Multilingual versus Monolingual WSD

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Abstract

Although it is generally agreed that Word Sense Disambiguation (WSD) is an application dependent task, the great majority of the efforts has aimed at the development of WSD systems without considering their application. We argue that this strategy is not appropriate, since some aspects, such as the sense repository and the disambiguation process itself, vary according to the application. Taking Machine Translation (MT) as application and focusing on the sense repository, we present evidence for this argument by examining WSD in English-Portuguese MT of eight sample verbs. By showing that the traditional monolingual WSD strategies are not suitable for multilingual applications, we intend to motivate the development of WSD methods for particular applications.

1 Introduction

Word Sense Disambiguation (WSD) is concerned with the choice of the most appropriate sense of an ambiguous word given its context. The applications for which WSD has been thought to be helpful include Information Retrieval, Information Extraction, and Machine Translation (MT) (Ide and Verónis, 1998). The usefulness of WSD for MT, particularly, has been recently subject of debate, with conflicting results. Vickrey et al. (2005), e.g., show that the inclusion of a WSD module significantly improves the performance of their statistical MT system. Conversely, Carpuat and Wu (2005) found that WSD does not yield significantly better translation quality than a statistical MT system alone. In this latter work, however, the WSD module was not specifically designed for MT: it is based on the use of monolingual methods to identify the source language senses, which are then mapped into the target language translations.

In fact, although it has been agreed that WSD is more useful when it is meant for a specific application (Wilks and Stevenson, 1998; Kilgarriff, 1997; Resnik and Yarowsky, 1997), little has been done on the development of WSD modules specifically for particular applications. WSD models in general are application independent, and focus on monolingual contexts, particularly English.

Approaches to WSD as an application-independent task usually apply standardised sense repositories, such as WordNet (Miller, 1990). For multilingual applications, a popular approach is to carry out monolingual WSD and then map the source language senses into the corresponding target word translations (Carpuat and Wu, 2005; Montoyo et al., 2002). Although this strategy can yield reasonable results for certain pairs of languages, especially those which have a common sense repository, such as EuroWordNet (Vossen, 1998), mapping senses between languages is a very complex issue (cf. Section 2).

We believe that WSD is an intermediate, application dependent task, and thus WSD modules for particular applications must be developed following the requirements of such applications. Many key factors of the process are application-dependent. The main factor is the sense inventory. As emphasized by Kilgarriff (1997), no sense inventory is suitable for all applications. Even for the same application there is often little consensus about the most appropriate sense inventory. For example, the use of WordNet, although very frequent, has been criticized due to characteristics such as the level sense granularity and the abstract criteria used for the sense distinctions in that resource (e.g., Palmer 1998). In particular, it is generally agreed that the granularity in WordNet is too refined for MT.

In addition to requiring different sense inventories (Hutchins and Somers, 1992), the disambiguation process itself often can be varied according to the application. For instance, in monolingual WSD, the main information source is the context of the ambiguous word, that is, the surrounding words in a sentence or paragraph. For MT purposes, the context can be also that of the translation in the target language, i.e., words which have been already translated.

In this paper we focus on the differences in the sense inventory, contrasting the WordNet inventory for English disambiguation, which was created according to psycholinguistics principles, with the Portuguese translations assigned to a set of eight verbs in a corpus, simulating MT as a Computational Linguistics application.

We show that the relation between the number of senses and translations is not a one-to-one, and that it is not only a matter of the level of refinement of WordNet. The number of translations can be either smaller or larger, i.e., either two or more senses can be translated as the same word, or the same sense can be translated using different words. With that, we present evidence that employing a monolingual WSD method for the task of MT is not appropriate, since monolingual information offers little help to multilingual disambiguation. In other words, we argue that multilingual WSD is different from monolingual WSD, and thus requires specific strategies. We start by presenting approaches that show cognate results for different pairs of languages, and also approaches developed with the reverse goal of using multilingual information to help monolingual WSD (Section 2). We then present our experiments (Sections 3 and 4) and their results (Section 5).

2 Related work

Recently, others have also investigated the differences between sense repositories for monolingual and multilingual WSD. Chatterjee et al. (2005), e.g., investigated the ambiguity in the translation of the English verb "to have" into Hindi. 11 translation patterns were identified for the 19 senses of the verb, according to the various target syntactic structures and/or target words for the verb. They argued that differences in both these aspects do not depend only on the sense of the verb. Out of the 14 senses analyzed, six had 2-5 different translations each.

Bentivogli et al. (2004) proposed an approach to create an Italian sense tagged corpus (MultiSemCor) based on the transference of the annotations from the English sense tagged corpus SemCor (Miller et al., 1994), by means of word-alignment methods. A gold standard corpus was created by manually transferring senses in SemCor to the Italian words in a translated version of that corpus. From a total of 1,054 English words, 155 annotations were considered non-transferable to their corresponding Italian words, mainly due to the lack of synonymy at the lexical level.

Miháltz (2005) manually mapped senses from the English in a sense tagged corpus to Hungarian translations, in order to carry out WSD between these languages. Out of 43 ambiguous nouns, 38 had all or most of their English senses mapped into the same Hungarian translation. Some senses of the remaining nouns had to be split into different Hungarian translations. On average, the sense mapping decreased the ambiguity from 3.97 English senses to 2.49 Hungarian translations.

As we intend to show with this work, differences like those mentioned above in the sense inventories make it inappropriate to use monolingual WSD strategies for multilingual disambiguation. Nevertheless, some approaches have successfully employed multilingual information, especially parallel corpora, to support monolingual WSD. They are motivated by the argument that the senses of a word should be determined based on the distinctions that are lexicalized in a second language (Resnik and Yarowsky, 1997). In general, the assumptions behind these approaches are the following:

(1) If a source language word is translated differently into a second language, it might be ambiguous and the different translations can indicate the senses in the source language.

(2) If two distinct source language words are translated as the same word into a second language, it often indicates that the two are being used with similar senses.

Ide (1999), for example, analyzes translations of English words into four different languages, in order to check if the different senses of an English word are lexicalized by different words in all the other languages. A parallel aligned corpus is used and the translated senses are mapped into WordNet senses. She uses this information to determine a set of monolingual sense distinctions that is potentially useful for NLP applications. In subsequent work (Ide et al., 2002), seven languages and clustering techniques are employed to create sense groups based on the translations.

Diab and Resnik (2002) use multilingual information to create an English sense tagged corpus to train a monolingual WSD approach. An English sense inventory and a parallel corpus automatically produced by an MT system are employed. Sentence and word alignment systems are used to assign the word correspondences between the two languages. After grouping all the words that correspond to translations of a single word in the target language, all their possible senses are considered as candidates. The sense that maximizes the semantic similarity of the word with the others in the group is chosen.

Similarly, Ng et al. (2003) employ English-Chinese parallel word aligned corpora to identify a repository of senses for English. The English word senses are manually defined, based on the WordNet senses, and then revised in the light of the Chinese translations. For example, if two occurrences of a word with two different senses in WordNet are translated into the same Chinese word, they will be considered to have the same English sense.

In general, these approaches rely on the two previously mentioned assumptions about the interaction between translations and word senses. Although these assumptions can be useful when using cross-language information as an approximation to monolingual disambiguation, they are not very helpful in the opposite direction, i.e., using monolingual information for cross-language disambiguation, as we will show in Section 4.

3 Experimental setting

We focused our experiments on verbs, which represent difficult cases for WSD. In particular, we experimented with five frequent and highly ambiguous verbs identified as problematic for MT systems in a previous study (Specia, 2005): "to come", "to get", "to give", "to look", and "to make"; and other three frequent verbs that are not so ambiguous: "to ask", "to live", and "to tell". The inclusion of the additional verbs allows us to analyze the effect of the ambiguity level in the experiment. These verbs will then be translated into Portuguese so that the resulting translations can be contrasted to the English senses.

3.1 Corpus selection

We collected all the sentences containing one of the eight verbs and their corresponding phrasal verbs from SemCor, Senseval-2 and Senseval-3 corpora[1]. These corpora were chosen because they are both widely used and easily available. In each of these corpora, ambiguous words are annotated with WordNet 2.0 senses. Occurrences which did not identify a unique sense were not used. The numbers of sentences selected for each verb and its phrasal verbs are shown in Table 1.

Verb	# Verb Occurrences	# Phrasal Verb Occurrences
ask	414	8
come	674	330
get	683	267
give	740	79
live	242	5
look	370	213
make	1463	105
tell	509	3

Table 1. Number of verbs and phrasal verbs extracted from SemCor and Senseval corpora

It is worth mentioning that the phrasal verbs include simple verb-particle constructions, such as "give up", and more complex multi-word expressions, e.g., "get in touch with", "make up for", "come to mind", etc.

In order to avoid biasing the experiment due to possible misunderstandings of the verb uses, and to make the experiment feasible, with a reasonable number of occurrences to be analyzed, we selected a subset of the total number of sentences in Table 1, which were distributed among five professional English-Portuguese translators (T1, T2, T3, T4, T5), according to the following criteria:

- The meaning of the verb/phrasal verb in the context of the sentence should be understandable and non-ambiguous (for human translators).

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[1] Available at http://www.cs.unt.edu/~rada/downloads.html.

- The experiment should be the most comprehensive possible, with the largest possible number of senses for each verb/phrasal.

- Each translator should be given two occurrences (when available) of all the distinct senses of each verb/phrasal verb, in order to make it possible to contrast different uses of the verb.

- The translators should not be given any information other than the sentence to select the translation.

To meet these criteria, a professional translator, who was not involved in the translation task, post-processed the selected sentences, filtering them according to the criteria specified above. Due to both the scarce number of occurrences of each phrasal verb sense and the large number of different phrasal verbs for certain verbs, the post-selection of phrasal verbs was different from the post-selection of verbs. In the case of verbs, the translator scanned the sentences in order to get 10 distinct occurrences of each sense (two for each translator), eliminating those sentences which were too complex to understand or used the verb in an ambiguous way. This process did not eliminate any senses, and thus did not reduce the coverage of the experiment. When there were fewer than 10 occurrences of a given sense, sentences were repeated among translators to guarantee that each translator would be given examples of all the senses of the verb. For instance, if a sense had only four occurrences, the first two occurrences were given to T1, T3 and T5, while the other two occurrences were given to T2 and T4. If a sense occurred only once for a verb, it was repeated for all five translators.

For phrasal verbs, the same process was used to eliminate the complex and ambiguous sentences. Two occurrences (when available) of each sense of a phrasal verb were then selected. Due to the large number of different phrasal verbs for certain verbs, they were divided among translators, so that each translator was given two occurrences of only some phrasal verbs of each verb. Sentences were distributed so that all translators had a similar number of cases, as shown in Table 2.

In order to avoid biasing the translations according to the English senses, the original sense annotations were not shown to the translators and the sentences for each of the verbs, together with their phrasal verbs, were randomly ordered.

Additionally, we gave the same set of selected sentences to another group of five translators, so that we could analyze the reliability of the experiment by investigating the agreement between the groups of translators on the same data.

Translator Verb	# T1	# T2	# T3	# T4	# T5
ask	13	13	13	10	10
come	53	52	52	51	47
get	59	59	56	59	57
give	46	50	48	47	48
live	11	11	11	16	16
look	15	19	17	19	14
make	47	45	44	46	41
tell	14	12	12	15	10
Total	**258**	**261**	**253**	**263**	**243**

Table 2. Number of selected sentences and its distribution among the five translators

3.2 English senses and Portuguese translations

As mentioned above, the corpora used are tagged with WordNet senses. Although this may not be the optimal sense inventory for many purposes, it is the best option in terms of availability and comprehensiveness. Moreover, it is the most frequently used repository for monolingual WSD systems, making it possible to generalize, to a certain level, our results to most of the monolingual work. The number of senses for the eight selected verbs (and their phrasal verbs) in WordNet 2.0, along with the number of their possible translations in bilingual dictionaries[2], is shown in Table 3.

Verb	# Senses	# Translations
ask	12	16
come	108	226
get	147	242
give	92	128
live	15	15
look	34	63
make	96	239
tell	12	28

Table 3. Verbs, possible senses and translations

As we can see, the number of possible translations is different from the number of possible senses, which already shows that there is not a one-to-one correspondence between senses and translations (although there is a high correlation between the number of senses and translations: Pearson's Correlation = 0.955). In general, the number of possible translations is greater than

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[2] For example, DIC Pratico Michaelis®, version 5.1.

the number of possible senses, in part because synonyms are considered as different translations. As we will show in Section 5 (Table 4), we eliminate the use of synonyms as possible translations. Moreover, we are dealing with a limited set of possible senses, provided by the SemCor and Senseval data. As a consequence, the number of translations pointed out by the human translators for our corpus will be considerably smaller than the total number of possible translations.

4   Contrasting senses and translations

In order to contrast the English senses with the Portuguese translations, we submitted the selected sentences (cf. Section 3.1) to two groups of five translators (T1, T2, T3, T4, and T5), all native speakers of Portuguese. We asked the translators to assign the appropriate translation to each of the verb occurrences, which we would then compare to the original English senses. They were not told what their translations were going to be used for.

The translators were provided with entire sentences, but for practical reasons they were asked to translate only the verb and were allowed to use any bilingual resource to search for possible translations, if needed. They were asked to avoid considering synonyms as different translations.

The following procedure was defined to analyze the results returned by the translators, for each verb and its phrasal verbs separately:

1) We grouped all the occurrences of an English sense and looked at all the translations used by the translators in order to identify synonyms (in those specific uses), using a dictionary of Portuguese synonyms. Synonyms were considered as unique translations.

2) We then analyzed the sentences which had been given to multiple translators of the same group (when there were not enough occurrences of certain senses, as mentioned in Section 3.1), in order to identify a single translation for the occurrence and eliminate redundancies. The translation chosen was the one pointed out by the majority of the translators. When it was not possible to elect only one translation, the n equally most used were kept, and thus the sentence was repeated n times.

3) Finally, we examined the relation between senses and translations, focusing on two cases: (1) if a sense had only one or many translations; and (2) if a translation referred to only one or many senses, i.e., whether the sense was shared by many translations. We placed each sense into two of the following categories, explained below: (a) or (b), mutually exclusive, representing the first case; and (c), (d) or (e), also mutually exclusive, representing the second case.

(a) 1 sense → 1 translation: all the occurrences of the same sense being translated as the same Portuguese word. For example, "to ask", in the sense of "inquire, enquire", is always translated as "perguntar".

(b) 1 sense → n translations: different occurrences of the same sense being translated as different, non-synonyms, Portuguese words. For example, "to look", in the sense of "perceive with attention; direct one's gaze towards" can be translated as "olhar", "assistir", and "voltar-se".

(c) n senses → 1 translation (ambiguous): Different senses of a word being translated as the same Portuguese word, which encompasses all the English senses. For example, "make", in the sense of "engage in", "create", and "give certain properties to something", is translated as "fazer", which carries the three senses.

(d) n senses → 1 translation (non-ambiguous): different senses of a word being translated using the same Portuguese word, which has only one sense. For example, "take advantage" in both the senses of "draw advantages from" and "make excessive use of", being translated as "aproveitar-se".

(e) n senses → n translations: different senses of a word being translated as different Portuguese words. For example, the "move fast" and "carry out a process or program" senses of the verb "run" being translated respectively as "correr" and "executar".

Items **(a)** and **(e)** represent cases where multilingual ambiguity only reflects the monolingual one, that is, to all the occurrences of every sense of an English word corresponds a specific Portuguese translation. On the other hand, items **(b)**, **(c)** and **(d)** provide evidence that multilingual ambiguity is different from monolingual ambiguity. Item **(b)** means that different criteria are needed for the disambiguation, as ambiguity arises only during the translation, due to specific principles used to distinguish senses in Portuguese. Items **(c)** and **(d)** mean that disambiguation is not necessary, as either the Portuguese

translation is also ambiguous, embracing the same senses of the English word, or Portuguese has a less refined sense distinction.

5 Results and discussion

Table 4 presents the number of different sentences analyzed for each of the verbs (after grouping and eliminating the repeated sentences), the English (E) senses and (non-synonyms) Portuguese (P) translations in our corpus, followed by the percentage of occurrences of each of the categories outlined in Section 4 (**a – e**) with respect to the number of senses (**# Senses**) for that verb. Items (**c**) and (**d**) were grouped, since for practical purposes it is not important to tell if the P word translating the various E senses encompasses one or many senses. For items (**b**) and (**c&d**) we also present the average of P translations per E sense ((**b**) **average**), and the average of E senses per P translation, respectively ((**c&d**) **average**).

We divided the analysis of these results according to our two cases (cf. Section 4): the first covers items (**c&d**) and (**e**) (light grey in Table 4), while the second covers items (**a**) and (**b**) (dark grey in Table 4).

1) Items (c), (d) and (e): *n* senses → ? translation(s)

The number of senses in the corpus is almost always greater than the number of translations, suggesting that the level of sense distinctions in WordNet can be too fine-grained for translation applications The numbers of senses and translations are in an opposite relation comparing to the one shown in Table 3, where the number of possible translations was larger than the number of possible senses. This shows that indeed many of the possible translations are synonyms.

On average, the level of ambiguity decreased from 40.3 (possible senses) to 24.4 (possible translations), if the monolingual and multilingual ambiguity are compared in the corpus. If we consider the five most ambiguous verbs, the level of ambiguity decreased from 58.8 to 35. For the other three less ambiguous verbs, the level of ambiguity decreased from 9.3 to 6.7.

Column **% (c&d)** shows the percentage of senses, with respect to the total shown in the third column (**# Senses**), which share translations with other senses. A shared translation means that several senses of the verb have the same translation. **(c&d) average** indicates the average number of E senses per P translation, for those cases where translations are shared. For all verbs, on average translations cover more than two senses. The level of variation in the number of shared translations among senses is high, e.g., from 2 (translation = "organizar") to 27 (translation = "dar") for the verb "to give". Contrasting the percentage of senses that share translations, in **% (c)**, with the percentages in **% (d)**, which refers to the senses for which translations are not shared, we can see that the great majority of senses have translations in common with other senses, and thus the disambiguation among these senses would not be necessary in most of the cases. In fact, it could result in errors, since an incorrect sense could be chosen.

2) Items (a) and (b): 1 sense → ? translation(s)

As previously mentioned, the differences in the sense inventory for monolingual and multilingual WSD are not only due to the fact that sense distinctions in WordNet are too refined. That would only indicate that using monolingual WSD for multilingual purposes implies unnecessary work. However, we consider that the most important problem is the one evidenced by item (**b**) in the sixth column in Table 4. For all the verbs except "to ask" (the least ambiguous), there were cases in which different occurrences of the same sense were translated into different, non-synonyms words. Although the proportion of senses with only one translation is greater, as shown by item (**a**) in the fifth column, the percentage of senses with more than one translation is impressive, especially for the five most ambiguous verbs. In face of this, the lack of disambiguation of a word during translation based on the fact that the word is not ambiguous in the source language can result in very serious translation errors when monolingual methods are employed for multilingual WSD. Therefore, this also shows that, for these verbs, sense inventories that are specific to the translation between the pair of languages under consideration would be more appropriate to achieve effective WSD.

5.1 Agreement between translators

In an attempt to quantify the agreement between the two groups of translators, we computed the Kappa coefficient for annotation tasks, as defined by Carletta (1996). Kappa was calculated separately for our two areas of inquiry, i.e., cases (**1**) and (**2**) discussed in Section 5.

In the experiment referring to case (**1**), groups were considered to agree about a sense of a verb if they both judged that the translation of such

Verb	# Sentences	# Senses	# Translations	% (a)	% (b)	(b) average	% (c&d)	(c&d) average	% (e)
ask	83	8	3	100	0	0	87.5	3.5	12.5
come	202	68	42	62	38	3.1	73.2	6.3	26.8
get	226	90	61	70	30	2.6	61.1	3.4	38.9
give	241	57	12	48.7	51.3	3.3	84.2	6.3	15.8
live	55	10	7	83.3	16.7	3.0	70	2.7	30
look	82	26	18	63.2	36.8	2.4	84.6	2.7	15.4
make	225	53	42	51.4	48.6	2.9	77.4	4.1	22.6
tell	73	10	10	37.5	62.5	2.8	60	4.0	40

Table 4. Results of the procedure contrasting senses and translations

verb was or was not shared by other senses. For example, both groups agreed that the word "fazer" should be used to translate occurrences of many senses of the verb "to make", including "engage in", "give certain properties to something", and "make or cause to be or to become". On the other hand, the groups disagreed about the sense "go off or discharge" of the phrasal verb "to go off": the first group found that the translation of that sense, "disparar", did not refer to any other sense, while the second group used that word to translate also the sense "be discharged or activated" of the same phrasal verb.

In the experiment with case (**2**), groups were considered to agree about a sense if they both judged that the sense had or had not more than one translation. For example, both groups agreed that the sense "reach a state, relation, or condition" of the verb "to come" should be translated by more than one Portuguese word, including "terminar", "vir", and "chegar". They also agreed that the sense "move toward, travel toward something or somebody or approach something or somebody" of the same verb had only one translation, namely "vir".

The average Kappa coefficient obtained was 0.66 for item (**1**), and 0.65 for item (**2**). There is not a reference value for this particular annotation task (translation annotation), but the levels of agreement pointed by Kappa here can be considered satisfactory. The agreement levels are close to the coefficient suggested by Carletta as indicative of a good agreement level for discourse annotation (0.67), and which has been adopted as a cutoff in Computational Linguistics.

6   Conclusions and future work

We presented experiments contrasting monolingual and multilingual WSD. It was found that, in fact, monolingual and multilingual disambiguation differ in many respects, particularly the sense repository, and therefore specific strategies could be more appropriate to achieve effective multilingual WSD. We investigated the differences in sense repositories considering English-Portuguese translation, using a set of eight ambiguous verbs collected from sentences in SemCor and Senseval corpora. The English sense tags given by WordNet were compared to the Portuguese translations assigned by two groups of five human translators.

Results corroborate previous cognate work, showing that there is not a one-to-one mapping between the English senses and their translations (to Portuguese, in this study). In most of the cases, many different senses were translated into the same Portuguese word. In many other cases, different, non-synonymous, words were necessary to translate occurrences of the same sense of the source language, showing that differences between monolingual and multilingual WSD are not only a matter of the highly refined sense distinction criterion adopted in WordNet. Therefore, these results reinforce our argument that applying monolingual methods for multilingual WSD can either imply unnecessary work, or result in disambiguation errors.

As future work we plan to carry out further investigation of the differences between monolingual and multilingual WSD contrasting the English senses and translations into other languages, and analyzing other grammatical categories, particularly nouns.

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