Extracting semantic relations from Portuguese corpora using lexical-syntactic patterns

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Abstract

The growing investment on automatic extraction procedures, together with the need for extensive resources, makes semi-automatic construction a new viable and efficient strategy for developing of language resources, combining accuracy, size, coverage and applicability. These assumptions motivated the work depicted in this paper, aiming at the establishment and use of lexical-syntactic patterns for extracting semantic relations for Portuguese from corpora, part of a larger ongoing project for the semi-automatic extension of WordNet.PT. 26 lexical-syntactic patterns were established, covering hypernymy/hyponymy and holonymy/meronymy relations between nominal items, and over 34 000 contexts were manually analyzed to evaluate the productivity of each pattern. The set of patterns and respective examples are given, as well as data concerning the extraction of relations - right hits, wrong hits and related hits-, as well as the total of occurrences of each pattern in CPRC. Although language-dependent, and thus clearly of obvious interest for the development of lexical resources for Portuguese, the results depicted in this paper are also expected to be helpful as a basis for the establishment of patterns for related languages such as Spanish, Catalan, French or Italian.

Keywords: lexical-syntactic patterns, semantic relations, corpora

1. Introduction

The advances in the area of Natural Language Processing (NLP) make apparent the importance of understanding and processing informational content of natural languages, critical for the development of an ever growing number of applications dealing with word sense disambiguation, information retrieval, machine translation, human-machine communication, and so on. In this context, lexical semantic resources, specifically ontological or concept-based relational ones, play a crucial role and their development constitutes a major concern for researchers in the fields of Computer Science and Computational Linguistics (Jing et al. 2000; Wandmacher et al. 2007). Also in this context, wordnets (lexical-conceptual relational databases; Miller 1990, Fellbaum 1998, Vossen 2002) gain importance and usability, being their development widely stimulated.

Given that most NLP applications require lexicons of 20 to 60000 word-forms (Dorr & Jones 1996), the need for extensive resources has led to many fully automatic approaches to extract ontological knowledge from raw or structured data (Maedche 2002, Cimiano & Staab 2005), resulting however in large but unreliable resources, as expected in unsupervised procedures. On the contrary, fully manual developed lexica are very reliable, but time-consuming, expensive and often small. The two strategies have been followed in the development of wordnet-like resources for Portuguese: manual construction, as WordNet.PT1, and automatic construction, whether by the translation of or the strict alignment with already existent wordnets, as MultiWordNet2, whether by the extraction of semantic relations from corpora, thesauri or dictionaries, as Onto.PT 3. The translation and alignment strategies can be suitable alternatives for some applications but do not solve issues concerning different lexicalizations of concepts (Hirst 2004), for instance, and are limited to the input data and relations and subject to options and mistakes of a third party, non-speaker of the target language. Fully automatic extraction of lexica and semantic relations from data, on the other hand, can sometimes cope with language-dependent phenomena, but deals with inaccurate degrees of semantic granularity, ambiguity and parsing issues and inference inconsistencies (Oliveira & Gomes 2010). Finally, manually built lexica result in accurate, balanced and dense resources, but too often of non-sufficient size.

The growing investment on automatic extraction procedures, together with the already mentioned need for extensive resources, makes semi-automatic construction a new viable and efficient strategy for developing such resources, which combine accuracy, size, coverage and applicability (Piasecki et al. 2009). These assumptions motivated the work depicted in this paper, aiming at the establishment and use of lexical-syntactic patterns for extracting semantic relations for Portuguese from corpora, part of a larger ongoing project for the semi-automatic extension of WordNet.PT.

Although language-dependent, and thus clearly of obvious interest for the development of lexical resources for Portuguese, the results depicted in this paper are expected to be helpful as a basis for the establishment of

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1 http://www.clul.ul.pt/clg/wordnetpt/index.html
2 http://mwnpt.dl.fc.ul.pt/index.html
3 http://ontopt.dei.uc.pt/
patterns for related languages such as Spanish, Catalan, French or Italian.

2. General approach
The determination of lexical-syntactical patterns conveying semantic relations aims at extracting candidates semantically and conceptually related from corpora, as opposed to structured data such as dictionaries or encyclopedias. The following sections describe the data used and the methodology followed to obtain the relevant patterns.

2.1 Data description
Aiming at defining and testing lexical-syntactical patterns in language data for the purpose of extracting semantic relations, more specifically, lexical items related by hypernymy/hyponymy and holonymy/meronymy relations, the data used was the Reference Corpus of Contemporary Portuguese (CRPC), developed by the Center of Linguistics of the University of Lisbon. CRPC is a large electronic corpus of more than 311 million words, mostly from European Portuguese. It covers several types of written texts (309.8 million words) and spoken texts (1.6 million words), dated from the second half of the 19th century up until 2006, although the majority of texts are dated from after 1970. The written texts include literary, newspaper, technical, scientific, didactic, leaflets, decisions of the supreme court of justice, parliament sessions texts, etc. The spoken sub corpus includes formal and informal speech of a variety of spoken interaction types: monologues, dialogues, conversations, phone conversations, lectures and homilies. CRPC can be characterized as a ‘reference’ corpus since its composing texts are sampled before being included in the corpus.

The lexical-syntactical patterns described in this paper were tested through the CRPC online queries tool.

2.1 Methodology

2.1.1 Pattern drafting
The determination of patterns expressing semantic relations – to extract candidates semantically and conceptually related from raw data – considered:

a) distributional information, based on the assumption that items similar in meaning tend to occur in the same contexts (Fillmore 1968; Grimshaw 1990; Jackendoff 1990; Hearst 1991; Levin 1993), and collocation analysis;

b) lexical-syntactical patterns (Hearst 1992), handmade patterns defined a priori according to the target language structures; also considering syntactic and morph and syntactic information, such as recurrent modification structures (Buitelaar et al. 2004) or predicate-argument relations (Wagner 2000), to assure the wider coverage possible. This resulted in two types of patterns, according to the way they were designed: handmade (HM) patterns and distributional information-based (DI) patterns.

HM patterns were first shaped based on the relations available in WordNet.PT and on the linguistic tests defined for each relation, an approach that gathers several advantages (Piasecki et al. 2009: 105), but also on introspective language knowledge. The candidate patterns were then tested in controlled data (CRPC v2.3 mainly, but also in non-controlled data through online queries for low frequency items).

The results of these patterns were manually revised and analyzed in order to determine which patterns worked and which did not. Not always the results were the expected: the pattern did occur in the corpus or on in non-controlled data; the pattern did not extract directly the semantic relation aimed at.

The patterns that returned results were then registered in a database to be further used; the patterns that did not worked were abandoned.

DI patterns emerged from the analysis of collocations and distributional information in CRPC of particular lexical items already encoded in WordNet.PT, i.e. items linked by a particular semantic relation: a given lexical item was search for in CRPC, collocations were obtained from these results and then analyzed to find semantically related words; or a given pair of semantic related words was looked for in CRPC. This analysis allowed for determining more patterns relating disambiguated word-forms and possible candidates.

This preliminary stage did not include automatic acquisition of patterns, considered for a later stage of the project. The future approach for the automatic acquisition of patterns requires a first testable set of patterns, needed to evaluate the automatic acquisition results. In this way, the results of the current work function also as the basis for future automatic acquisition of patterns.

The work depicted in this paper focuses on nouns, since these constitute the majority of items in the database. However, data on several cross-part of speech (POS) relations concerning other POS, including adverbs and prepositions, was collected for future analysis, specifically in what concerns function (agent, patient, and so on) or other less salient relations in wordnet model, such as cause or manner relations.

2.1.2 Pattern adjustment
The HM and DI candidate patterns obtained were subject to a screening process since their determination was not always straightforward.

In what concerns HM patterns, not always the selected lexical items produced results: i) they did not occur in the data; ii) the related items did not co-occur in the same sentence or in the considered 5 to 10 word pre and post target interval; and so different formulations had to be tested or the pattern was excluded.

Also, sometimes the results were not straightforward: the pattern did not occur; the pattern did not always only express the particular semantic relation tested; and in the last case, not always the semantic relation tested was the most prominent relation expressed by the pattern.

More than 50 patterns were first drafted and tested, resulting
in the definition of 26 patterns with potential use for extracting candidates from corpora. Ambiguous, rare or wrong patterns were dismissed.

2.1.3 Pattern search and selection

The next step involved the large-scale use of both HM and DI patterns on CRPC data to extract lexical candidates related by semantic relations. Each of the patterns was converted into a query regular expression to extract the contexts of occurrence in CRPC, using, whenever possible and productive, POS annotation tags to boost the search accuracy. All results, in a total of 34 747 contexts, were manually analyzed to accurately evaluate the productivity of the pattern, i.e., the number of occurrences that expressed a given relation obtained vs. the non-relevant occurrences and, thus, the potential of usability of the pattern in the semi-automatic extension of WordNet.PT. Results are presented in the next section.

3. Results

The lexical-syntactic patterns established cover hypernymy/hyponymy and holonymy/meronymy relations between nominal items. Table 1 presents this set of patterns, with examples from CRPC.

| Nr. | Pattern | Example | Type |
|-----|---------|---------|------|
| P1  | $N_1$, especially/homeadament $N_2$ | lacticípios, especialmente manteiga dairy products, especially butter | DI |
| P2  | DET $N_1$, especially/homeadament DET $N_2$ | os resíduos, nomeadamente a biomassa the residues, namely the biomass | DI |
| P3  | PREP$_1$ DET $N_1$, especially/homeadament PREP$_1$ DET $N_2$ | pelos insetos, especialmente pelas moscas by the insects, especially by the flies | DI |
| P4  | $N_1$, como $N_2$, | cancríos, como leucemia cancers, as leucemia | DI |
| P5  | $N_1$s, tais como $N_2$, $N_1$s, as $N_2$, | diversos desportos, tais como natação, several sports, such as swimming | HM |

| Nr. | Pattern | Example | Type |
|-----|---------|---------|------|
| P6  | DET.IND $N_1$ e DET.IND $N_2$ | um isótopo é um átomo an isotope is an atom | HM |
| P7  | DET.DEF $N_1$s DET.IND $N_2$ | o óleo é um residuo the oil is a residue | HM |
| P8  | DET.DEF $N_2$s, PUNCTUATION $N_1$s são $N_2$s | os computadores são máquinas the computers are machines | HM |
| P9  | DET.DEF $N_2$s, PUNCTUATION $N_1$s são $N_2$s | creches são estabelecimentos daycare centers are facilities | HM |
| P10 | $N_1$ é um tipo de $N_2$, $N_1$ is a kind/type of $N_2$ | pedofilia é um tipo de crime pedophilia is a type of crime | HM |
| P11 | $N_1$ e/ou outras $N_2$s, $N_1$ and/or other $N_2$s | escolas ou outras instituições schools or other institutions | DI |
| P12 | apontar|apresentar|definir|descrever|identificar|indicar DET.DEF $N_1$ como DET.DEF $N_2$, point out|present|define|describe|identify|indicate DET.DEF $N_1$ as DET.DEF $N_2$ | apontando o catolicismo como a religião pointing out the catholicism as the religion | DI |
| P13 | classificar|conceber|considerar|entender|qualificar|tomar DET.DEF $N_1$ como DET.DEF $N_2$, classify|conceive|consider|figure|qualify|take DET.DEF $N_1$ as DET.DEF $N_2$ | se tomasse a azálea como a flor if (he) took the azalea as the flower | DI |
| P14 | aludir|confirmar|consagrar|embramar|reconhecer DET.DEF $N_1$ como DET.DEF $N_2$, mention|confirm|acclaim|remember|recognize DET.DEF $N_1$ as DET.DEF $N_2$ | confirm o azeite como a gordura confirm the olive oil as the fat | DI |
| P15 | estabelecer|importar|instituir|proclamar DET.DEF $N_1$ como DET.DEF $N_2$, establish|impose|institute|proclaim DET.DEF $N_1$ as DET.DEF $N_2$ | estabelece a segunda-feira como o dia establish the monday as the day | DI |
Data concerning relations extraction - right hits, wrong hits and related hits, as well as the total of occurrences of each pattern in CPRC, are presented in Table 2. Related hits concern cases of i) indirect relations, for instance, the lexical items retrieved are and indirectly related (ex.: escravo – indivíduo (slave – individual), instead of escravo – pessoa (slave – person (– individual))); ii) proper names (ex.: jornalistas – Ramirez (journalists – Ramirez)); iii) items associated by relations different from the targeted one (ex.: cabine – casa (cabin – house)).

Patterns whose related hits were higher than the right hits (concerning the targeted relation) were dismissed for a given relation or, according to the analyzed results, used to extract other relations. The percentage of wrong hits is variable, being quite high in several patterns. However, in most cases, right hits do not amount to the majority of cases, even in “paradigmatic” patterns such as “is a”, for hyponymy, (pattern P6) or “is part of”, for meronymy (pattern P22) that do not perform as efficiently as could be expected. These results further motivate the need for human intervention to assure accuracy.

For these reasons, and at this stage of the project, the extracted relations are always submitted to manual revision. The final process considers human decision, to include or exclude automatically extracted relations in the WordNet.PT database, central.

Table 2: Quantitative results of patterns search

| Right hits | Related hits | Wrong hits | Total occurrences |
|------------|--------------|------------|------------------|
| P1         | 36.2%        | 9.3%       | 54.5%            | 789              |
| P2         | 53.8%        | 28.7%      | 17.5%            | 383              |
| P3         | 50.5%        | 11.9%      | 37.6%            | 1021             |
| P4         | 33.6%        | 5.7%       | 58.7%            | 506              |
| P5         | 65.1%        | 4.8%       | 30.2%            | 63               |
| P6         | 26.1%        | 0.2%       | 73.7%            | 1063             |
| P7         | 24.8%        | n.a.       | 75.2%            | 10914            |
| P8         | 18.9%        | 0.9%       | 80.2%            | 1740             |
| P9         | 11.7%        | 2.2%       | 86.1%            | 231              |
| P10        | 33.3%        | 3.7%       | 63.0%            | 54               |
| P11        | 58.4%        | 0.6%       | 41.0%            | 14874            |
| P12        | 17.4%        | 9.9%       | 72.7%            | 161              |
| P13        | 24.5%        | 9.5%       | 66.0%            | 200              |
| P14        | 29.4%        | 20.6%      | 50.0%            | 34               |
| P15        | 66.7%        | n.a.       | 34.3%            | 18               |
| P16        | 21.7%        | n.a.       | 78.3%            | 143              |
| P17        | 31.2%        | 8.7%       | 60.1%            | 173              |
| P18        | 12.2%        | 0.6%       | 87.2%            | 500              |
| P19        | 20.6%        | 11.1%      | 68.3%            | 848              |
| P20        | 42.6%        | 10.3%      | 47.1%            | 68               |
| P21        | 12.7%        | n.a.       | 87.3%            | 379              |
| P22        | 32.0%        | n.a.       | 68.0%            | 25               |
| P23        | 7.8%         | n.a.       | 92.2%            | 377              |
| P24        | 16.6%        | n.a.       | 84.0%            | 95               |
| P25        | 20.7%        | 12.1%      | 67.2%            | 58               |
| P26        | 30.0%        | 3.3%       | 66.7%            | 30               |

Table 1: PT lexical-syntactic patterns for nominal hyponymy/hyponymy and holonymy/meronymy relations
However, and to minimize the human effort in this process, several strategies for automatic selection of results are being considered, based on the results analyzed and considering frequent expressions (locations and other structures) that fit the pattern and that can be dismissed before human validation.

4. Final remarks

The establishment of lexical-syntactic patterns for Portuguese has as main goal the extraction of semantic relations from corpora, as part of a larger ongoing project aiming at the semi-automatic extension of WordNet.PT. As illustrated above, a necessary element of this project concerns, thus, a reliable pattern database to provide the grounds to anchor the whole process. For this reason, the resulting database of patterns will be publicly released, pending project conclusion. The lack of this type of data for Portuguese, on the one hand, and the importance of this kind of language-dependent information for the automatic and/or manual development of lexical resources on the other, led us to consider that the publication and availability of such a database will be of great value for research and for language resources development for Portuguese. However, although language-dependent, the results depicted in this paper are expected to be also helpful as a basis for the establishment of patterns for related languages such as Spanish, Catalan, French or Italian.

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