Alignment-based profiling of Europarl data in an English-Swedish parallel corpus

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Abstract
This paper profiles the Europarl part of an English-Swedish parallel corpus and compares it with three other subcorpora of the same parallel corpus. We first describe our method for comparison which is based on alignments, both at the token level and the structural level. Although two of the other subcorpora contains fiction, it is found that the Europarl part is the one having the highest proportion of many types of restructurings, including additions, deletions and long distance reorderings. We explain this by the fact that the majority of Europarl segments are parallel translations.

1. Introduction
The Europarl corpus (Koehn, 2005) is the most widely used corpus for training and evaluating statistical machine translation systems for European languages, as evidenced by several recent workshops on the topic. The reasons are not hard to understand; it is very large, it is freely available, and it has data for all pairs of EU languages.

When a parallel corpus is used for statistical machine translation, filters are often applied to the selection of sentence pairs to restrict processing time for training and limit the amount of noise. The filters used are quite simple, however. One way is to put an upper bound on the length of sentences, and another is to remove pairs where one sentence has 5-7 times more tokens than its correspondent.

One can easily observe sentence pairs in the Europarl corpus where the two aligned sentences differ much in structure, and even content. A few examples are given below.

| EN       | This report is no exception |
| SE       | Så är fallet även i detta betänkande |
| Gloss:   | So is case-DEF also in this report |

| EN       | There are several reasons for this |
| SE       | Det beror på flera omständigheter |
| Gloss:   | It depends on several circumstances |

| EN       | ...there has been an attempt to put technical make-up on the political face |
| SE       | ...tekniken har försökt dölja politiken |
| Gloss:   | ...technology has tried hide politics |

There are several possible explanations for these differences: the translation strategy is fairly free, many translators are involved, and, if all available data is used, a majority of the data will be parallel translations rather than original source texts and their translations. Such sentence pairs are likely to introduce noise and could be harmful for the translation models. In any case, since the models of reordering and restructuring that current SMT models employ are fairly crude, it is unlikely that the systems will be able to reproduce translations with the same amount of deletions, additions, reordering and paraphrasing, that are found in such sentence pairs. Thus, it might be a good idea to have them filtered out too, at least from the test sets used for evaluation, if one can find some way to identify them automatically.

This paper, however, has a more restricted goal. It is a study of structural correspondences in a small parallel corpus with English-Swedish Europarl data in focus. All data is taken from the LinES English-Swedish parallel treebank, (Ahrenberg, 2007b), where one of the subcorpora is made up of Europarl data. Comparisons are made with three other subcorpora of the same treebank. The comparisons explore the manual alignments of the corpus and the syntactic annotation based on dependencies. The results indicate that the Europarl part is, in many respects, the most complex one in terms of the frequency of many types of non-isomorphic correspondences and non-local reorderings, in spite of the fact that two of the other subcorpora are drawn from fiction.

Section 2 presents the data, section 3 presents the method, and section 4 makes a number of comparisons using basic measures at the text, lexical and phrasal levels. Section 5, finally, holds the conclusions and suggestions for further work.

2. Method
Comparisons of monolingual corpora are often made on the basis of frequency profiling of words as well as word categories, such as parts of speech or semantic tags (Rayson and Garside, 2000). The same principles can be applied to the comparison of parallel corpora with respect to translational correspondences, but is not as straight-forward, as it has to deal with two texts. Notions such as deletion, reordering and restructuring are somewhat loose and there are different ways to make them more precise and measure them. Thus, we first need to define types of relations that can be counted.

Second, even if we find that one corpus has more of one type of restructuring than another, this need not be due to choices made by a translator, but to properties of the source
text. It may be that the source part of the corpus has a
greater number of constructions that, when translated in
mostly standard ways, necessitates structural changes be-
cause of language differences.

Generally, a Swedish translation of an English text has
fewer tokens than the source as a number of very common
constructions are usually translated with fewer tokens. Some of the most common cases are listed below:

**Compound tenses** translated with simple tense forms:
- *is sleeping* ~ *söver*
- *were given* ~ *gavs*

**Compound nouns** are subject to different orthographic
conventions:
- *file system* ~ *filsystem*,
- *world market prices* ~ *världsmarknadspriser*

**Definite articles** are expressed with a suffix in Swedish
when there are no modifiers:
- *the market* ~ *marknaden*
- *the world market* ~ *världsmarknaden*

**Do-support** is absent in Swedish.\(^1\)
- *Did she leave?* ~ *Gick hon?*
- *She did not go* ~ *Hon gick inte*

Thus, if an English source text has significantly more in-
stances of these constructions than another text, we expect
to see a larger drop in the number of tokens of its Swedish
translation.

A third factor that needs to be kept in mind is the princi-
ples used for word alignment. In LinES, function words are
null-aligned when there is no corresponding function word
on the other side, even though, as is often the case for the
definite article, the same function is expressed by a mor-
pheme. Obviously, any parallel English-Swedish parallel
corpus aligned in this way will have a high number of dele-
tions. Hence we must focus the comparisons on relative
numbers rather than absolute ones.

The paper reports both absolute and relative frequencies
for different types of correspondences. We also provide
definitions for the types. The definitions are encoded in a
suite of Perl scripts that generate the actual counts. The \(\chi^2\)
statistic has been used for tests of statistical significance.
For the reasons given above, we also quantify properties of
the English (source) texts to see to what extent the observed
structural differences between the English and the Swedish
texts can be accounted for on the grounds of well-known
grammatical differences.

3. Data

The parallel corpus used for this study is a fairly small one,
but on the other hand all syntactic annotations and word
alignments have been manually checked so as to be in ac-
Table 1: Corpus overview showing text type and size.

| Subcorpus  | Text type            | Sentences | Src words | Trg words | Ratio |
|------------|----------------------|-----------|-----------|-----------|-------|
| Access     | online help texts    | 595       | 10,451    | 8,898     | 0.85  |
| Europarl   | parliamentary debates| 594       | 9,334     | 8,715     | 0.93  |
| Bellow     | fiction              | 604       | 10,310    | 9,962     | 0.97  |
| HarryP     | fiction              | 600       | 10,171    | 10,501    | 1.03  |
| Sums:      |                      | 2393      | 40,266    | 38,076    | 0.95  |

We refer to the smallest index of an index list $\lambda$ as $\min(\lambda)$ and the largest index as $\max(\lambda)$. Thus, with $\lambda = 4-5-7$, $\min(\lambda) = 4$, and $\max(\lambda) = 7$.

4. Comparisons

We report absolute and relative frequencies based on different (combinations of) data. First, we discuss the figures from Table 1 and try to explain the differences that can be seen with respect to token counts. Then we make several alignment-based comparisons, first using alignment only, and then combining it with the syntactic annotation.

Table 2: Distribution of Noun-Noun sequences in the four subcorpora. Note that not all N N sequences are compounds and that proper nouns are not included in these counts.

| Subcorpus  | En N   | En N N | Sw N   | Sw N N |
|------------|--------|--------|--------|--------|
| Access     | 2852   | 695    | 2196   | 92     |
| Europarl   | 1944   | 193    | 1795   | 107    |
| Bellow     | 1767   | 152    | 1736   | 70     |
| HarryP     | 1690   | 154    | 1622   | 30     |
| Σ          | 8253   | 1194   | 7349   | 299    |

While the main focus is on the Europarl subcorpus, we also note properties of the other subcorpora when they stick out from the others.

4.1. Comparisons based on monolingual files

Already Table 1 indicates differences between the subcorpora. For HarryP the translation actually has more tokens than the source, while the Access translation has much fewer tokens than the others. The reason for these differences is not obvious without a more fine-grained inspection. We can find some clues, however, by looking at how tokens are distributed on different parts-of-speech and dependency functions. This reveals, for instance, that Access has the largest percentage drop in nouns, something which is explained by the higher numbers of compound nouns in Access. As shown in Table 2, there are more Noun-Noun sequences in Access than in the other three subcorpora combined, and a corresponding drop in the number of nouns in the Swedish version. Further inspection shows that a large part of this reduction (585 instances) is explained by a drop in the number of nouns that are attributes, i.e., nouns that make up the first part of an English nominal compound.

4.2. Comparisons based on word alignments

Alignment-based comparisons can provide more detailed information on restructuring. A basic typing scheme is...
The number of tokens in a link is given by the number of tokens, as shown in Table 3.

In Table 3, unlike Tables 1 and 2, Europarl comes out as extreme in certain aspects. It is the subcorpus with the least percentage of 1-to-1 word links, and it is the subcorpus with the highest number of deletions, and is close to the top in terms of additions. Moreover, a smaller share, some 38%, of the deletions are explained by null-links for non-corresponding function words, such as the definite article the and copular instances of the verb be, than for the other subcorpora, where the share is 40-50%.

If the Europarl corpus is compared to the union of the other three corpora, it is significantly different at the 0.01 level from them in the number of deletions, additions and isomorphisms. It has a larger share of deletions and additions and a smaller share of 1-to-1 correspondences.

We can also see that the large reduction of tokens for Access, as observed in Table 1, is largely explained by a high proportion of many-to-1 word links, the link type that applies to compound nouns.

For HarryP there is a high proportion of both additions and expansions, and a low proportion of deletions. This agrees well with the high ratio of target tokens to source tokens that was observed in Table 1.

Counting only the number of tokens in a link pays no regard to whether the tokens occur in a sequence or not. The types that involve more than one token on either side, i.e., reductions, expansions and paraphrases could be further categorized based on the occurrence of splits. Splits are not very numerous and occur on average in just above 1% of all sentences. In general, there are more splits on the Swedish side although the ratio varies from 1.4 (Access) to 3.9 (Bellow). Total sums are given in Table 4.

### Table 3: Distribution of word alignments on different types. Significant extremes are marked in boldface.

| Correspondence       | Access     | Europarl  | Bellow    | HarryP    |
|----------------------|------------|-----------|-----------|-----------|
| 1-1 (isomorphism)    | 6916 (69.7%) | 6236 (64.9%) | 7828 (74.8%) | 7585 (71.3%) |
| 1-0 (deletion)       | 1415 (14.2%)  | 1488 (15.4%)  | 1150 (10.9%)  | 1120 (10.5%) |
| 0-1 (addition)       | 474 (4.7%)    | 1001 (10.4%)   | 661 (6.3%)    | 1020 (9.6%) |
| many-1 (reduction)   | 816 (8.1%)    | 427 (4.4%)     | 343 (3.2%)     | 290 (2.6%)  |
| 1-many (expansion)   | 255 (2.5%)    | 349 (3.6%)     | 403 (3.8%)     | 501 (4.3%)  |
| many-many (paraphrase)| 40 (0.4%)    | 100 (1.0%)     | 74 (0.6%)      | 108 (1.3%)  |
| Σ                    | 9916         | 9601        | 10459       | 9724       |

Table 4: Number of links with a split token sequence and ratio per 1000 tokens.

| Subcorpus | Split src | Split trg | Sum | Ratio |
|-----------|-----------|-----------|-----|-------|
| Access    | 20        | 27        | 47 | 2.43  |
| Europarl  | 23        | 52        | 75 | 4.15  |
| Bellow    | 12        | 47        | 59 | 2.91  |
| HarryP    | 23        | 56        | 79 | 3.82  |

Here, HarryP is the subcorpus with most splits in absolute numbers, whereas Europarl has the highest ratio of splits compared to the number of tokens. The difference between these two is not significant.

### 4.3. Comparing reordering

Another informative feature of a word alignment is the amount of reordering it contains. (Fox, 2002) made a study of reorderings in the English-French test corpus from the Hansards used by (Och and Ney, 2000) – and many others after them. To measure the amount of reordering she identified instances of crossings, where a crossing was defined as two phrases having overlapping spans on the target side. In addition she took into account the fact that her corpus contains both sure and possible links and distinguished crossings of heads with modifiers and crossings of modifiers.

With a syntactic analysis that is based on dependencies rather than phrase structure we can gain useful information by restricting attention to word links. Also, the relevant feature is permutation rather than overlap, as the word alignment divides the tokens of a sentence pair into clearly separate links. For the metric only link pairs that are adjacent on the source side are considered, ignoring intervening deletions. Thus, a crossing occurs if there are two links \( \sigma_1, \tau_1 >, < \sigma_2, \tau_2 > \) such that

\[
\max(\sigma_1) < \min(\sigma_2), \text{ and } \max(\tau_2) < \min(\tau_1),
\]

and there is no other non-null link \( \sigma_3, \tau_3 > \) with those two properties for which \( \max(\sigma_1) < \min(\sigma_3) < \min(\sigma_2) \).

In case there is a split, we check positions both before and after the split. Thus, what are counted are instances where a link has a crossing with the nearest non-deleted neighbor. For example, in Figure 1 there are two crossings, one for the pair of links \(<report:betänkande, is:äär>\) and one for the pair \(<is:äär, no exception:så>\).

In addition, we need a measure for the span, or spread, of a crossing. For this purpose we measure the size of a crossing in terms of the difference in target word indices: \( \min(\tau_1) - \max(\tau_2) \). Note that this difference will be greater when there are null-aligned (i.e., added) tokens on the target side in between \( \max(\tau_2) \) and \( \min(\tau_1) \). Alternatively, we could count the number of links in the same interval.

Table 5 presents data on crossings. Bellow is the corpus with the highest number of crossings and both Bellow and HarryP have a larger proportion of length 1 crossings than Europarl. This is partly due to a high number of crossings involving a one-word subject and a finite verb. This in turn can be explained by their genre as written narratives with...
| Measure              | Access    | Europarl | Bellow   | HarryP   |
|---------------------|-----------|----------|----------|----------|
| Length 1 crossings  | 247 (46.7%) | 257 (43.6%) | 378 (57.5%) | 275 (55.1%) |
| Length 2-5 crossings| 224 (42.3%) | 260 (44.1%) | 230 (35.0%) | 183 (36.7%) |
| Longer crossings    | 58 (11.0%)  | 73 (12.4%)  | 49 (7.5%)  | 41 (8.2%)  |
| Sums (No. per sentence): | 529 (0.89) | 590 (0.99) | 657 (1.09) | 499 (0.83) |

Table 5: Number of crossings of different types in each subcorpus.

many source sentences beginning with an adverbial and a subject before the finite verb, where the translator is forced to move one of them after the finite verb in the Swedish translation, as in the following examples (from Bellow):

EN: Then someone says that it can’t be long now...
SE: Då säger någon att det inte kan dröja länge nu...
Gloss: Then says someone that it not can be long now...

EN: Silent, I give his case some thought
SE: Under tystnad ägnar jag en smula eftertanke åt fallet
Gloss: Under silence give I a bit afterthought to case-DEF

While Europarl is the second subcorpus in order as regard number of crossings, it is the one with the highest proportion of long crossings, i.e., crossings that are not simple swaps. Such crossings are present also in quite short sentences as evidenced by the examples listed in Section 1.

It may be noted that our way of measuring crossings is asymmetric. While absolute numbers are slightly different when crossings are counted in the opposite direction, the general tendencies and relative differences are the same.

4.4. Types of structural correspondence

To estimate the amount of restructuring in a parallel corpus, it is obviously of interest to look at phrasal correspondences. It is not evident, however, how phrasal correspondences should be typed. Most methods for generating sub-sentential correspondences from parse trees rely on some form of wellformedness constraints, whether performed manually (Samuelsson and Volk, 2007) or automatically (Lavie et al., 2008; Tinsley et al., 2007). A common assumption is that head-dependent relations are kept, i.e., if two non-terminal nodes have been aligned, the daughters of one of them can only be aligned to daughters of the other. Head-dependency reversals are not uncommon, though, as in the example below (from Europarl), where the main verb, have a place, from the source text has been made the head of an embedded clause in the translation, due to the introduction of a presentation construction det är naturligt ... (it is natural) as a translation of the adverbial Naturally:

EN: Naturally, the Turkish Cypriots will have a place in the representation.
SE: Och det är naturligt att i delegationen för Cyperns lagliga och erkända regering även turkcypriter kommer att kunna inga.
Gloss: And it is natural that in delegation.DEF for Cyprus’ legal and recognized government also Turkish Cypriots will be able to take.part

To assess how common this type of restructuring is, the English sentence heads that correspond to Swedish sentence heads have been counted. These counts are shown in Table 6, again putting the Europarl corpus on top. It has significantly more of restructuring in this respect than the other subcorpora.

In another experiment we considered all binary head-dependency relations in the source data and their correspondents in the target data. The taxonomy for these relations is based on the following features: (1) the occurrence of null links for one or both of the source tokens; (2) whether the tokens correspond to the same or different target tokens; (3) whether the dependency direction is kept, reversed, or levelled out; (4) whether the target tokens have an immediate dependency relation, when they have a dependency relation at all. The following types were defined, where D refers to the dependent token, H to its head, and D’ and H’ to their respective translations:

- **Deletion.** The dependant D, or the head H, or both of them have been null-aligned.
- **Confimation.** The dependent and the head correspond to the same token on the target side.
- **Isomorphism.** The source dependency D→H corresponds to a dependency D’→H’ on the target side.
- **Stretched dependency.** The dependent, D, corresponds to a token D’ for which H’ is a head, but not an immediate head.
- **Reversal.** The source dependency D→H corresponds to a reversed dependency H’→D’ on the target side.
- **Stretched reversal.** The source head, H, corresponds to a token, H’, for which D’ is a head, but not an immediate head.
- **Levelling.** H’ is not a head for D’, nor is D’ a head for H’.

Table 7 shows the distribution of dependency correspondences for these different types. Only links where both tokens have at most one corresponding token in the target data have been included. Source dependencies that do not meet this criterion are noted as ‘Skipped’.

The picture from Table 7 largely corroborates the earlier findings. Europarl has the highest share of deletions, which is not surprising, since it has the highest share of deletions at the word level. It also has the lowest share of pure isomorphisms.

The relative frequency of reversals may seem high and is partly explained by differences in syntactic annotation for
Table 6: Alignments of sentence heads in the four subcorpora. Note that the category main-main includes 1-many, many-1 and many-many links as well, when both sides contain the main token.

Table 7: Frequencies for different types of relation between a source text dependency relation and its corresponding target image. Percentages are based on the number of relations that could be typed, stated in the row Subtotals.

the two languages. For example, Swedish passive participles agree in number and gender with their subjects, as do adjectives, and are usually analysed as subject predicatives, while English passive participles are analysed as heads. To illustrate: in an English sentence \( X \) is installed the participle is the head of the copula, while in the corresponding Swedish sentence \( X \) är installerad, the direction of the dependency goes in the opposite direction. Another contributing factor is that some common English verbs, such as \( \text{want} \) are analysed as main verbs, while the common Swedish translation \( \text{vill} \) is analysed as an auxiliary. And coordinations that relate two first parts of a compound are also analyzed differently. Normally in a coordinated construction the first conjunct is taken to be the head. When two first parts of a compound are coordinated in Swedish, however, the second part is taken to be the head, as in the following example:

EN: row and column areas  
SE: rad- och kolumnområden

Here, in the English phrase, column is a dependent of row, while in the Swedish translation, the correspondent of row, namely rad is a dependent of kolumnområden.

However, the relative difference in the number of reversals for the Access subcorpus and the others is still significant. It is explained by a large number of noun phrases consisting of a proper noun, or a noun used as a name, and a descriptive noun, where the Swedish translation reverses both the linear order and the dependency direction, as in the following examples:

EN: the Orders field  
SE: fältet Order  
Gloss: field-DEF Order

EN: Enable system administrator user name check box  
SE: kryssrutan Aktivera användarnamn för systemadministratör  
Gloss: check-box-DEF Enable user-name for system-administrator

Access also shows the highest number of conflations but this is not so surprising since we know from Table 2 that Access has a large number of compound nouns.

5. Conclusions and future work

This is a small study which does not permit very definite conclusions. There is a clear indication, however, that Europarl data contains a high share of structurally complex relations, in particular additions, deletions, and long distance reorderings on a level comparable to those that can be found in fiction. It also has a high share of non-corresponding sentence heads. At least, this seems to be the case for the English-Swedish data in the LinES parallel treebank. We believe that a major reason is that Europarl data includes parallel translations, not just source text and translation.

The study can be extended in several ways. First, more detailed studies can be performed by further categorization in terms of the parts-of-speech and dependency relations involved. We have shown a few examples of such more fine-grained analyses, but the picture could easily be made more complete. Second, we would like to include other corpora that are much used in statistical MT, such as the JRC-Acquis (Steinberger et al., 2006) in the LinES treebank and perform a similar study. The method itself can also be improved by the inclusion of a more developed taxonomy for correspondences at the phrasal level.

Another extension is to see whether profiling can be based on automatic tools. In particular, it would be interesting to compare results from precision-oriented align-
ment methods such as symmetrized Giza++ with intersection (Och and Ney, 2003) or Holmqvist’s pattern-based word alignment (Holmqvist, ).

Another line of research is the development of appropriate automatic filters on existing training corpora to reduce complexity, and the compilation of alternative parallel and annotated corpora of less complexity. Of course, we cannot say on the basis of this study how instances of complex correspondence relations affect the translation models and phrase tables that are generated from Europarl data and used in statistical machine translation, nor whether they have any adverse effects at all. This should also be a topic for further investigation. However, the restructuring that is found certainly goes beyond what current SMT systems can produce, and rather calls for an example-based approach. Thus, we believe that it is not a good idea to include such translations in reference sets used for testing, since the prime application for statistical systems is gisting rather than translations with publishing-quality.

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