GIVING SHAPE TO AN N–VERSION DEPENDENCY PARSER
Improving Dependency Parsing Accuracy for Spanish using Maltparser

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Abstract: Maltparser is a contemporary dependency parsing machine learning–based system that shows great accuracy. However 90% of the Labelled Attachment Score (LAS) seems to be a *de facto* limit for these kinds of parsers. In this paper we present an n–version dependency parser that will work as follows: we found that there is a small set of words that are more frequently incorrectly parsed so the n-version dependency parser consists of n different parsers trained specifically to parse those *difficult* words. An algorithm will send each word to each parser and combined with the action of a general parser we will achieve better overall accuracy. This work has been developed specifically for Spanish using Maltparser.

1 INTRODUCTION

In the 10th edition of the Conference of Computational Natural Language Learning (CoNLL) a first shared task on Multilingual Dependency parsing was accomplished (Buchholz and Marsi, 2006). Thirteen different languages including Spanish were involved and parsing performance was studied. In this Shared Task, participants implemented a parsing system that could be trained for all these languages. Maltparser 0.4 (Nivre et al., 2007) is the publicly available software that is contemporary to the system presented by Nivre's group to the CoNLL–X Shared Task, in which Spanish was proposed for parsing and Nivre's group achieved great results.

Dependency parsing machine learning–based systems show exceptional accuracy. However 90% of the Labelled Attachment Score (LAS) seems to be a *de facto* limit for such kinds of parsers. Since generally such systems can not be modified, we developed some works to study what can be done with the training corpora in order to improve parsing accuracy. High level techniques, such as controlling sentences' length or corpora's size, seem useless for these purposes. However they appeared useful for the design of systematic processes for building training corpora (Ballesteros et al., 2010b). Low level techniques, based on an in–depth study of the errors produced by the parser at the word level, seem promising. Prospective low level studies suggested the development of n–version parsers. Each one of these n versions should be able to tackle a specific kind of dependency parsing at the word level and the combined action of all them should reach more accurate parsings. Since n–version parsers could be a valid tool for improving parsing accuracy, we present in this paper a study on their usefulness and expected limits, as a continuation of our previous work described in (Ballesteros et al., 2010a) and (Ballesteros et al., 2010c).

The paper is organized as follows: Section 2 describes some state of the art on multilinugal dependency parsing. Section 3 describes the previous work done on Spanish parsing focusing on the feasibility of an n–version dependency parser. In Section 4 we describe the current state of the algorithm that sends every setence to the more appropriated specific parser and combines the action of several parsers over a certain sentence; also we point out which work must be done to conclude it. Finally, Section 5 shows the conclusions of the presented work and proposes some ideas for potential future studies.

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2 THE CONLL–X SHARED TASK ON MULTILINGUAL DEPENDENCY PARSING

The goal of the CoNLL–X Shared Task (Buchholz and Marsi, 2006) was to label dependency structures by means of fully automatic dependency parsers. This task provided a benchmark for evaluating parsers accross 13 languages, one being Spanish. Systems were scored by computing their Labelled Attachment Score (LAS), i.e. the percentage of "scoring" tokens for which the system had predicted the correct head and dependency label (Nivre et al., 2004), their Unlabelled Attachment Score (UAS), i.e. the percentage of "scoring" tokens for which the system had predicted the correct head (Eisner, 1996) and their Label Accuracy (LA), i.e. the percentage of "scoring" tokens for which the system had predicted the correct dependency label (Yamada and Matsumoto, 2003).

The results for Spanish across the 19 participants ranged from 47% to 82.3% LAS, with an average of 73.5%. The treebank used was AnCora (Taulé et al., 2008). The two participant groups with the highest total score for Spanish were (McDonald et al., 2006) and (Nivre et al., 2006) with 82.3% and 81.3% LAS, respectively. Maltparser 0.4 is the freely available software of the system presented by Nivres group to the CoNLLX Shared Task. It is a tool easy to configure and use. Since we have developed some previous work on dependency parsing using Maltparser 0.4 (Herrera and Gervás, 2008; Herrera et al., 2007a; Herrera et al., 2007b), we decided to use Nivre's group system again to carry out the experiments related not only to the work presented here but to all the previous ones (Ballesteros et al., 2010a; Ballesteros et al., 2010b; Ballesteros et al., 2010c).

In our work, the first step was to replicate the participation of Nivre's group in the CoNLL–X Shared Task for Spanish (Ballesteros et al., 2010a). We obtained the same results as Nivre's group, i.e., LAS = 81.30%, UAS = 84.67% and LA = 90.06%. These results served as a baseline for this work to determine ways to improve them.

3 PREVIOUS WORK IN IMPROVING PARSING ACCURACY FOR SPANISH USING MALTPARSER

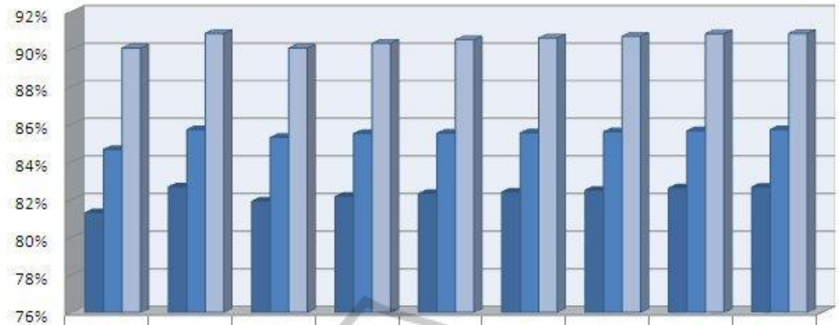
The ideas given in this paper were inspired by (McDonald and Nivre, 2007), where the performances of two dependency parsing systems are compared, showing that they are complementary and when one of them fails the other one can obtain a good parsing. So if one system can achieve better results for some kinds of sentences and another system is better for others kinds of sentences, why not use them in synergy? This led us to consider an n–version model in which we choose *a priori* what dependency parser is better for parsing some specific wordforms. This way, by combining the action of several parsers we expect to obtain a better overall accuracy by means of enhancing local accuracy.

As described in (Ballesteros et al., 2010a), when analyzing the results after parsing the test corpus provided in the CoNLL–X Shared Task, we found that there is a small set of words that more frequently show an incorrect attachment, incorrect labelling or both. These words are the prepositions "a" (*to*), "de" (*of*), " en" (*in*), "con" (*with*), "por" (*for*), the conjunction *and*, which has two wordings: "y" or "e", and the nexus "que" (*that*). For instance there are 20 sentences (340 wordforms), in the test corpus, with only one error after parsing. That is 9.7% of the corpus' sentences and 5.98% of its wordforms. We found that in 10 of these 20 sentences the only failure is caused by one of the words listed above.

These words listed above are very important for dependency parsing because they are usually connecting major parts of the sentences. In the event of bad parsing of one of those words, the dependency subtree under these words is badly connected and for all practical purposes the overall tree is useless.

Our hypothesis was that by enhancing local accuracy not only overall accuracy should be enhanced, but end user satisfaction should be increased. We carried out a set of experiments to confirm or reject this hypothesis. The basic idea was to do an in–depth study for each one of the important words listed above. This study, as described in (Ballesteros et al., 2010a) and (Ballesteros et al., 2010c) identified the set of different cases in which each word could be attached and labelled and a specific parser for each case found was trained.

By doing so, we analyzed the conjunction, the prepositions "a","de","en", "con" and "por" and the nexus "que", to determine the feasibility of the technique. We found some different cases in which those words could be attached and labelled. So we trained n different specific parsers for covering the set of cases given, being n = 28. After this, the test set was parsed by combining the action of the general parser and the 28 specific parsers. This way, when parsing a sentence that contains one of the words listed above, the part of the output tree of the general parser that corresponds with the "wrong" word was ignored and was



	Baseline	29 version	y/e	a	de	que	en	con	por
LAS	81,30%	82,67%	81,92%	82,17%	82,32%	82,40%	82,50%	82,62%	82,67%
UAS	84,67%	85,73%	85,31%	85,51%	85,53%	85,55%	85,61%	85,67%	85,73%
LA	90,06%	90,84%	90,06%	90,32%	90,50%	90,60%	90,70%	90,82%	90,84%

Figure 1: Improvements given by the action of the specific parsers.

substituted by the output given by the specific parser for the given case. So the attachment and the label given for this word by the general parser were substituted by the attachment and the label given by the specific one. By doing so, not only local but overall LAS, UAS, and LA were enhanced.

The results given for all these words when applying the combined action of the general and the 28 specific parsers (29-version parser) are shown in Figure 1. Our 28 specific parsers improve the results for all the words that showed an incorrect attachment or labelling. These results encouraged us to build an algorithm that could send each different wordform to the most aproppriate specific parser, as shown in the following section.

4 COMBINING THE ACTION OF N PARSERS

Once we concluded that the combination of several specific parsers could be a feasible technique for improving parsing accuracy, the following step was to develop the algorithm that makes all the specific parsers work in synergy. That brings us to the current point in our research and in this section we explain the current state of this development.

4.1 The Algorithm under Development

Our approach for the algorithm that sends each different wordform to the most aproppriate specific parser is based on pattern matching and rules. So when a certain pattern is recognized in the sentence to be parsed, it is sent to the most suitable specific parser by means of a rule. For the time being, this algorithm has been implemented only for the preposition "a" and for the conjunction and, that in Spanish has two wordings: "e" and "y", because these two words are the most frequently incorrectly parsed by the general parser. It works as follows:

1. A sentence is parsed with the general parser (which is trained with the same specification that Nivre's group published in the 2006 CoNLL–X Shared Task (Nivre et al., 2006)). In Figure 2 we show how the general parser parses the sentence: *Trasladó el material a Madrid* [*he (or she) moved the material to Madrid*], we can observe that the general parser makes an error in the node containing the preposition "a". The correct attaching for this node must be the main action of the sentence: *Trasladó*, and the correct label is "CC" that is the adjunct of the verb. The general parser produces an error in both things.
2. If the algorithm detects that there is a conjunction or a preposition "a" in the sentence, it sends the whole sentence to the most aproppriate specific parser. Each parser is set with different specifications.
3. The selected specific parser parses the sentence. In Figure 3 we can observe how the specific parser parses the same sentence as the general parser and it does not make the same error as the general parser. In this case, the specific parser parses correctly the node containing the preposition "a" (nevertheless it does not correctly parse other sections of the sentence).

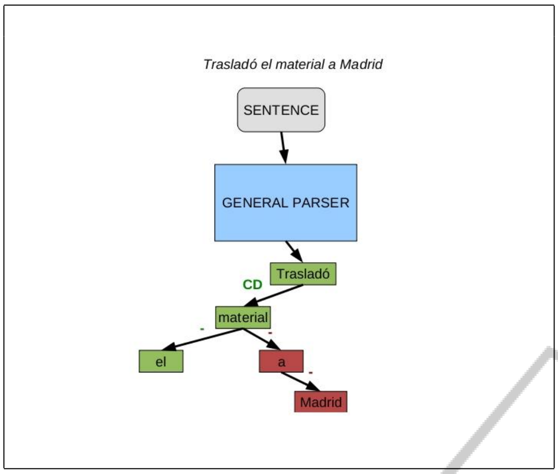


Figure 2: The General Parser parsing the sentence: *Trasladó el material a Madrid.*

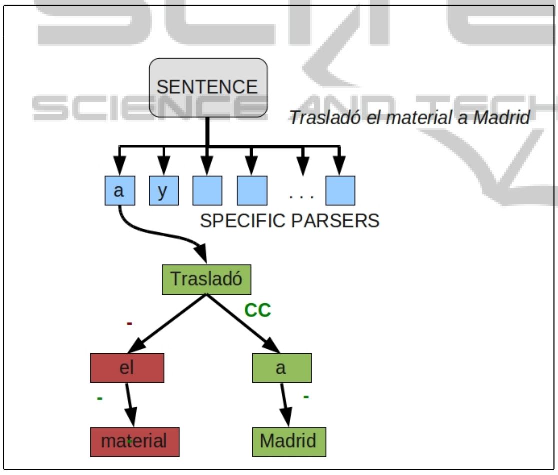


Figure 3: The Specific Parser parsing the sentence: *Trasladó el material a Madrid.*

4. The algorithm removes the node containing the conjunction or the preposition "a" from the tree returned by the general parser. In Figure 4 we can observe how the system avoids the useless information given by both parsers, the general parser and the specific one.
5. The algorithm inserts the node containing the conjunction or the preposition "a", produced by the specific parser into the general parsed tree. In Figure 5 we can observe how the algorithm inserts the node containing the preposition "a" into the tree given by the general parser. When inserting the node, the algorithm also inserts its subtree.
6. The algorithm returns the whole dependency tree that is produced from the suitable combination of the dependency trees given by the general and the specific parsers.

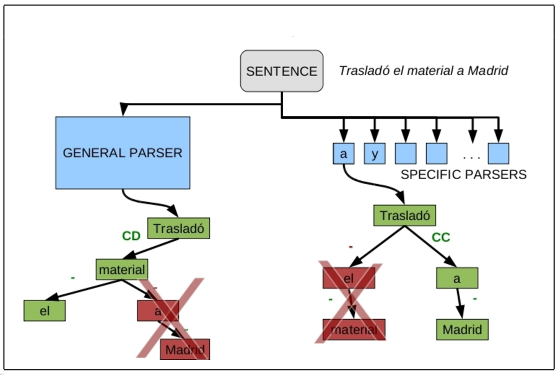


Figure 4: Removing useless information given by both parsers.

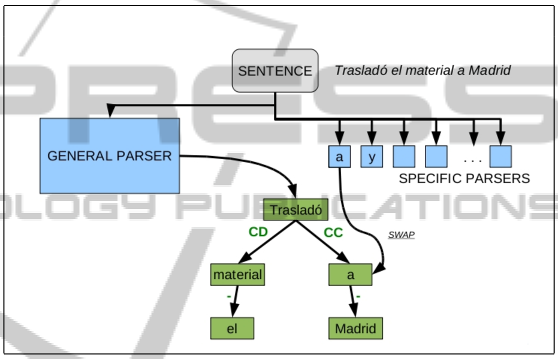


Figure 5: Swapping the node containing the preposition 'a' given by both parsers.

4.2 The Problems we Found

By applying the algorithm described in Subsection 4.1 we get that our n–version system incorrectly parsed 57 conjunctions while the general parser by itself parsed 56 conjunctions incorrectly. For the preposition "a" we get similar results: our n–version system parsed incorrectly parsed 50 prepositions and the general one parsed 48 prepositions incorrectly.

These very first negative results do not mean that the n–version technique should be rejected. An explanation to this problem can be found in the AnCora corpus. This corpus was built automatically with a strong linguistic and manual validation step, but we have identified some errors that still remain. For instance, we realized that two sentences with the same syntactic structure can be found in AnCora with different taggings, as shown in Figure 6. The sentences of the example are the following: *La prensa mostró su afecto a los candidatos [The press showed its affection towards the candidates]* and *La telefonía permitió abrir el mercado a operadores externos [The telephone system opened the market to external operators]*. Since our approach sends both sentences to

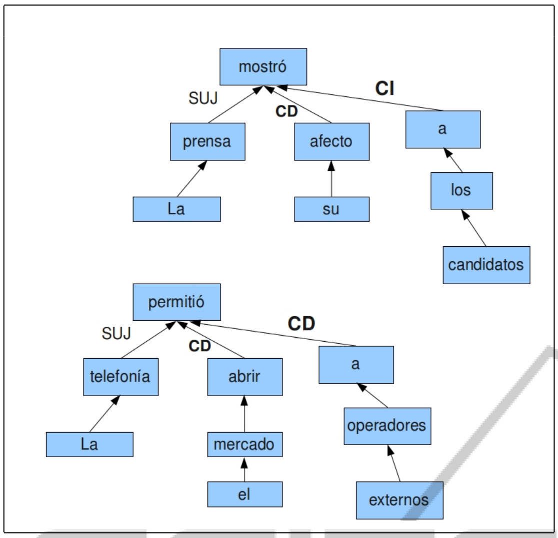


Figure 6: Two sentences with the same syntactic structure but showing different taggings in AnCora.

the same specific parser when detecting the preposition "a", one of them is wrongly parsed according to the current version of AnCora, but actually it is objectively well parsed.

A second example of an incorrect tagging of the indirect object when the preposition "a" is involved is found in the following sentence: *Fox sólo podrá vencer a Labastida [Fox will only be able to beat Labastida]*. This sentence has as its indirect object, the subsentence *a Labastida*, but in AnCora the node containing the preposition "a" is tagged as a direct object. When our algorithm finds the preposition "a" in such a context then it considers any subtree that has "a" as its root to be an indirect object. Then, once again we have a sentence that is formally well parsed by the n–version parser but it is marked as wrong in the testing process because the test corpus is not well tagged. In Figure 7 we can observe two dependency trees for the sentence *Fox sólo podrá vencer a Labastida*, the first one is its objectively well parsed tree and the second one is the tree contained in AnCora.

Thus, as seen in the previous examples, we have the problem that we can not suitably evaluate our n–version model because we do not have a 100% error free corpus to compare to.

4.3 What is Next?

In spite of having a promising technique for improving parsing accuracy using Maltparser, we have a secondary problem that we have to tackle in order to make progress. So the next step is to find and fix the

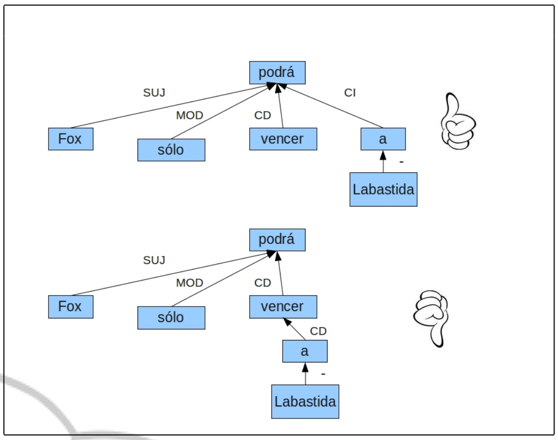


Figure 7: Bad and good ways of parsing a sentence.

errors in AnCora that impede us from correctly developing and testing the proposed n–version dependency parsing model.

Of course, after fixing the errors found in AnCora we will probably find different accuracy values to the ones presented in Sections 2 and 3. Moreover, we could find that the set of words that are more frequently incorrectly parsed (showed in Section 3) could change due to the enhanced training and testing processes. That will lead us to develop a revision of the set of specific parsers needed to improve the action of the general parser and to tune the algorithm that sends each wordform to the more suitable specific parser.

5 CONCLUSIONS AND FUTURE WORK

The study described in (Ballesteros et al., 2010a) and (Ballesteros et al., 2010c) shows that an n–version dependency parser system is feasible, but there is much work to do to have an algorithm that sends each different wordform to the most aproppriate specific parser.

We are making progress in aquiring a fully automated n–version dependency parser able to improve current parsing accuracy. However, this has been hinded in one of its last steps by tagging errors found in the train and test corpora. To solve this problem, the most important thing is to make a strong validation step of these corpora, tagging the sentences that follow the same structure in the same way, avoiding the ambiguity. With fixed corpora our algorithm should send the sentences correctly, and we will obtain the same results given in the previous feasibility studies. Equally important, is the completion of the algorithm that sends each wordform to the more suitable specific parser by implementing the rules related to the rest of the *problematic* words, including the other prepositions explained in Section 3 and the nexus “que”. In doing so we would get a real and competitive n–version dependency parser.

A basic aspect that may be strongly considered when developing machine learning–based dependency parsers is the accuracy and suitability of the train and test corpora, this has been claimed in our previous related work and has been observed again during the development of the present one. Not only does it mean that the samples must be 100% error free tagged, but that they should be carefully selected to ensure a high recall both in the train and the test sets.

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