Annotating Predicate-Argument Structure for a Parallel Treebank

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Abstract

We report on a recently initiated project which aims at building a multi-layered parallel treebank of English and German. Particular attention is devoted to a dedicated predicate-argument layer which is used for aligning translationally equivalent sentences of the two languages. We describe both our conceptual decisions and aspects of their technical realisation. We discuss some selected problems and conclude with a few remarks on how this project relates to similar projects in the field.

1. Introduction

Parallel corpora are widely accepted as a valuable data source for machine translation and other research. So far, however, the amount of linguistic annotation in these corpora is limited, and particularly multilingual corpora annotated with syntactic information are rare. Our goal is to build a treebank of aligned parallel\footnote{In accordance with the terminology suggested in (Sinclair, 1994), we understand “parallel” to mean that the texts are translations of each other.} texts in English and German with the following linguistic levels: POS tags, constituent structure, functional relations and predicate-argument structure for each monolingual subcorpus, plus an alignment layer to “fuse” the two – hence our working title for the treebank, FuSe, which additionally stands for functional semantic annotation (Cyrus et al., 2003).

We use the Europarl Corpus (Koehn, 2002), which contains sentence-aligned proceedings of the European parliament in eleven languages and thus offers ample opportunity for extending the treebank at a later stage.\footnote{There are a few drawbacks to Europarl, such as its limited register and the fact that it is not easily discernible which language is the source language. However, we believe that at this stage the easy accessibility, the amount of preprocessing and particularly the lack of copyright restrictions make up for these disadvantages.} For syntactic and functional annotation we basically adapt the TIGER annotation scheme (Albert et al., 2003), making adjustments where we deem appropriate and changes which become necessary when adapting to English an annotation scheme which was originally developed for German.

The fusion of the language pair will take place on an alignment layer which connects the predicate-argument layers of both monolingual subcorpora. Only the alignment layer is explicitly defined for a language pair rather than for a single language. Apart from this layer, the subcorpora are monolingual resources in their own right.

Although, eventually, the treebank will prove useful for several fields of application, the most obvious one being machine translation, our main motivation is to contribute to linguistic research. The treebank will serve as a resource for both monolingual and contrastive analyses.

2. Reasons for Predicate-Argument Structure

In a parallel treebank, it is necessary to capture the translational equivalence between two sentences. Our basic assumption is that this equivalence can best be represented by means of a predicate-argument structure. It is sometimes assumed that predicate-argument structure can be derived or recovered from constituent structure or functional tags such as subject and object.\footnote{See e.g. (Marcus et al., 1994).} While it is true that these annotations provide important heuristic clues for the identification of predicates and arguments, predicate-argument structure goes beyond the assignment of phrasal categories and grammatical functions, because the grammatical category of predicates and consequently the grammatical functions of their arguments can vary.

For instance, it is very common for an English verbal predicate to be expressed by a nominalisation in German, as is the case in the NPs in (1) and (2), where the English verb nominate is translated as the German noun Nominierung.

\begin{enumerate}
\item \textit{their} automatic right to nominate a member of the European Commission\footnote{Europarl:de-en/ep-00-02-15.al, 326. Note that throughout this paper, sentences are sometimes cited with irrelevant parts omitted.}
\item \textit{ihres} automatisches Recht auf Nominierung eines Mitglieds der Europäischen Kommission member of the European Commission
\end{enumerate}

The annotations of these noun phrases are shown in Figure 1.\footnote{All figures are at the end of the paper.} It can be seen that the correspondence between \textit{NP\textsubscript{908}} and \textit{NP\textsubscript{505}} cannot be inferred from the constituent structure, since \textit{NP\textsubscript{505}} is an immediate constituent of an IE ("extended infinitive") while \textit{NP\textsubscript{505}} is deeply embedded in a PP. Neither can the correspondence of \textit{NP\textsubscript{508}} and \textit{NP\textsubscript{505}} be inferred from their respective functional categories, since \textit{NP\textsubscript{508}} is a direct object (OD) while \textit{NP\textsubscript{505}} is a modifier (AG: "genitive attribute"). However, the resemblance between these constituents becomes apparent when they are marked for their argument status, because they both fulfill a similar role.
We have therefore chosen to represent predicate-argument structure on a dedicated layer in our treebank in order to be able to capture the parallelism between translations and to use it as the basis for alignment.

3. Details of the Predicate-Argument Annotation

The predicate-argument structures used here consist solely of predicates and their arguments. Although there is usually more than one predicate in a sentence, no attempt is made to nest structures or to join the predications logically in any way. The idea is to make the predicate-argument structure as rich as is necessary to be able to align a sentence pair while keeping it as simple as possible so as not to make it too difficult to annotate. In the same vein, quantification, negation, and other operators are not annotated. In short, the predicate-argument structures are not supposed to capture the semantics of a sentence exhaustively in an interlingual-like fashion.

3.1. Predicates and Arguments

In determining what a predicate is and how many there are in a sentence we rely on a few assumptions that are of a heuristic nature. One of these assumptions is that predicates are more likely to be expressed by tokens belonging to some word classes than by tokens belonging to others. Potential predicate expressions in FuSe are verbs, deverbal adjectives and nouns or other adjectives and nouns which show a syntactic subcategorisation pattern. The predicates are represented by the capitalised citation form of the lexical item (e.g. NOMINATE). Homonymous or polysemous predicates are differentiated by means of a disambiguator, predicates are assigned a class based on their syntactic form, and derivationally related predicates form a predicate group.

Arguments are given short intuitive role names (e.g. ENT_NOMINATED) in order to facilitate the annotation process. These role names have to be used consistently only within a predicate group. If, for example, an argument of the predicate NOMINATE has been assigned the role ENT_NOMINATED and the annotator encounters a comparable role as argument to the predicate NOMINATION, the same role name for this argument has to be used.

Keeping the argument names consistent for all predications within a group while differentiating the predications on the basis of syntactic form are complementary principles, both of which are supposed to facilitate querying the corpus. The consistency of argument names within a group, for example, enables the researcher to analyse paradigmatically all realisations of an argument irrespective of the syntactic form of the predicate. At the same time, the differentiation of predications makes possible a syntagmatic analysis of the differences of argument structures depending on the syntactic form of the predicate.

3.2. Binding Layer

All elements of the predicate-argument structure must be bound to elements of the phrasal structure (terminal or non-terminal nodes). These bindings are stored in a dedicated binding layer between the constituent layer and the predicate-argument layer.

When an expected argument is absent on the phrasal level due to specific syntactic constructions, the binding of the predicate is tagged accordingly, thus accounting for the missing argument. For example, in passive constructions like in Table 1, the predicate binding is tagged as pv. Other common examples are imperative constructions. Although information of this kind may possibly be derived from the constituent structure, it is explicitly recorded in the binding layer as it has a direct impact on the predicate-argument structure.

<table>
<thead>
<tr>
<th>Sentence</th>
<th>wenn korrekt gedolmetscht wurde</th>
<th>pvv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pred/Arg</td>
<td>DOLMETSCHEN</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Example of a tagged predicate binding (Europarl:de-en/ep-00-01-18.al, 2532)

Bindings of arguments may be tagged as well, for example for this being object-control (cf. Table 2). To account for the deviant case of the subject of the embedded clause in an object-control construction, the binding of this argument is tagged (oc-case). With this information, a researcher or a machine learner will be able to ignore a specific argument which might distort statistics on the phrasal realisations of arguments.

The predicate binding is tagged as well to mark the entire object-control construction (oc). This tagging enables the researcher to filter out this specific predicate-argument structure, so as to ignore these constructions completely.

Section 4.1. will show that linking predicates or arguments to constituents cannot always be achieved by binding them to a single node in the constituent structure. In order to be flexible in this respect, the binding layer allows for complex bindings, with more than one node of the constituent structure to be included in and sub-nodes to be explicitly excluded from a binding to a predicate or argument.

3.3. Alignment Layer

On the alignment layer, the elements of a pair of predicate-argument structures are aligned with each other. Arguments are aligned on the basis of corresponding roles within the predications. Comparable to the tags used in the binding layer that account for specific constructions (see Table 1), the predicate-argument structures may be tagged (pv).

See the database documentation (Feddes, 2004) for a more detailed description of this mechanism.

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6 Since the predicate-argument structure is always bound to the constituent structure (see Section 3.2.), it might well be possible to derive this information, e.g. through coordination structures and the hierarchical ordering of constituents.

7 For all non-verbal predicate expressions for which a derivationally related verbal expression exists it is assumed that they are deverbal derivations, etymological counter-evidence notwithstanding.

8 See the database documentation (Feddes, 2004) for a more detailed description of this mechanism.
Section 3.2.), the alignments may also be tagged with further information. This becomes necessary when the predications are incompatible in some way. Section 4.3. will give examples.

If there is no corresponding predicate-argument structure in the other language or if an argument within a structure does not have a counterpart in the other language, there will simply be no alignment. Section 4.2. provides an example where a predication is left dangling.

Table 3 gives an overview of the annotation layers as described in this section.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phrasal</td>
<td>constituent structure of language A</td>
</tr>
<tr>
<td>Binding</td>
<td>binding ( \uparrow ) predicates/arguments to ( \uparrow ) nodes</td>
</tr>
<tr>
<td>Alignment</td>
<td>aligning ( \uparrow ) predicates and arguments</td>
</tr>
<tr>
<td>PA</td>
<td>predicate-argument structures</td>
</tr>
<tr>
<td>Binding</td>
<td>binding ( \uparrow ) predicates/arguments to ( \downarrow ) nodes</td>
</tr>
<tr>
<td>Phrasal</td>
<td>constituent structure of language B</td>
</tr>
</tbody>
</table>

Table 3: The layers of the predicate-argument annotation

4. Problematic Cases

In this section we will elaborate on some problematic cases of predicate-argument annotation which we have encountered so far, some of them particular to the annotation and alignment of predicate-argument structures for a language pair.

4.1. Binding Predicate-Argument Structure to Constituent Structure

It was mentioned in Section 3. that all predications and arguments must be bound to either terminal or non-terminal nodes in the constituent structure. However, this is not always possible since in some cases there is no direct correspondence between argument roles and constituents. For instance, this problem occurs whenever a noun is postmodified by a participle clause: in Figure 2, the argument role ENT\textunderscore RAISED of the predicate \textsc{raise} is realised by NP\textsubscript{525}, but the participle clause (IPA\textsubscript{517}) containing the predicate (raised\textsubscript{5}) needs to be excluded, because not excluding it would lead to recursion. Consequently, there is no simple way to link the argument role to its realisation in the tree.

In these cases we link the argument role to the appropriate phrase (here: NP\textsubscript{525}) and prune out the constituent that contains the predicate (IPA\textsubscript{517}; see Section 3.2. for this mechanism), which results in a discontinuous argument realisation.

4.2. Coping with Modality

Generally, modal verbs are not considered to be predications and are consequently not included in our predicate-argument database. This can cause a problem when a verbal predication that is modified by a modal auxiliary in L1 (3) is represented by a deverbal noun in the corresponding sentence in L2 (4).

(3) The laws against racism must be harmonised.\footnote{Europarl:de-en/ep-00-01-19.al, 489.}

(4) Die Harmonisierung der Rechtvorschriften gegen den Rassismus ist dringend erforderlich.

This can be illustrated by Figure 3: the realisation of the verbal predicate HARMONISE (harmonised\textsubscript{3}) is modified by the modal auxiliary must\textsubscript{4}. In the German sentence, the nominal predicate HARMONISIERUNG (Harmonisierung\textsubscript{1}) is used. Here, the modality is expressed by a predicate of its own, namely ERFORDERLICH (erforderlich, ‘necessary’). This second predicate does not correspond to any predication in the English sentence.

It would be an easy way out to resort to annotating modal auxiliaries as if they were full verbs and consequently predications, but we have opted against this makeshift solution. One has to keep in mind that the predicate-argument annotation is done monolingually and only later serves as the basis for alignment. It should not be assumed that the corresponding equivalent is known to the annotator during the annotation process. Even though the way a sentence is expressed in another language can give valuable insights into its structure and meaning, this should not go so far as to change the way the original language is annotated. This is particularly true since the idea behind the FuSe treebank is that it is in principle extendable and may well include languages other than English and German in the future. As it cannot be foretold what phenomena will be encountered once further languages are added, the decisions as to what is annotated and what is not should not be guided by cross-linguistic considerations.

Thus, the simple fact alone that a predication in one language does not correspond to a predication in another should not induce one to alter the annotation praxis so as to make the two versions more compatible with each other. Modality, in particular, can be expressed in a variety of ways, and just because one of them is the realisation as a predicative adjective does not make, say, a modal adverbial like certainly a predication. The same argumentation holds for modal auxiliaries.
4.3. Incompatible Predications

Sometimes, the predications in two corresponding sentences express approximately the same idea but are otherwise incompatible with each other. This can be demonstrated with sentences (5) and (6), the annotation, argument structure and alignment of which are illustrated in Figure 4.

(5) Our motion will give you a great deal of food for thought, Commissioner.\ footnotetext[10]{Europarl:de-en/ep-00-01-18.al, 53.}
(6) Eine Reihe von Anregungen werden wir Ihnen, Herr Kommissar, mit unserer Entscheidung Mr. Commissioner, with our resolution mitgeben\ footnotetext[11]{Europarl:de-en/ep-00-01-18.al, 2522.}

The incompatibility results from the fact that, while the predicates GIVE and MITGEBEN are roughly equivalent in meaning, the two sentences are organised differently with regard to their information structure. This has caused the two corresponding argument roles of GIVER and MITGEBER to be realised by two incompatible expressions representing different referents (NP\textsubscript{500} vs. \textit{wir\textsubscript{7}}). The English version is somewhat metaphorical in that, unlike in the German sentence, there is no animate entity in this agent-like argument position. The actual agent is not realised as such and can only be identified by a process of inference based on the presence of the possessive pronoun \textit{our\textsubscript{0}}. To complicate matters even further, the translational equivalent of NP\textsubscript{500} (i.e. the constituent realising the English GIVER), is not even an argument in the German sentence (PP\textsubscript{508}).

Consequently, it seems impossible to reach a satisfactory alignment in this case: either two arguments with the same role but different meanings would have to be aligned, or else the alignment would rely solely on translational equivalence, which would reduce to absurdity our reasons for including predicate-argument structure.

We solve the problem as follows: since cases like this are at the same time potentially interesting for contrastive analyses and a hazard for applications using the treebank for automatic learning, we keep up the alignment on the basis of argument roles but tag the alignment (see Section 3.3.) between the arguments in question and thus mark them as being incompatible (incomp) with each other. This enables the interested researcher to formulate explicit searches for this alignment type while making it possible for applications to skip these cases if this is preferred.

Sentences (7) and (8) are a second case where we make use of the possibility to tag the alignment. Here, the adjectival predicate INAPPLICABLE in (7) is represented by the negated predicate ANWENDBAR (‘applicable’) in the German counterpart (8).

(7) the Directive is inapplicable in Denmark.\ footnotetext[11]{Europarl:de-en/ep-00-01-18.al, 53.}
(8) die Richtlinie ist in Dänemark nicht anwendbar\ footnotetext[11]{Europarl:de-en/ep-00-01-18.al, 2522.}

Since whether or not a predicate is negated does not alter its argument structure we do not annotate negation (see Section 3.). As this leads to an alignment of predicates with opposite meanings, we tag the alignment between the two predicates as abs-opp (“absolute opposites”). In theory, this method could also be applied to cases where a predicate is translated by its relational opposite (e.g. buy vs. sell). So far, however, we have not yet come across this type of translation in our data. It will be interesting to discover what types of incompatibility will come to light as the annotation proceeds.

5. Database Structure and Tools

We use ANNOTATE (Plaehn, 1998a) for the semi-automatic assignment (Brants, 1999) of POS tags, hierarchical structure, phrasal and functional tags. ANNOTATE stores all annotations in a relational database.\footnote{For details about the ANNOTATE database structure see (Plaehn, 1998b).} To stay consistent with this approach we have developed an extension to the ANNOTATE database structure to model the predicate-argument layer and the binding layer.

Due to the monolingual nature of the ANNOTATE database structure, the alignment layer (Section 3.3.) cannot be incorporated into it. Hence, additional types of databases are needed. For each language pair (currently, English and German), an alignment database is defined which represents the alignment layer, thus fusing two extended ANNOTATE databases. Additionally, an administrative database is needed to define sets of two ANNOTATE databases and one alignment database. The final parallel treebank will be represented by the union of these sets (Feddes, 2004).

While annotators use ANNOTATE to enter phrasal and functional structure comfortably, the predicate-argument structures and alignments are currently entered into a structured text file which is then imported into the database. A graphical annotation tool for these layers is under development. It will make binding the predicate-argument structure to the constituent structure easier for the annotators and suggest argument roles based on previous decisions.

6. Relation to Other Projects and Outlook

This section will show briefly how our approach relates to other projects annotating some kind of predicate-argument structure, such as PropBank (Palmer et al., 2003) and FrameNet (Johnson et al., 2003), and how the alignment structures of the parallel treebank make up for certain drawbacks of our annotation scheme.

Since our annotation of predicates and their arguments is not a means in itself but to the end of aligning constituents of a parallel treebank, it is kept deliberately simple. It resembles the mnemonic descriptors clarifying the numbered arguments in the PropBank framesets. We do not, however, attempt any generalisation whatsoever: neither do we organise our predicates in frames, as is done by FrameNet and adopted by SALSA (Erk et al., 2003), nor do we follow the Levin classes (Levin, 1993), as is done in the PropBank project.
Some problems we encounter with our simple scheme could be avoided with a deeper predicate-argument structure. As the first example in Section 4.3. shows, predications which are incompatible in our scheme need not be incompatible in a FrameNet-like scheme: if the argument roles were deeper than our intuitive role names, i.e., if our motion in example (5) were not a GIVER but, e.g., a CAUSE, the incompatibility with the corresponding structure in (6) would not arise.

There are several reasons for us to stick to our simple approach. For one thing, a more complex scheme would make the annotation more susceptible to inconsistencies. Secondly, transferring the approaches mentioned above to other languages than English is not a straightforward matter. While this seems to be working quite well for the FrameNet frames (Erk et al., 2003), Levin’s verb classes are inherently English and cannot be directly applied to German. In a later stage of the project, it might be possible to work through the predicate-argument database and map our very specific scheme to a more general one, e.g. by assigning each predicate to a frame and each argument to a frame element. However, other studies show that mapping one scheme onto another is far from trivial (Hajiˇcov´a and Kuˇcerov´a, 2002), and quite a lot of manual work will presumably be necessary.

Finally, we believe it is possible to exploit the corpus as a parallel lexical resource to see how different predicates can be clustered automatically by analysing their mappings in the other language. Figure 5 sketches the general idea. Suppose that in the English sub-corpus, two predicate-argument structures have different predicates (BUY and PURCHASE) which subcategorise for comparable arguments and express the same concept. In a FrameNet-like annotation, these predicates would be instantiations of the same frame (e.g. COMMERCIAL_TRANSACTION). In our scheme, neither are these predicates grouped in any way, nor do the comparable arguments get the same role names.

However, it is well conceivable that both predicates are translated identically in the corresponding German structures (e.g. by KAUFEN ‘buy’). Since predicates and arguments are aligned to each other, the comparability of the predicates (BUY – PURCHASE) and their arguments (BUYER – PURCHASER and ENT_BOUGHT – ENT_PURCHASED) can be derived (cf. the dashed lines). It will then be instructive to investigate how these clusters compare to FrameNet frames and to explore to what extent such a data-driven approach to frame semantics is feasible.

7. References


their automatic 
right to nominate a member of the European Commission

Predicate–argument layer
NOMINATE–v [28]
ENT_NOMINATED [508]

Alignment layer

Predicate–argument layer
NOMINIERUNG–n [25]
NOMINIERTES [505]

Figure 1: Alignment of a verb/direct-object construction with a noun/modifier construction

their automatisches Recht auf Nominierung eines Mitglieds der Europäischen Kommission

Predicate–argument layer
RAISE–v (6)
ENT_RAISED [525–517]

Figure 2: Complex constituent binding of an argument
The laws harmonising against racism must be harmonised. It is urgently required.

Figure 3: Modality

Figure 4: Incompatible predications
Figure 5: Deriving predicate clusters by exploiting alignment structures