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Cross-lingual Parse Disambiguation based on Semantic Correspondence

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Abstract

We present a system for cross-lingual parse disambiguation, exploiting the assumption that the meaning of a sentence remains unchanged during translation and the fact that different languages have different ambiguities. We simultaneously reduce ambiguity in multiple languages in a fully automatic way. Evaluation shows that the system reliably discards dispreferred parses from the raw parser output, which results in a pre-selection that can speed up manual treebanking.

1 Introduction

Treebanks, sets of parsed sentences annotated with a syntactic structure, are an important resource in NLP. The manual construction of treebanks, where a human annotator selects a gold parse from all parses returned by a parser, is a tedious and error prone process. We present a system for simultaneous and accurate partial parse disambiguation of multiple languages. Using the pre-selected set of parses returned by the system, the treebanking process for multiple languages can be sped up.

The system operates on an aligned parallel corpus. The languages of the parallel corpus are considered as mutual semantic tags: As the meaning of a sentence stays constant during translation, we are able to resolve ambiguities which exist in only one of the languages by only accepting those interpretations which are licensed by the other language.

In particular, we select one language as the target language, translate the other language's semantics for every parse into the target language and thus align maximally similar semantic representations.

The parses with the most overlapping semantics are selected as preferred parses.

As an example consider the English sentence *They closed the shop at five*, which has the following two interpretations due to PP attachment ambiguity:¹

- (1) “At five, they closed the shop”
`close(they, shop); at(close, 5)`
- (2) “The shop at five was closed by them”
`close(they, shop); at(shop, 5)`

The Japanese translation is also ambiguous, but in a completely different way: it has the possibility of a zero pronoun (we show the translated semantics).

- (3) 彼らは5時に店を開めた
kare ra wa 5 ji ni mise wo shime ta
he PL TOP 5 hour at shop ACC close PAST
“At 5 o'clock, they closed the shop.”
`close(they, shop); at(close, 5)`
- (4) “At 5 o'clock, as for them, someone closed the shop.”
`close(ϕ , shop); at(close, 5)`
`topic(they, close)`

We show the semantic representation of the ambiguity with each sentence. Both languages are disambiguated by the other language as only the English interpretation (1) is supported in Japanese, and only the Japanese interpretation (3) leads to a grammatical English sentence.

2 Related Work

There is no group using exactly the same approach as ours: automated parallel parse disambiguation on the basis of semantic analyses. Zhechev and

¹In fact it has four, as *they* can be either plural or the androgynous singular, this is also disambiguated by the Japanese.

Way (2008) automatically generate parallel treebanks for training of statistical machine translation (SMT) systems through sub-tree alignment. We do not aim to carry out the complete treebanking process, but to optimize speed and precision of manual creation of high-quality treebanks.

Wu (1997) and others have tried to simultaneously learn grammars from bilingual texts. Burkett and Klein (2008) induce node-alignments of syntactic trees with a log-linear model, in order to guide bilingual parsing. Chen et al. (2011) translate an existing treebank using an SMT system and then project parse results from the treebank to the other language. This results in a very noisy treebank, that they then clean. These approaches align at the syntactic level (using CFGs and dependencies respectively).

In contrast to the above approaches, we assume the existence of grammars and use a semantic representation as the appropriate level for cross-lingual processing. We compare semantic sub-structures, as those are more straightforwardly comparable across different languages. As a consequence, our system is applicable to any combination of languages. The input is plain parallel text, neither side needs to be treebanked.

3 Materials and Methods

We use grammars within the grammatical framework of head-driven phrase-structure grammar (HPSG Pollard and Sag (1994)), with the semantic representation of minimal recursion semantics (MRS; Copestake et al. (2005)). We use two large-scale HPSG grammars and a Japanese-English machine translation system, all of which were developed in the DELPH-IN framework:² The English Resource Grammar (ERG; Flickinger (2000)) is used for English parsing, and Jacy (Bender and Siegel, 2004) for parsing Japanese. For Japanese to English translation we use Jaen, a semantic-transfer based machine translation system (Bond et al., 2011).

3.1 Semantic Interface and Alignment

For the alignment, we convert the MRS structures into simplified elementary dependency graphs

²<http://www.delph-in.net/>

```
x4:pronoun_q[]
e2:_close_v_c[ARG1 x4:pron, ARG2 x9:_shop_n_of]
x9:_the_q[]
e8:_at_p_temp[ARG1 e2, ARG2 x16:_num_hour(5)]
x16:_def_implicit_q[]
```

Figure 1: EDG for *They closed the shop at five.*

(EDGs), which abstract away information about grammatical properties of relations and scopal information. Preliminary experiments showed that the former kind of information did not contribute to disambiguation performance, as number is typically underspecified in Japanese. As we only consider local information in the alignment, scopal information can be ignored as well. An example EDG is displayed in Figure 1.

An EDG consists of a bag of elementary predicates (EPs) which are themselves composed of relations. Each line in Figure 1 corresponds to one EP. Relations are the elementary building blocks of the EDG, and loosely correspond to words of the surface string. EPs consist either of atomic relations (corresponding to quantifiers), or a predicate-argument structure which is composed of several relations. During alignment, we only consider non-atomic EPs, as quantifiers should be considered as grammatical properties of (lexical) relations, which we chose to ignore.

Given the EDG representations of the translated Japanese sentence, and the original target language EDGs, we can straightforwardly align by matching substructures of different granularity.

Currently, we align at the predicate level. We are experimenting with aligning further dependency relation based tuples, which would allow us to resolve more structural ambiguities.

3.2 The Disambiguation System

Ambiguity in the analyses for both languages is reduced on the basis of the semantic analyses returned for each sentence-pair, and a reduced set of preferred analyses is returned for both languages. For each sentence-pair, we (1) parse the English and the Japanese sentence (MRS_E and MRS_J) (2) transfer the Japanese MRS analyses to English MRSs (MRS_{JE}) (3) convert the top 11 translated MRSs

and the original English MRSs to EDGs³ (EDG_E and EDG_{JE}) (4) align every possible E and JE EDG combination and determine the set of best aligning analyses (5) from those, create language specific sets of preferred parses.

We are comparing semantic representations of the **same** language, the English text from the bilingual corpus and the English machine translation of the Japanese text. In order to increase robustness of our alignment system we not only consider complete translations, but also accept partially translated MRSs in case no complete translation could be produced. This step significantly increases the recall, while the partial MRSs proved to be informative enough for parse disambiguation.

4 Evaluation and Results

We evaluate our model on the task of parse disambiguation. We use full sentence match as evaluation metric, a challenging target.

The Tanaka corpus is used for training and testing (Tanaka, 2001). It is an open corpus of Japanese-English sentence pairs. We use version (2008-11) which contains 147,190 sentence pairs. We hold out 4,500 sentence pairs each for development and test.

For each sentence, we compare the number of theoretically possible alignments with the number of preferred alignments returned by our system. On average, ambiguity is reduced down to 30%. For English 3.76 and for Japanese 3.87 parses out of (at most) 11 analyses remain in the partially disambiguated list: both languages benefit equally from the disambiguation.

We evaluate disambiguation accuracy by counting the number of times the gold parse was present in the partially disambiguated set (full sentence match). Table 1 shows the alignment accuracy results.

The correct parse is included in the reduced set in 80% of the cases for Japanese, and for 82% of the cases in English. We match atomic relations when aligning the semantic structures, which is a very generic method applicable to the vast majority of sentence pairs. This leads to a recall score of

³These are ranked with a model trained on a hand-treebanked set. The cutoff was determined empirically: For both languages the gold parse is included in the top 11 parses in more than 97% of the cases.

| | English | | Japanese | |
|-------------------|---------|-------|----------|-------|
| | Prec | F | Prec | F |
| Included | 0.820 | 0.897 | 0.804 | 0.887 |
| First Rank | 0.659 | 0.791 | 0.676 | 0.803 |
| MRR | 0.713 | 0.829 | 0.725 | 0.837 |

Table 1: Accuracy and F-scores for disambiguation performance of our system. Recall was 99% in every case. 'Included': inclusion of the gold parse in the reduced set of parses or not. 'First Rank': ranking of the preferred parse as top in the reduced list. 'MRR': mean reciprocal rank of the gold parse in the list.

99%, and an F-Score of 89.7% and 88.7% for English and Japanese, respectively.

The reduced list of parser analyses can be further ranked by the parse ranking model which is included in the parsers of the respective languages (the same models with which we determined the top 11 analyses). Given this ranking, we can evaluate how often the preferred parse is ranked top in our partially disambiguated list; results are shown in the two bottom lines of Table 1.

A ranked list of possible preferred parses whose top rank corresponds with a high probability to the gold parse should further speed up the manual tree-banking process.

Performance in the context of the whole pipeline

The performance of parsers and MT system strongly influences the end-to-end results of the presented system. In the results given above, this influence is ignored. We lose around 29% of our data because no parse could be produced in one or both languages, or no translation could be produced. and a further 5% of the sentences did not have the gold parse in the original set of analyses (*before* alignment): our system could not possibly select the correct parse in those cases.

5 Discussion

Our system builds on the output of two parsers and a machine translation system. We reduce ambiguity for all sentence pairs where a parse could be created for both languages, and for which there was at least a partial translation. For these sentences, the cross-lingual alignment component achieves a recall of above 99%, such that we do not lose any addi-

tional data. The parsers and the MT system include a parse ranking system trained on human gold annotations. We use these models in parsing and translation to select the top 11 analyses. Our system thus depends on a range of existing technologies. However, these technologies are available for a range of languages, and we use them for efficient extension of linguistic resources.

The effectiveness of cross-lingual parse disambiguation on the basis of semantic alignment highly depends on the languages of choice. Given that we exploit the differences between languages, pairs of less related languages should lead to better disambiguation performance. Furthermore, disambiguating with more than two languages should improve performance. Some ambiguities may be shared between languages.⁴

One weakness when considering the disambiguated sentences as training for a parse ranking model is that the translation fails on similar kinds of sentences, so there are some phenomena which we get no examples of — the automatically trained treebank does not have a uniform coverage of phenomena. Our models may not discriminate some phenomena at all.

Our system provides large amounts of automatically annotated data at the only cost of CPU time: so far we have disambiguated 25,000 sentences: 10 times more than the existing hand annotated gold data. Using the parser output for speeding up manual treebanking is most effective if the gold parse is reliably included in the reduced set of parses. Increasing precision by accepting more than only the most overlapping parses may lead to more effective manual treebanking.

The alignment method we propose does not make any language-specific assumptions, nor is it limited to align two languages only. The algorithm is very flexible, and allows for straightforward exploration of different numbers and combinations of languages.

6 Conclusion and Future Work

Translating a sentence into a different language changes its surface form, but not its meaning. In

⁴For example the PP attachment ambiguity in *John said that he went on Tuesday* where either the saying or the going could have happened on Tuesday holds in both English and Japanese.

parallel corpora, one language can be viewed as a semantic tag of the other language and vice versa, which allows for disambiguation of phenomena which are ambiguous in only one of the languages.

We use the above observations for cross-lingual parse disambiguation. We experimented with the language pair of English and Japanese, and were able to accurately reduce ambiguity in parser analyses simultaneously for both languages to 30% of the starting ambiguity. The remaining parses can be used as a pre-selection to speed up the manual treebanking process.

We started working on an extrinsic evaluation of the presented system by training a discriminative parse ranking model on the output of our alignment process. Augmenting the Gold training data with our data improves the model. Our next step will be to evaluate the system as part of the treebanking process, and optimize the parameters such as disambiguation precision vs. amount of disambiguation.

As no language-specific assumptions are hard coded in our disambiguation system, it would be very interesting to apply the system to different language pairs as well as groups of more than two languages. Using a group of languages for disambiguation will likely lead to increased and more accurate disambiguation, as more constraints are imposed on the data.

Probably the most important goal for future work is improving the recall achieved in the complete disambiguation pipeline. Many sentence-pairs cannot be disambiguated because either no parse can be generated for one or both languages, or no (partial) translation can be produced. Following the idea of partial translations, partial parses may be a valid backoff. For purposes of cross-lingual alignment, partial structures may contribute enough information for disambiguation. There has been work regarding partial parsing in the HPSG community (Zhang and Kordoni, 2008), which we would like to explore. There is also current work on learning more types and instances of transfer rules (Haugereid and Bond, 2011).

Finally, we would like to investigate more alignment methods, such as dependency relation based alignment which we started experimenting with, or EDM-based metrics as presented in (Dridan and Oepen, 2011).

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