Transplanting Supertags from English to Spanish

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Abstract
In this paper, we present an approach to quickly develop supertags for a target language given supertags for another language (reference language), along with a sentence-aligned parallel corpus between reference language and target language pairs. Our method can be interpreted as composing the alignment relation with dependency relation of the reference sentence to obtain the dependency relation for the target sentence. This dependency relation is then used to induce the supertags for the target words.

1 Introduction
Supertags localize lexical and structural ambiguity by associating rich and complex descriptions to words of a language. This localization allows us to compute lexical and contextual distributional properties of supertags. In earlier work (JS94; Sri97a; Sri97b) we have shown that this distributional information can be used in a novel way to perform almost parsing. Trained on a million words of correctly supertagged Wall Street Journal Text, a simple trigram based supertagger assigns the same supertags to 92% of the words as they would have been assigned in the intended parse of a sentence. In subsequent work we have demonstrated the utility of supertags in a variety of applications including, Language Modeling (Sri96), Information Filtering (CS97b; CS97c), Information Extraction (DNB+97) and Sentence Simplification (CS97a).

2 An issue in Supertagging approach
However, constructing a rich repertoire of supertags for a language is a time consuming and tedious task as exemplified by the history of development of the English XTAG Grammar (XTA95) at University of Pennsylvania and the French XTAG Grammar at University of Paris. In this paper, our attempt is to provide a solution to alleviate the task of building a supertag collection for a language (target language) based on the set of supertags of another language (reference language). In particular, we present a method of transplanting the set of supertags from the XTAG Grammar for English to Spanish using a parallel corpus of sentence-aligned English-Spanish sentences.

3 Grammar Induction vs Grammar Transplantation
Previous proposals (Res92; Sch92) for learning LTAG grammars involved inducing elementary trees from unannotated corpora. However, these proposals require training of a large number of parameters on even larger collections of corpora and yet the resulting structures may not be linguistically motivated. In contrast, our approach is based on the premise that elementary trees of natural language grammars are related and that these structures can be inherited almost as is, from the reference language to the target language. We use the term grammar transplantation as opposed to grammar induction in order to differentiate the amount effort involved in the development of supertags for the target language. However, a limitation of our approach is that the target language is imposed with structures that closely resemble the source language structure.

4 Methodology
Our approach to transplanting supertags involves applying the following steps to each sen-

\[ \text{But this should not be regarded as a limitation exclusively of the supertag-based parsing paradigm. Treebank-based statistical parsing methods are limited by the effort involved in constructing a treebank.} \]
tence pair in the reference-target parallel corpus. We have applied this method to an English-Spanish ATIS corpus.

- We first obtain a word alignment for each sentence pair using the alignment algorithm described in (ABD98). The alignment algorithm is completely unsupervised and only requires a sentence aligned corpus in two languages. It uses a correlation metric among reference-target word-pairs as a cost of reference-target word pairing and performs an alignment search that minimizes the sum of the costs of a set of pairings which map the reference sentence to its target sentence.

- The words of the English sentence are supertagged using a supertagger. The supertagger used for the ATIS domain was trained on 2000 word-supertag pairs and performs at 92% accuracy on a 500 word test set.

- The supertagged English sentence is further annotated with dependency links using the Lightweight Dependency Analyzer described in (Sri97b).

- The dependency links are then migrated to the target sentence as follows: if words $w_i$ and $w_j$ are linked in the reference sentence, $w_i$ is aligned with $v_p$ and $w_j$ is aligned with $v_q$, then a dependency link is posited between $v_p$ and $v_q$.

- Finally, the dependency structure migrated on to the target sentence is used to recover the correct ordering of arguments of each word. This information is used to construct the supertag for the word.

Our method can be interpreted as composing the alignment relation with dependency relation of the reference sentence to obtain the dependency relation for the target sentence. This dependency relation is then used to induce the supertags for the target words.

5 Example

Consider the following pair of sentences from the sentence-aligned English-Spanish ATIS corpus.

| Target Position | Source Position |
|-----------------|-----------------|
| 1               | 1               |
| 2               | 4               |
| 3               |                 |
| 4               | 3               |
| 5               | 2               |
| 6               | 5               |
| 7               | 6               |
| 8               | 7               |
| 9               | 8               |
| 10              | 9               |
| 11              | 10              |
| 12              | 11              |
| 13              | 12              |
| 14              |                 |
| 15              |                 |
| 16              |                 |
| 17              |                 |

The result of the alignment algorithm is shown below. Notice that the result contains alignments between one word in the source string (FARES) to two words in the target string (LAS:TARIFAS). Multi-word alignments are shown separated by a "::". The alignment algorithm allows mapping between at most two words in the source string to two words in the target string.

The output of the supertagger for the English string is in Table 1. The supertagger assigns to each word the part-of-speech and supertag information. The supertag information is used to assign dependency information among the words of the sentence.

The POS, supertag and dependency links are transplanted on to the target string using the
Table 1: Result of applying the supertagger and the LDA on the English string

| Position | Words    | POS | Supertag             | Dependency links |
|----------|----------|-----|----------------------|------------------|
| 1        | SHOW     | VB  | A_Inx0Vnx1           | 4                |
| 2        | BUSINESS | NN  | B_Nn                 | 3*               |
| 3        | CLASS    | NN  | B_Nn                 | 4*               |
| 4        | FARES    | NNS | A_NXXN               |                  |
| 5        | ON       | IN  | B_nxPnx              | 4* 8             |
| 6        | U        | NNP | B_Nn                 | 7*               |
| 7        | S        | NNP | B_Nn                 | 8*               |
| 8        | AIR      | NNP | A_NXXN               |                  |
| 9        | FROM     | IN  | B_nxPnx              | 8* 10            |
| 10       | BOSTON   | NNP | A_NXXN               |                  |
| 11       | TO       | IN  | B_nxPnx              | 8* 12            |
| 12       | TORONTO  | NNP | A_NXXN               |                  |

Table 2: Result of combining the alignment information with the dependency information

| Position | Words      | POS | Supertag | Dependency links |
|----------|------------|-----|----------|------------------|
| 1        | MUESTRE    | NN  | A_Inx0Vnx1 | 2:3.            |
| 2:3      | LAS:TARIFAS| NNS | A_NXXN       |                 |
| 4        | EN         |     |           |                  |
| 5        | CLASE      | NN  | B_Nn        | 2:3*             |
| 6        | DE         |     |           |                  |
| 7        | NEGOCIOS   | NN  | B_Nn        | 4*               |
| 8        | EN         | IN  | B_nxPnx     | 2:3* 11.        |
| 9        | U          | NNP | B_Nn        | 10*              |
| 10       | S          | NNP | B_Nn        | 11*              |
| 11       | AIR        | NNP | A_NXXN      | 11* 13.         |
| 12       | DE         | IN  | B_nxPnx     |                  |
| 13       | BOSTON     | NNP | A_NXXN      |                  |
| 14       | A          | TO  | B_nxPnx     | 11* 15.         |
| 15       | TORONTO    | NNP | A_NXXN      |                  |

The target string dependency structure is examined for completeness and consistency. Completeness requires that each word is assigned a supertag and its dependency requirements are satisfied. Consistency requires that the direction of the head/dependent of a given word matches the direction of its dependency requirement.

In our example, the words at positions 4 and 6 are not assigned any supertags and hence violate completeness constraint and the words at positions 5 and 7 violate consistency constraints since the supertag (B_Nn) requires the head to appear to its right while the head appears on the left.

We solve the consistency and completeness problems by assigning to a word the most frequent supertag it is associated with, given the entire corpus, which can fit into the dependency context of the target string and at the same time respect the dependency constraints imposed by the source language. The corrected POS, supertag and dependency structure for the target string is shown in Table 3.

6 Evaluation
The system can be evaluated in a number of ways: in the context of an application, in terms of the supertags assigned, in terms of the dependency links assigned or in terms of time reduced in developing a full-fledged domain independent grammar. We are in the process of evaluating the system on its performance in assigning
supertags and dependency links to 1000 words of annotated test corpus from the ATIS domain. Preliminary results suggest that the performance in assigning supertags is about 80% accurate.

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| Position | Words       | POS | Supertag   | Dependency links |
|----------|-------------|-----|------------|-----------------|
| 1        | MUESTRE     | NN  | A_nxx0Vnx1 | 2:3.            |
| 2:3      | LAS:TARIFAS | NNS | A_NXX      | 2:3* 5.         |
| 4        | EN          | IN  | B_nxpNx    | 5* 7.           |
| 5        | CLASE       | NN  | A_NXX      | 2:3* 11.        |
| 6        | DE          | IN  | B_nxpNx    | 10*             |
| 7        | NEGOCIOS    | NN  | A_NXX      | 11* 13.         |
| 8        | EN          | IN  | B_nxpNx    |                 |
| 9        | U           | NNP | B_Nn       |                 |
| 10       | S           | NNP | B_Nn       |                 |
| 11       | AIR         | NNP | A_NXX      |                 |
| 12       | DE          | IN  | B_nxpNx    |                 |
| 13       | BOSTON      | NNP | A_NXX      |                 |
| 14       | A           | TO  | B_nxpNx    |                 |
| 15       | TORONTO     | NNP | A_NXX      |                 |