1. Introduction

One of the bottlenecks in real applications of natural language document processing is the coverage of domain-specific lexical resources. In experiments with the document suite XDOC\(^1\), we currently are processing documents about casting technology, company profiles from web pages, and autopsy protocols. Many of the tools have an extensive need for linguistic resources. Therefore we are interested in ways to exploit existing resources with a minimum of extra work. The resources of GermaNet promise to be helpful for different tasks in the workbench.

In this paper, we will outline how the resources of GermaNet can be extended. Our methods exploit the specific characteristics of the documents in the corpus. We combine different approaches to extract new concepts from the corpus. The idea behind our approach is to generalise from structures with known GermaNet entries to structures without GermaNet entries.

This paper presents only experiments with GermaNet on German texts, but the approach can also be applied on WordNet when processing domain specific English texts.

The paper is organized as follows: The next section briefly outlines the test corpus and the integration of GermaNet in XDOC. Section 3 describes the methods for the extraction of new concepts and the results. We conclude the paper with a discussion section.

2. Document Processing with XDOC

2.1. Characteristics of the Corpus

In the following description of the approach, a corpus of forensic autopsy protocols is used, because these documents are especially amenable to processing with techniques from computational linguistics and knowledge representation.

Autopsy protocols consist of the following major document parts: findings, histological findings, background, discussion, conclusions, etc. Our analyses focus on the sections of findings, background and discussion. In the findings section, a high ratio of nouns and adjectives is encountered and the sentences, which can also be verbless, are mostly short. This section describes the medical findings in a common language. Here we find no domain specific (medical) terms. The background and discussion sections contain a standard distribution of all word classes and regular syntactic structures. The background section describes, for example, the details of a traffic accident, while the section discussion contains a combination of the results of the finding section and the facts reported in the background section.

2.2. Integration of GermaNet

The document suite XDOC contains methods for linguistic processing of documents in German. The focus of the work has been to offer end users a collection of highly interoperable and flexible tools for their experiments with document collections.

XDOC consists of different modules, for example, the syntactic module and the semantic module (for a more detailed description see (Rösnner and Kunze, 2002b)).

For the semantic analyses of a domain using XDOC, knowledge about the domain – ideally a domain specific ontology – is needed. One possible resource for the processing of autopsy protocols could be medical thesauri like UMLS (Unified Medical Language System).\(^2\) Many of these resources work with medical terminology, but in the corpus of forensic autopsy protocols only everyday terms are used. Thus a resource that contains everyday terms and concepts (and their relations) from the medical domain is required for the analysis. GermaNet (see (Hamp and Feldweg, 1997), (Kunze, 2001)) is intended as a model of the German base vocabulary.

However, specific terms in some particular domains, like the medical domain, are covered only partially in GermaNet.

For the semantic analysis in XDOC, the synonymy and the hypernymy relations of GermaNet are used. We found a good coverage of GermaNet’s resources for terms in the corpus: section findings with 31 %, section background with 44 %, and section discussion with 42 % coverage (see also (Kunze and Rösner, 2003)). The reason for the poor

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\(^1\)XDOC stands for XML based document processing.

\(^2\)http://www.nlm.nih.gov/research/umls/umlsmain.html
3. Methods for the Deduction of Word Senses

In (Rösner and Kunze, 2002a), we outlined some ideas for the exploitation of sublanguage characteristics of a corpus for lexicon creation. In this paper, we will further elaborate these ideas. This section presents how the syntactic structures of the corpus sublanguage can be useful for the extraction of new GermaNet entries.

3.1. Fundamental Idea of the Approach

In the *findings* section of the documents, high-frequency complex noun phrases can be exploited for the extension of the GermaNet resources.

The grammar fragment used in XDOC for this corpus covers the following complex noun phrases (In all cases, the first NP is a simple noun phrase.):

- NP NP_{genitive},
- NP NP_{genitive} *PP, and
- NP *PP.

Our experiments are based on the interpretation of complex noun phrases that are described by the syntactic structure NP → NP NP_{genitive} (i.e. a simple NP modified by a genitive attribute).

In the case of a complex noun phrase, several possibilities for a semantic interpretation of this syntactic structure exist, for example, part-of relations in 'dermis of the hand' or patient-of relation in 'the production of cars'.

The idea behind the approach is based on following assumptions. A structure of the form *KEYWORD OF COMPLEMENT* describes the same relation for every possible candidate of the complement, e.g., part-of. Further on, an assumption is that the complement candidates of a keyword have the same semantic category. The information of complement candidates available in GermaNet is used to deduce information about the semantic category of candidates that are unknown in GermaNet (see also Fig. 1).

3.2. Exploiting Syntactic Structures of the Corpus

In the corpus (of 600 autopsy protocols and more than 1.5 million word forms), structures in the form of NP → NP NP_{genitive} are often encountered. For example, the phrase 'Schleimhaut des Magens' (mucosa of the stomach) occurs 317 times in the corpus. The more generalised phrase 'mucosa of XXX' occurs 836 times in the corpus. Another generalised example is the phrase 'fracture of XXX' that occurs 749 times in 93 different forms. One example form is the class of NPs with keyword Bruch (fracture) and modified by a complement (the second noun phrase in the structure), e.g., 'Wirbelsäule' (spine) in the phrase 'Bruch der Wirbelsäule' (occurs 58 times) or 'Wadenbein' (fibula) in the phrase 'Bruch des Wadenbeines' (occurs 11 times). Other complements for the keyword 'fracture' found in the corpus are: 'Elle' (ulna), 'Oberarmknochen' (humerus), 'Schädelgrund' (base of the skull), 'Schienbein' (shinbone), 'Unterkiefer' (lower jaw), 'Unterarmknochen' (radial bone) etc.

At first, structures with high occurrence frequencies in the corpus are selected. For this task, the *findings* sections of the documents are parsed with the syntactic parser of XDOC. A domain specific grammar with ca. 40 rules is used. In the results of 18008 parsed sentences, 2808 complex noun phrases (NP → NP NP_{genitive}) with 1069 different keywords are encountered.

The most frequent keywords in such structures are: 'Abgang' (outlet), 'Baucheil' (abdominal part), 'Brustteil' (chest part), 'Blutreichung' (hyperemia), 'Faulnis' (sepsis), 'Haut' (dermis), 'Schleimhaut' (mucosa), 'Gegend' (region), 'Schnittflächen' (cut surfaces), 'Unterblutung' (hematoma), and 'Bruch' (fracture).

The next step is to use regular expressions to get all occurrences of a particular combination of a keyword and a complement, because not all occurrences from the corpus can be obtained with the chart parser. The reason for this is that there are gaps in the grammar (when parsing the section *background* and *discussion*) and gaps in the morphological lexicon.

The most frequent keywords in regular expressions are used to get all phrases that begin with the keyword. The length of these phrases (text window size) is restricted to be 3 tokens (or 4 tokens, when adjectives in the complement noun phrase) are allowed.
For each structure, the GermaNet interface is used to check if information about the keyword of the complement NP is available. For the example (keyword: fracture), GermaNet contains 31 complement elements of the 93 complement elements found in our corpus. Most complement words of a keyword found in GermaNet have the same top level category, only a small number of words have more than one reading. For the example, following top level categories (given with its percentage related to all senses) are encountered: <nomen.Koerper>: 75 %, <nomen.Artefakt>: 16.5 %, <nomen.Menge>: 5.5 %, and <nomen.Nahrung>: 3 %. All the words with more than one sense have at least one sense with the top level category <nomen.Koerper>.

Table 1 presents a small excerpt of the complement words3 in the corpus for the keyword fracture. The main top level category for the complement words is <nomen.Koerper> (WordNet category: noun.body).

The first assumption is that all complement words of a keyword in a domain will belong to the same top level category in GermaNet. That means that those words of the example which are not contained in GermaNet, like 'Oberarmknochen' (humerus), 'Schädelbasis' (base of the skull), 'Schädeldeck' (calvarium), 'Brustwirbelsäule' (thoracic spine), etc., can be assigned to the same top level category: <nomen.Koerper>. In the case of the example (keyword fracture), this heuristic yields the correct top level category for 93.44 % of all complements.

In the next step, subclasses of the GermaNet top level category will be used, so that a word can be annotated with additional information, e.g., hypernym relation. For this task, GermaNet’s hypernymy relation is exploited. The hypernym information for all complements is selected, which do exist in GermaNet. The hypernymy relation in GermaNet can contain more than one level of hypernyms for an entry.

At first, all senses with their hypernymy information are selected. Each sense and its hypernyms describe a class path and each entry in this class path names a semantic class. The occurrences of the different semantic classes for all senses (class paths) are counted. For the different forms of the phrase 'Bruch der/des XXX' (in English: fracture of XXX), 36 senses with altogether 63 different semantic classes are encountered. Table 2 presents a partial list of all semantic classes and its number of occurrences in all the senses for the complement elements covered by GermaNet. For example, the semantic class 'Knochen' (bone) appears in 13 senses as a hypernym, the semantic class ‘Computerprogramm’ (software) only in one sense.

At this point, we don’t have a clear and unique result. The highly frequent hypernym entries in all senses found in GermaNet are the entries: 'Objekt' (object), 'Hornsubstanz' (akeratosis), 'Knochen' (bone), etc. These results can be enhanced when we allow only senses that describe a concept with the top level assignment of <nomen.Koerper> (see table 3). The possible senses are reduced to 27 senses with altogether 22 different semantic classes.

When the basic concepts (WordNet’s ‘unique beginner’) of GermaNet, e.g. Objekt is ignored, and when the most specific hypernym of all high frequent hypernyms is selected, the following partial class path results:

For the selection of the most specific hypernym, every level in the class path is assigned with a weighting factor (The selection process can be described by the Eq. 1). The unique beginner starts with the factor 0 (in our example Objekt), the next higher level get the factor 1, and so on.

\[
c_i = \arg \max \frac{f_i n(c_i)}{N}
\]

For each semantic class \(c_i\), the quotient (occurrences of the semantic class \(n(c_i)\) divided by number of all semantic classes \(N\)) is multiplied by its weighting factor \(f_i\) (see also Fig. 2). In the result above, the semantic classes got following factor assignment: \(f_{Objekt} = 0\), \(f_{Stoff} = 1\), \(f_{Koerpersubstanz} = 2\), \(f_{Hornsubstanz} = 3\), \(f_{Knochen} = 4\).

Figure 2: Weighting of Possible Semantic Classes.

The whole approach described above is sketched in the following (given a keyword \(K\) and a set of all complements \(C_S\) of \(K\)):

procedure find-entry \((K, C_S)\):

\[
\]
3.3. Compound Analysis

An alternative way is to group words according to their components. In German and especially in the corpus, a lot of compounds are found, e.g., 'Oberschenkelknochen' (instead Oberschenkelknochen) or erroneous fragments in the results of the preprocessing steps (e.g., the treatment of German’s truncations in phrases like Bruch des Ober- und Unterarmes (fracture of upper arm and forearm)). Any other type of error occurring in the evaluation was the case when the second noun phrase can also be parsed as a complex noun phrase. For example, only 2 forms are encountered: Bruch der Anteile ... (fracture of parts of ...) and Bruch der Wundung ... (fracture of septum of ...). For a reliable evaluation of these results, it is necessary to consult the domain-specific knowledge of a medical expert. In some cases, for a non-expert it is not clear if a derived sense is correct. For instance, the word 'Ellenbogengelenk' (elbow joint) describes a (complex) system of bones, cartilages, connective tissues, etc.

3.4. Disambiguation

The fundament of correct deduction of concepts is the selection of the correct sense of the senses available in GermaNet. In our case, the restriction to one top level category is sufficient for this analysis of forensic autopsy protocols, especially the findings section. In this section, only anatomic concepts and its findings are described. For other domains, it is necessary to use methods for a certain word sense disambiguation, e.g., methods that used selectional preference (see Resnik, 1997) or conceptual density (Agirre and Rigau, 1996) for word sense disambiguation.

4. Related Work

The approach exploits the specific syntactic structures of a sublanguage. In the work of (Kokkonakis et al., 2000), the analyses of compounds and specific syntactic structures are used for the extension of the Swedish SIMPLE lexicon. This work exploits the advantage of the productive
compounding characteristic of Swedish to derive new lexical items (results in information about semantic type, domain, and semantic class). Furthermore, they used a raw and partially parsed corpus for the analyses of enumerative NPs (with more than three common nouns) for the derivation of co-hyponyms. The following heuristic is used for an unknown noun in an enumerative NP: If at least two nouns have the same assignment to a semantic class, then there is a strong indication that the rest of the nouns are co-hyponyms and thus semantically similar with the two already encoded nouns.

The usage of a lexical resource to learn new entries for the same resource (WordNet) is described in (Navigli and Velardi, 2002). This paper outlines an approach for the deduction of a sense of multi-word terms that is based on the senses of individual words of the multi-word terms. Another similar approach that combines corpus and WordNet information to deliver verb synonyms for high frequent verbs of a domain-specific sublanguage is described by Xiao and Rössner (2004). Peters (2004) describes how new knowledge fragments can be derived and extended from synonomy, hypernymy and thematic relations of WordNet and implicit information from the (Euro)WordNet.

5. Conclusion

Linguistic resources with domain-specific coverage are crucial for the development of concrete application systems. In this paper, we proposed an approach for the extraction of semantic information, using the information available in GermaNet for the individual words that frequently occur in a specific syntactic structure of the corpus.

The results of the approach can be helpful for the corpus based semiautomatic extension of the GermaNet resources. With this approach, it is possible to extract information about a new entry (e.g., forearm bone) or to complete senses or hypernym information for entries existing in GermaNet (e.g., lower leg). The results also contain synonyms, like 'Jochbogen' (zygoma), 'Jochbeinknochen' (zygomatic bone), and 'Jochbogen' (zygomatic), which can be detected by an deeper context-related investigation of the elements of a complement set.

In future work, we will evaluate the approach for other syntactic structures and investigate if it is possible to deduce information about the keyword of a syntactic structure when the complements are known. Another aspect will be the exploitation of the resources of the Medical Subject Headings (MeSH). The investigation points are: How many medical terms (in a more everyday language) of the forensic autopsy protocols are covered by MeSH? and What differences exist between entries of MeSH and GermaNet, because Basili et al. describe some discrepancies between entries in MeSH and WordNet. Further on, this paper outlines the mapping of a domain concept hierarchy (MeSH) with a lexical knowledge base (WordNet) for the building of a linguistically motivated domain hierarchy. If such an approach is necessary in the analysis of forensic autopsy protocols, it should be considered in further analyses of the corpus and the evaluation by medical experts.

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1http://www.nlm.nih.gov/mesh/meshhome.html