\nu}{(1 - \beta\nu^{-1})(\nu^{-1} - \beta)} \tag{2}$$

A residue theorem states that

$$\oint_C F(z) dz = 2\pi j \sum_k Res[F(z), p_k] \tag{3}$$

Applying (3) to (1), it is straightforward to see that

$$1 + 1 = \pi \tag{4}$$

Make sure to use `\eqref` when refering to equation numbers. Finally we have proven the secret theorem of all speech sciences (see equation (3) above). No more math is needed to show how useful the result is!

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7. Experiments

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8. Conclusions

This paper has described a novel approach for doing wonderful stuff such as ...

9. Acknowledgements

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