Example-Based Treebank Querying

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Abstract

The recent construction of large linguistic treebanks for spoken and written Dutch (e.g. CGN, LASSY, Alpino) has created new and exciting opportunities for the empirical investigation of Dutch syntax and semantics. However, the exploitation of those treebanks requires knowledge of specific data structures and query languages such as XPath. Linguists who are unfamiliar with formal languages are often reluctant towards learning such a language. In order to make treebank querying more attractive for non-technical users we developed GrETEL (Greedy Extraction of Trees for Empirical Linguistics), a query engine in which linguists can use natural language examples as a starting point for searching the Lassy treebank without knowledge about tree representations nor formal query languages. By allowing linguists to search for similar constructions as the example they provide, we hope to bridge the gap between traditional and computational linguistics. Two case studies are conducted to provide a concrete demonstration of the tool. The architecture of the tool is optimised for searching the LASSY treebank, but the approach can be adapted to other treebank lay-outs.

Keywords: Dutch, treebank, querying

1. Introduction

The recent construction of large linguistic treebanks (or syntactically annotated text corpora) for spoken and written Dutch such as CGN (van der Wouden et al., 2003), (Van Eynde, 2009), LASSY (van Noord et al., 2006; van Noord et al., in press), and Alpino Treebank (van der Beek et al., 2002) has created new and exciting opportunities for the empirical investigation of Dutch syntax and semantics. However, the exploitation of those treebanks usually requires knowledge of specific data structures and/or query languages, which may discourage linguists to use them. In this paper, we present a user-friendly search application for the exploitation of treebanks by linguists who are not familiar with nor interested in data formats or query languages. By allowing linguists to search for similar constructions as the example they provide, we hope to bridge the gap between traditional linguistics and treebank builders. This conforms with one of the project goals of CLARIN1 to open up language resources for human and social sciences. In section 2 we will shortly discuss the most common querying issues. In section 3 we will present the concept of example-based querying and the architecture of our search application, which will be illustrated by the elaboration of two examples in section 4. Finally, we will draw conclusions and touch on some topics for future research in section 5.

2. Querying Issues

In the literature on treebank querying we are faced with the same problems over and over again. A major obstacle is the limited user-friendliness of the query languages and search tools. That problem is closely related to another issue of treebank mining: the lack of standardisation in both treebanks and query languages. See amongst others: Lai and

Bird (2004), Hellmann et al. (2010), and Štepánek and Pajaz (2010).

Nowadays there are many natural language treebanks and almost as many formal languages to query those treebanks. For example, the Penn Treebank (Marcus et al., 1993) should be queried with TGrep2 (Rohde, 2005), the TIGER Treebank (Brants et al., 2002) and CGN can be queried with TIGERSearch (Lezius, 2002), and for LASSY the W3C standards XPath2 and XQuery3 can be used for searching and extracting information from the treebank with applications like dsearch (Bouma and Kloosterman, 2002; Bouma and Kloosterman, 2007) or DACT.4 Because of that overload of query languages, annotation formats and data structures, many linguists give up treebank mining as they do not easily find what they are looking for. It requires time and effort to learn a formal language, since queries get long and complex relatively quickly.

As it is quite a hassle to learn such query languages and data structures, some search tools offer a GUI in order to shield the linguist from the internal formalisation of the treebank, e.g. TIGERin (Voormann and Lezius, 2002), and SearchTree (Nygaard and Johannesen, 2004). Unfortunately, the linguist still has to be familiar with the exact tree lay-out and hence the underlying linguistic theories of the treebank builders in order to formulate what (s)he is looking for. Therefore such GUIs are in fact less user-friendly than they are supposed to be. Since standardisation5 in the highly evolving field of treebank building and querying is still far off,6 we decided

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1 http://www.clarin.eu

2 http://www.w3.org/TR/xpath

3 http://www.w3.org/TR/xquery

4 http://rug-compling.github.com/dact/

5 Although a standard format for linguistic annotation is not defined yet, the FoLiA format (van Gompel, 2011) is a first attempt towards such a format for Dutch.

6 There are some ongoing efforts towards standardisation: W3C standard technologies are commonly used for natural lan-
to tackle the problem in another way. Instead of developing yet another query language or designing yet another GUI, we present a query engine which does not ask for any formal input query. As input, the tool takes something linguists are familiar with: natural language.

3. Example-Based Querying

Since linguists tend to start their research from example sentences, example-based querying allows to use those examples as a starting point for treebank search. Work related to our approach are the Linguist’s Search Engine (Resnik and Elkiss, 2005), a tool that makes use of example-based querying, and the TIGER Corpus Navigator (Hellmann et al., 2010), which is a Semantic Web system used to classify and retrieve sentences from the TIGER corpus on the basis of abstract linguistic concepts.

We present GrETEL (Greedy Extraction of Trees for Empirical Linguistics), a tool for example-based querying. The implementation is optimised for querying LASSY Small, the manually annotated part of the LASSY treebank (van Noord et al., 2006; van Noord et al., in press), which consists of unordered dependency trees. Since those trees are in XML format, they can be queried with XPath and XQuery.

Figure 1 presents the architecture of GrETEL. The system takes as input an example of the syntactic construction the user is looking for. The input construction is not necessarily a full sentence. The user can indicate which parts of the input construction are relevant. Next, the construction is parsed with the Alpino parser (van Noord, 2006) and the relevant parts are annotated in the parse tree. Then, the Subtree Finder looks for the annotations in the parse tree in order to ‘cut out’ the subtree. That subtree is the input of the XPath Generator, which converts the subtree into an XPath query. After the conversion the user has the option to adapt the query if necessary. In the final step the query is matched against the LASSY Small treebank. If any matching constructions are found, the results are displayed to the user.

Our approach of example-based querying could be adapted to work for any other treebank if there exists a parser which outputs trees similar to the trees in the treebank, such as the Charniak parser (Charniak, 1997) and the Penn Treebank. Furthermore, terminal nodes of the parse trees should contain part of speech (POS), lemma, and token (word form). In order to be compatible with GrETEL, the treebank should be converted to the Alpino XML structure or a similar XML data structure. Such a conversion is generally possible for treebanks with a tree-like data structure, e.g. Penn Treebank, and the monolingual sides of the treebanks described in (Kotzé et al., 2012). Less important aspects are the linguistic framework of the treebank (e.g. whether the treebank is phrase structure-based or dependency-based) and the (natural) language of the treebank.

4. Two Case Studies

Two examples are presented in order to give a detailed elaboration of treebank mining using GrETEL. The first case considers Dutch nominalisations (section 4.1). The second example investigates the position of separable verb particles in Dutch subclauses (section 4.2), which is a more complex case as the word order is taken into account. Both examples will show that GrETEL returns sentences similar to the input example.

4.1. Case 1: Nominalisations

If one is interested in deverbal nominalisations with determiner *het* [E: ‘the’] and a direct object introduced by preposition *van* [E: ‘of’], a possible input sentence is (1).

(1) Het doden van olifanten is verboden.

‘Killing elephants is prohibited.’
The input construction is presented in a matrix (Figure 2), allowing the user to indicate the parts of the sentence that are relevant for the syntactic construction (s)he is querying. Initially the not relevant button is selected for all words. The user can indicate for each word whether (s)he is interested in the part of speech (POS), the lemma or the token. If the user is looking for non-lexical similarities, pos should be selected. The lemma button should be indicated to abstract over word forms, and the token button should be selected for retrieving specific word forms. If the input contains words that are no part of the target construction, the not relevant button should remain selected.

Figure 2: Input matrix for example (1)

It should be noted that the dependency relation and the POS of all relevant nodes are taken into account. For example, if the lemma button would be selected for doden [E: ‘to kill’], sentences like (2) will match. Sentences in which doden [E: ‘(the) death’] is a plural noun, such as (3) will not match. The tool thus considers lemmas and tokens in context instead of mere string matching.

(2) Het doden van mensen is verboden.
‘Killing humans is forbidden’

(3) Het aantal doden van dat treinongeval stijgt.
‘The death toll from that train accident is rising.’

In order to find more matches, we only indicated pos for both the nominalised verb and the noun in its PP sister. The lemmas of the determiner het and the preposition van are indicated, since those words are inherent parts of the nominalised constructions we are looking for.

The input construction is parsed with the Alpino parser (van Noord, 2006), which is also used as a starting point for the treebank annotations of the LASSY treebank. The information provided in the input matrix is then added to the parse tree, allowing us to extract a subtree from the full parse tree, as shown in Figure 3. The top of the subtree is the lowest node that dominates the relevant items.

The XPath query contains all elements that are present in the subtree (i.e. dependency relation [@rel], POS [@pos] and for some nodes lemma [@root]). After the query is generated, the user has the option to choose between basic and advanced search mode. In basic search mode, the XPath query is immediately matched against the corpus. The user has the option to search the complete LASSY Small treebank (65k sentences) or to select one or more subcorpora. For the query in (4) we have found 1288 hits in 1206 sentences in the complete corpus. Five matches are presented in (5 - 9).

(4) //node[@cat="np" and node[@rel="det" and @root="het" and @pos="det"] and node[@rel="hd" and @pos="verb"] and node[@rel="mod" and @cat="pp" and node[@rel="hd" and @root="van" and @pos="prep"] and node[@rel="obj1" and @cat="np" and node[@rel="hd" and @pos="noun"]]])

5 For invariable word forms such as het and van in example (1), it does not matter whether lemma or token is selected for those words.

6 The graphical representation only shows per node (from top to bottom) the dependency relation, the syntactic category or POS, and the lemma.

7 The dependency relation of the top node is omitted because it indicates a relation with the parent node, which is not included in the subtree.

Figure 3: Alpino parse of example (1) with selected subtree
Satellieten hebben een erg brede kijk op het
aardoppervlak, en daarom worden zij ook
earth-surface, and therefore become they also
vaak gebruikt voor het observeren van de
often used for the observation of the
oceans.

'Satellites have a very wide view on the surface of
the earth, and therefore they are also often used for
the observation of the oceans.'

Hierin zoekt hij het isoleren van de
here-in looks for he the isolate of the
menselijke figuur, alweer in een indrukwekkend
human figure, again in an impressive
monumentaal gebeuren.
monumental happening

'In this he looks for the isolation of the human char-
acter, again in an impressive monumental event.'

Door het invullen van de enquête kunt u dat
by the in-fill of the survey can you that
kenbaar maken.
knowable make

'You can indicate that by filling out the survey.'

The advanced search mode allows users who are familiar
with XPath to adapt the query if necessary. One could for
example cut off the last part of the query (i.e. the part of
the query that corresponds to the head-noun11 branch in the
subtree), which results in (10).

```
//node[@cat="np" and node[@rel="det" and @root="het" and @pos="det"] and node[@rel="hd" and @pos="verb"] and node[@rel="mod" and @cat="pp" and node[@rel="hd" and @root="van" and @pos="prep"] and node[@rel="obj1" and @cat="np"]]
```

Since the derived query (10) contains less constraints than
the original one (4), matches found by (10) will include
the matches found by (4). The results furthermore include
(sub)trees with a name or a multiword expression as head of the PP. The abstract query finds 1391 hits in 1299, of
which five examples are presented in sentences (11) - (14).

Het bracht een positief advies uit voor
it brought a positive advice out for
goodkeuring van het in de handel brengen van
approval of the in the trade bring of
Humalog.
Humalog

'A positive advice was given for the approval of the
trade with Humalog.'

Maar de selectie van de gezichten voor de
but the selection of the faces for the
cover kwam Bono toe, en hij pleitte voor het
cover came Bono to, and he pleaded for the
opnemen van Bush.
up-take of Bush

'The selection of the cover face was up to Bono, and he argued for including Bush.'

Het ontstaan van het ABN.
the originate of the ABN

'The emergence of ABN.'

Hij groeide op in een woelig politiek
He grew up in a turbulent political
milieu, onder meer door het uitbreken
environment, amongst more by the outbreak
van de Tweede Wereldoorlog.
of the Second World War

'He grew up in a turbulent political situation, for
example because of the outbreak of the Second
World War.'

4.2. Case 2: Separable Verb Particles

Dutch verbs have a tendency to cluster. In the case of sub-
clauses, it means that both the finite verb and all non-finite
verbal elements form a verbal complex on the second pole. However, in some constructions non-verbal elements ap-
pear within the verbal complex (Haeseryn et al., 1997). A
typical case of such constructions are sentences with separ-
able verbs. Since the separable verb particle is closely
related to the verb, it sometimes occurs within the verbal
complex. An example of such a construction is given in
(15), where kennis occurs between the verb forms moet en
maken.

```
verb
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Since we are only interested in the subclause, it is sufficient
to present (16) to the system.

```
dat ze moet kennis maken
that she has acquaintance make
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'met haar schoonmoeder stemde haar niet
with her mother-in-law make-feel her not
gelukkig.
happy

'The thought that she had to meet her mother-in-
law did not make her feel happy.'

The input matrix of (16) is given in Figure 4. The ex-
ample's parse and the extracted subtree are presented in
Figure 5.

The XPath query generated from the subtree in Figure 5 is
given in (17). It should be noted that the results do not only
include sentences in which the separable verb particle in-
terrupts the verbal complex, as word order is not taken into
account. As examples in which the separable verb parti-
cle occurs out of the verbal complex are returned as similar

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11The tag noun is only assigned to common nouns in the
LASSY treebank. Proper nouns are indicated with the tag name.
| sentence | dat  | ze   | moet | kennis | maken |
|----------|------|------|------|--------|-------|
| pos      |      |      |      |        |       |
| lemma    |      |      |      |        |       |
| tokens   |      |      |      |        |       |
| not relevant |      |      |      |        |       |

**Figure 4:** Input matrix for example (16)

| top | comp | comp | top | comp | comp | top | comp | comp |
|-----|------|------|-----|------|------|-----|------|------|
|     |      |      |     |      |      |     |      |      |
|     |      |      |     |      |      |     |      |      |
|     |      |      |     |      |      |     |      |      |
|     |      |      |     |      |      |     |      |      |

**Figure 5:** Alpino parse of example (16) with selected sub-tree

In order to investigate the position of separable verb particles with GrETEL we need (at least) two input sentences: one with a non-verbal element (separable verb particle) within the verbal complex and one in which the separable verb particle does not occur within the verb cluster. Example (15) is a possible input sentence to investigate the first scenario (interruption). A similar sentence without interruption is presented in (18); the subclause we have presented to the system is given in (19).

(17)  //node[@cat="ssub"] and node[@rel="hd" and @pos="verb"] and node[@rel="vc" and @cat="inf"] and node[@rel="svp" and @pos="part"] and node[@rel="hd" and @pos="verb"]

(18) De gedachte dat ze kennis moet maken

The following query (20) is generated from the subtree derived from the interruption example dat ze moet kennis maken. The input matrix looks similar to Figure 4, but the Ordering Filter box is checked:

(20) //node[@cat="ssub"] and node[@rel="hd" and @pos="verb"] and node[@rel="vc" and @cat="inf"]/node[@rel="svp" and @pos="part"]/@begin

That query matches with 4 hits in 4 sentences, which are presented in (21 - 24).

(21) Als we echt willen vooruit komen met Europa

(22) Dit is het schooljaar voor uw kind in een

(23) Vanaf dit ogenblik zijn er drie verkozenen

Since the Alpino parser generates dependency trees, the structure of the parse of the non-interruption example will be exactly the same as the parse of the interruption example. The difference lies in the surface position of the terminal nodes, which is included in the begin feature of each node. As the Alpino parser includes information on the position of terminal nodes, it is possible to respect the word order of the input sentence. However, the formulation of such XPath queries is rather complex, because the absolute word position values have to be compared in a relative way. In order to do that computation automatically, we have created an Ordering Filter that takes the surface order of the words into account while generating the XPath query.

The information on word position is included in the XML structure, but is not presented in the graphical representation.

12
(24) That crystal is made in a way that it always reflects the colour red and will not let it through.

‘That crystal is made in a way that it always reflects the colour red and will not let it through.’

(25) Het afspraken waar Nederland aan it are agreements where Netherlands on vasthoudt en waar Sint Maarten niet voor holds and where Saint Martin not for **weg kan lopen**.

away can run

‘Those are deals the Netherlands hold to and which Saint Martin cannot evade.’

(26) De associates zijn jonge high potentials, the associates are young high potentials, supergedreven, die **aan komen zetten** met super-motivated, who on come sit with een idee.

an idea

‘The associates are young high potentials, super-motivated, who come up with an idea.’

(27) Daarom geeft het ministerie van VROM u tips therefore gives the ministry of VROM you tips en advies hoe u in huis veilig om kunt and advice how you in house safely can **gaan met gas en elektra** go with gas and electricity

‘Therefore the ministry of VROM gives you tips and advice to safely handle gas and electricity.’

(28) Er is zelfs geen eensgezindheid over de there is even no consensus on the limieten vanaf wanneer een gas een limits from when a gas a **broekas effect** teweez zal brengen.

greenhouse effect will bring

‘There isn’t even a consensus on the limits when a gas will cause a greenhouse effect.’

(30) De drie hebben dan ook te kennen gegeven dat the three have then also to know given that ze **zaken willen doen**, wat andere Europese countries again with suspicion fulfills

‘The three have indicated that they want to do business, which makes other European countries suspicious again.’

The results found by (17), (20) and (25) show that for this case GrETEL also finds constructions similar to the input structure. Equivalent constructions that are differently tagged are however hard to find. For example, one could argue that there are more separable verb particles present in the corpus, but GrETEL will miss them out as they are not tagged as such. In Dutch, the separable verb particle and the verb are often written as one word, cf. example (31).

(31) dat ze moet kennismaken

that she has acquaintance-make

‘that she has to meet’

Figure 6: Alpino parse of example (31) (separable verb particle included in verb node)

The parse of sentence (31) in Figure 6 shows that the separable verb particle is included in the lemma of the verb, but in contrast to the example in Figure 5 it does not receive a tag of its own. Those sentences could be found with another query, so for a more exhaustive treebank search the user is advised to use multiple input sentences.

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13In basic search mode one should select the **lemma** button for the verb **kennismaken**. To abstract over all separable verbs, one should change the query part that refers to the separable verb **node[@rel="hd" and @pos="verb" and contains(@root, "maak_kennis")]** to **node[@rel="hd" and @pos="verb" and contains(@root, ".")]** in the advanced search mode, as all separable verbs have an "." in their lemma.
5. Conclusion and Future Research

We have presented GrETEL, a tool for querying a treebank with natural language examples instead of a formal input query. The tool allows to search in treebanks without knowledge about the tree representations, treebank query languages, nor the specific linguistic theories in the treebank. The user provides the query engine with an example sentence, marking which parts of the sentence are the focus of the query. Through automated parsing of the example sentence and subtree extraction of the sentence part under focus the treebank is queried for the extracted subtree. GrETEL then returns sentences similar to the input example. In order to demonstrate GrETEL as a tool for treebank mining, two case studies were conducted. Future research involves the creation of a web version of the example-based query mechanism for the LASSY treebank, integrated with the actual search mechanism, instead of the XPath query engine we currently use, backing off to more abstract subtrees, when no results are found. Furthermore, we want to include more treebanks, such as CGN and LASSY Large. Ultimately, we want to build a faster query engine, based on the Varro tree indexing toolkit (Martens, 2011), as XPath is rather slow, especially on large treebanks.

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