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# A database of German definitory contexts from selected web sources

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**Abstract**

We introduce work on the detection of definitory contexts designed to speed up two lexicographical tasks: searching for the exact meaning(s) of terms and providing usable input for paraphrasing. Our database is built from a specialized web corpus using a robust pattern-based extraction method. The corresponding interface displays information for a large range of lexical units. The contributions of this article are threefold: we describe both acquisition and extraction, provide a qualitative assessment of the method, and present an interface to access the data.

**Keywords:** Definition extraction, definitory contexts, computational lexicography, resource acquisition

## 1. Introduction

German is well-known for making extensive use of compounds (Schlücker, 2012), as composition is a productive process of German word formation. In the context of lexical resources and dictionaries, the number of potential words to define is very large if not infinite. For that matter, corpus data is crucial in order to perform lexicographic work. Furthermore, automatic definition extraction can be used to complement existing entries or help lexicographers creating new ones. This article introduces both a corpus and a database built to support lexicographers as well as interested users in sorting out the meaning(s) of lexemes. The acquisition draws on selected web sources containing a large number of lexical descriptions, which are expected to contain potential definitory contexts, from which handwritten definitions will be derived. We describe an experimental setting and front-end for pattern-based definition extraction from such resources.

We first describe the context and motivations of our work. In section 2 we summarize related work and place our contribution into this context. In section 3 we present our acquisition and extraction method. Section 4 describes the database, an interface to it as well as the results of a qualitative evaluation. In section 5 we conclude with the insights gained from our investigation.

### 1.1. Context and motivation

The Digital Dictionary of the German Language (*Digitales Wörterbuch der deutschen Sprache*, DWDS[1]) is a long term project of the Berlin-Brandenburg Academy of Sciences (BBAW). The goal of the DWDS project (Klein and Geyken, 2010) is to create a large-scale aggregated word information system based on legacy dictionaries, large corpora, word statistics and automated methods to provide additional types of linguistic information as well as to speed up the process of updating and amending the existing lexical resources.

The DWDS web platform provides access to this information and is among the most frequently used academic dictionary platforms. The dictionary component of the DWDS is based on high-coverage and detailed dictionaries of contemporary German, including the *Wörterbuch der deutschen Gegenwartssprache* and *Duden Großwörterbuch der deutschen Sprache*. Thus, the DWDS dictionary component with more than 170,000 entries provides a good coverage of the core vocabulary of German.

Having covered this core vocabulary, the current work focuses on the description of lexical units whose meaning reaches deeply into highly specialized domains. In order to revise the entries of existing legacy dictionaries and to work on the full lexicographic description of headwords that are not yet recorded, a team of 6 lexicographers has been employed for more than 4 years, with another 6 years to come. We would like to present to our users detailed information concerning the form and grammar as well as the meaning of as many headwords as possible. For instance, it has been shown in a corpus-based quantitative study that in a German newspaper corpus of one billion running words, a number of 4-5 million distinct base forms, i.e. lexical units in our sense, could be detected (Klein, 2013). In a more recent investigation using our morphological analyzer and lemmatizer and a corpus of ca. 5 billion running words, we have collected a total of 16.3 million base forms, most of which appear rather infrequently in the corpora.

However, providing hand-crafted definitions for such a large number of headwords is far beyond the scope of our project. That is why any corpus-based support is highly valuable, with two main areas of interest: on one hand the identification of senses and usage of specialized lexical units and on the other hand the elaboration of appropriate definitions (Geyken et al., 2017a).

In this context, it is expected that a specialized corpus and database with definitory contexts from selected web sources is highly relevant. Since we are reaching out into the periphery of the German vocabulary, i.e. targeting lexical units of specialized use in many domains, the research that is necessary for a correct description of the word senses is costly in time and effort. Typically, the lexicographers are not experts in such domains. That is why any support based on a corpus of reliable internet resources can be helpful. Secondly, it would also be an asset for the users of our dictionary if we can provide contexts for a large share of these words that help the users to sort out for themselves the meaning, hyperonyms, translation equivalents of such

[1] https://www.dwds.de/

lexical units. Geyken et al. (2017b) present a study that is based on user queries of the DWDS platform and show that 17% of the queries did not match a headword in our dictionary and would therefore not return any lexical information. A database of definitory contexts on top of our high-quality lexical descriptions would indeed be of great help and improve on coverage with our lexical information system.

In short, the corpus and database of contexts will support lexicographers in crafting definitions and help users of our information systems to glean useful semantic information even for headwords which fall beyond the scope of lexicographic work planned for the DWDS.

## 2. Related work

Automatic definition extraction has already been applied in a range of different contexts and tasks in computational linguistics (Navigli and Velardi, 2010), and the extraction of definitory contexts from free texts is currently a trending topic in lexicography and neighboring disciplines. Method and corpora are two key issues. The method of choice has been the drafting of lexico-syntactic patterns or features (Hearst, 1992) that more or less precisely describe the surface forms of prototypical definitory contexts. Empirical approaches such as the use of conditional random fields in order to label beginning and content of a definition as well as non-related material (Anke, 2013) detect common patterns such as the use of the verb "to be". While most of the work has focused on English (Borg, 2009; Zhang et al., 2014), there is also work to be found for Slavic languages (Przepiórkowski et al., 2007) and Dutch (Westerhout, 2010). Work on German includes the search for technical terms with a series of structural patterns with verbal predicates (Storrer and Wellinghoff, 2006) as well as methods for proper definition extraction based on hand-crafted rules or patterns, evaluated in numerical terms (Cramer, 2011) or with regard to their statistical relevance (Schumann, 2014). We chose to first follow the work of Cramer (2011) and employ some of her patterns, namely the ones she classifies as most efficient. While a qualitative evaluation of the patterns as well as a classification in terms of efficiency is included, her study does not present any accountable results in empirical, quantitative terms. In this sense, our article can be seen as a replication study on our data. We use the categories introduced by Cramer (2011) and compare them with a baseline consisting of more loosely defined patterns.

The sources used in related work mostly include small domain-specific datasets, e.g. instructional texts compiled for teaching purposes (Borg, 2009); large encyclopedic resources such as Wikipedia (Kovář et al., 2016); or general-purpose web corpora (Navigli et al., 2010); unfiltered noisy data such as the CommonCrawl (Seitner et al., 2016); or small sets of webpages (Schumann, 2014). Our approach is centered on a larger but still specialized web corpus of glossaries and similar lexical resources. While Kovár et al. (2016) for example restrict themselves to a version of the Wikipedia that is part of the *Sketch Engine*, we aim at a richer and more diverse collection of web sources. Having focused on specialized resources, the extraction in our case is slightly easier than on general-purpose texts, work reported e.g. by Zhang et al. (2014), and slightly more complex than in work targeting Wikipedia. The main challenge therefore is to find relevant information in loosely and diversely structured data, namely the headword (*definiendum*) and the defining context (*definiens*).

## 3. Acquisition, extraction and exploitation

### 3.1. Definitions and definitory contexts

In a strict sense that is applied e.g. in language philology and terminology, a definition supplies information that is sufficient to explicate either the content (or intension) of a concept or the set of individuals that form the extension of the concept. The classical logical form of such a definition is the formulation of *genus proximum* (the hyponym) and *differentiae specificae* (exactly those features of the concept that makes it distinguishable from all other concepts which are represented by co-hyponyms). For example, in Princeton WordNet the lexical unit *broom* is defined as "a cleaning implement for sweeping".[2] We do not employ this strict sense of definition in our work.

In the wider sense that is commonly employed in lexicography, a definition or, more precisely, a meaning paraphrase, is provided as part of the explication of the meaning of a particular sense of a lexical unit. Such a paraphrase is typically more elaborate than a *definition stricto sensu*, it is derived from examples of the usage of a word (and not necessarily based on an abstract concept) and in many dictionaries it is accompanied by a set of crafted or manually selected usage examples that illustrate the rules and conventions of the usage of the lexical unit. It is therefore not restricted to conceptual information but should also provide typical and relevant world knowledge that is related with the lexical unit. It might be worth mentioning in an extended meaning paraphrase that brooms are typically made of stiff fibers and typically have a long handle.[3] We will, in the following, use the terms *definition* and *definitory context* in that wider sense.[4]

### 3.2. Examples

Above we argued that for our lexicographical work we are particular interested in definitory contexts for lexical units of highly specialized domains. We will illustrate this point with some examples from our database. The examples consist of the headword, an English equivalent of it (in brackets), the definition proper, a pointer to the source of the definition and some further comments.

**Auseinandersetzungsbilanz** (dissolution balance)

> *Eine Auseinandersetzungsbilanz – auch Abschichtungsbilanz genannt – ist die Bilanz einer Personengesellschaft, die als Grundlage für die Auszahlung eines oder mehrerer Gesellschafter dienen soll. Das Ergebnis dieser Bilanz ist das Auseinanderset-*

[2] cf. http://wordnetweb.princeton.edu/perl/webwn?s=broom

[3] cf. https://en.wiktionary.org/wiki/broom

[4] For an in-depth discussion of the difference between scientific definitions and lexical meaning paraphrases (Wiegand, 1989).

*zungsguthaben.* (Source: Anlegerlexikon[5]). This is a highly specialized and non-transparent term form the domain of company / corporation law. A synonymous term is given as well as the factually related term *Auseinandersetzungsguthaben* (credit balance).

**Barett, Birett** (Biretta)
*Barett – auch Birett – ist die Kopfbedeckung von Akademikern und Geistlichen, ausgezeichnet durch die vier- oder fünfeckige Form.* (Source: Das Heiligenlexikon[6]). This is a simplex from the domain of church and religion. The term Barett itself is ambiguous. In addition, the reader learns something about the form of this kind of headdress.

**Direktionsrecht** (employer's executive prerogatives)
*Unter Direktionsrecht – auch Weisungsrecht genannt – wird das Recht des Arbeitgebers verstanden, die Leistungspflichten des Arbeitnehmers einseitig näher auszugestalten.* (Source: Lexikon Recht[7]). This is a non-transparent compound from the domain of labour relations. Both parts of the compound are highly ambiguous. In addition, a synonymous term, *Weisungsrecht* is given.

**Pelletheizung** (pellet stove)
*Pelletheizung ist eine Holzheizung, in deren Heizkessel zu Stäbchen geformte Holzabfälle – sogenannte Holzpellets – verbrannt werden.* (Source: Baulexikon[8]). This is a very recent term from the domain of heating engineering. This definition follows closely the pattern of *genus proximum* and *differentiae specificae*.

### 3.3. Acquisition

We chose to build a specialized web corpus, that is a collection of web documents targeting web pages which are defined in advance (Barbaresi, 2015), after identifying and manually selecting a series of relevant websites. We make the hypothesis that there are webpages in which it is probable to find definitions for highly specialized domains, because some feature a higher density of specialized vocabulary than others and some are explicitly characterized as explanatory. Thus, in order to find potential sources, we sift through large lists of URLs collected during web corpus construction for DWDS corpora and look for expressions such as "lexicon" or "glossary". Heuristic guesses on the URL determine the probable home page of the given website. The retrieved URLs are then manually screened with respect to their potential; out of more than 4200 candidates, a list of 285 websites forms the basis of the present experiment. They include highly specialized lexical domains such as apiculture, astronomy, chemistry, electronics, finance, fishing, metallurgy, politics, religion, and wine-making.
The corpus has been acquired by using focused crawling techniques (Olston and Najork, 2010). This strategy involves finding all pages located at levels deeper than the starting page, which means here that in the best case all definitory material is downloaded and stored. There is also a certain amount of noise: there might be pages with a poor yield in terms of definitions, e.g. *impressum* or unrelated content. This is a difficulty common to most web corpora, which require filtering operations. Because of the diversity of the websites to crawl, it is not possible to define a precise retrieval strategy. Furthermore, not all pre-selected domains are suitable for crawling, as they are deeply ramified and feature a large number of sub-pages. As a result, the corpus of downloaded pages consists of 268 different websites with a total of 501,308 web documents and about 29 Gb of data.
Additionally, we take already existing, generic web corpora into account in order to manually assess if this specially acquired corpus effectively provides more definitory contexts than a broad search in larger and more diverse corpora.

### 3.4. Extraction

The extraction process also has to be generic, because of the large number of lexica it would be too cumbersome to craft a targeted extraction algorithm for each webpage. However, the pages do not offer structural patterns which could allow for a reliable boilerplate and metadata extraction (Barbaresi, 2016). These are often loosely structured and mostly provide information in the form of tables, lists or simple paragraphs. On website level, the information can be divided in two different ways: either a web page features a series of entries, for example for each letter of the alphabet, or they provide a single page for each lexical entry.
We used the vocabulary coverage (known words and to-do list) of the DWDS project in order to provide lexemes to look for. Then a series of syntactic cues had to be defined. We chose a pattern-based method in order to extract the contexts in a robust manner. Most patterns are derived from the work of Cramer (2011), which is also the occasion to apply them systematically and to review them in terms of adequacy and efficiency. Our patterns first match a lexeme of our list and then look for cues left and right of the *definiendum*. We adopt the categories defined by Cramer ("strict", "less strict", "opportunistic"[9]) and evaluate them with respect to their helpfulness for definition writing. Additionally, heuristic criteria are used to determine which definitions may be directly transferable or not.
For example, a "strict" pattern is a constrained syntactic structure which is expected to be a strong case for a definitory context. The patterns by Cramer (2011) are described in human language, we translate them into regular expressions, which seem powerful enough to capture the desired context. The example below integrates a number of potential variants for the pattern "under a X1, one understands X2", where X1 is a *definiendum* and X2 a catchall

[5] www.anleger-beteiligungen.de/htm/de/html/Info_Center-Glossarf74a.html

[6] www.heiligenlexikon.de/Glossar/Priester-Ordensgewaender.html

[7] www.musterkanzlei.info/1041317/portal/lexikon/recht/d/direktionsrecht

[8] www.das-baulexikon.de/lexikon/Pelletheizung.htm

[9] In the original: *sehr genau*, *genau* and *mäßig genau*.

expression expected to contain a definition: */[Uu]nter (?:eine[mr])? $definiendum versteh(?:t|en) (?:man|wir) $catchall/*

A "less strict" pattern is a structure which features less contraints and whose output in less certain, for example "X1 is used for X2": */$definiendum verwendet man für $catchall/*

This pattern also raises issues concerning the definitory context, since the extracted sentences may not be strictly of lexicographic nature but rather entail practical advice. We believe that such patterns are still valuable, since they help determining what the lexeme is about.

An "opportunistic" pattern is a loosely constrained structure which may be a cue for a definitory context but which is also expected to be subject to noise. The most basic structure in our patterns is accordingly "a X1 is a X2", which can be translated into a pattern such as */[Ee]ine? $definiendum ist eine? $catchall/*

## 4. Database

We acquired web data corresponding to specialized lexical resources and extracted definitory contexts which were loaded into a database. In a first run, we could identify 191,951 contexts. 14,460 text snippets are supposed to be relevant contexts according to the extraction patterns of Cramer. In addition, we established a baseline by applying some looser, opportunistic patterns, that yielded another 177,491 hits. In the following subsection, we will describe an interface to this database and a lexicographic evaluation of the data.

### 4.1. Interface

We made the data available through a simple interface where users can search for a particular term and get a weighted list of resulting definitory contexts along with metadata such as origin and pattern type.

Figure 1 shows a prototype version of the interface with a wildcard search displaying results for *Trennscheibe*, where useful contexts can be returned for at least two of the senses of the word, and the adjective *trennscharf*, with several contexts to choose from. Figure 2 demonstrates the display of a single definition with an evaluation menu. In that case, the definition for *Freihandelsabkommen* (free-trade agreement), is a typical example of specialized vocabulary for which automatic definition extraction can be of great help.

### 4.2. Results

In order to perform a qualitative evaluation, we selected a random sample of 1000 definitory contexts containing both targeted and baseline contexts. A trained lexicographer assessed the quality of the data as follows:

**0** Not a definition at all (634; including missed targets, truncated definitory contexts and doublets);

**1** Provides helpful information but is not suitable for display (276);

**2** Appropriate for unfiltered presentation to a user of the dictionary website, with some minor flaws or errors (86);

**3** Can be directly integrated (14).

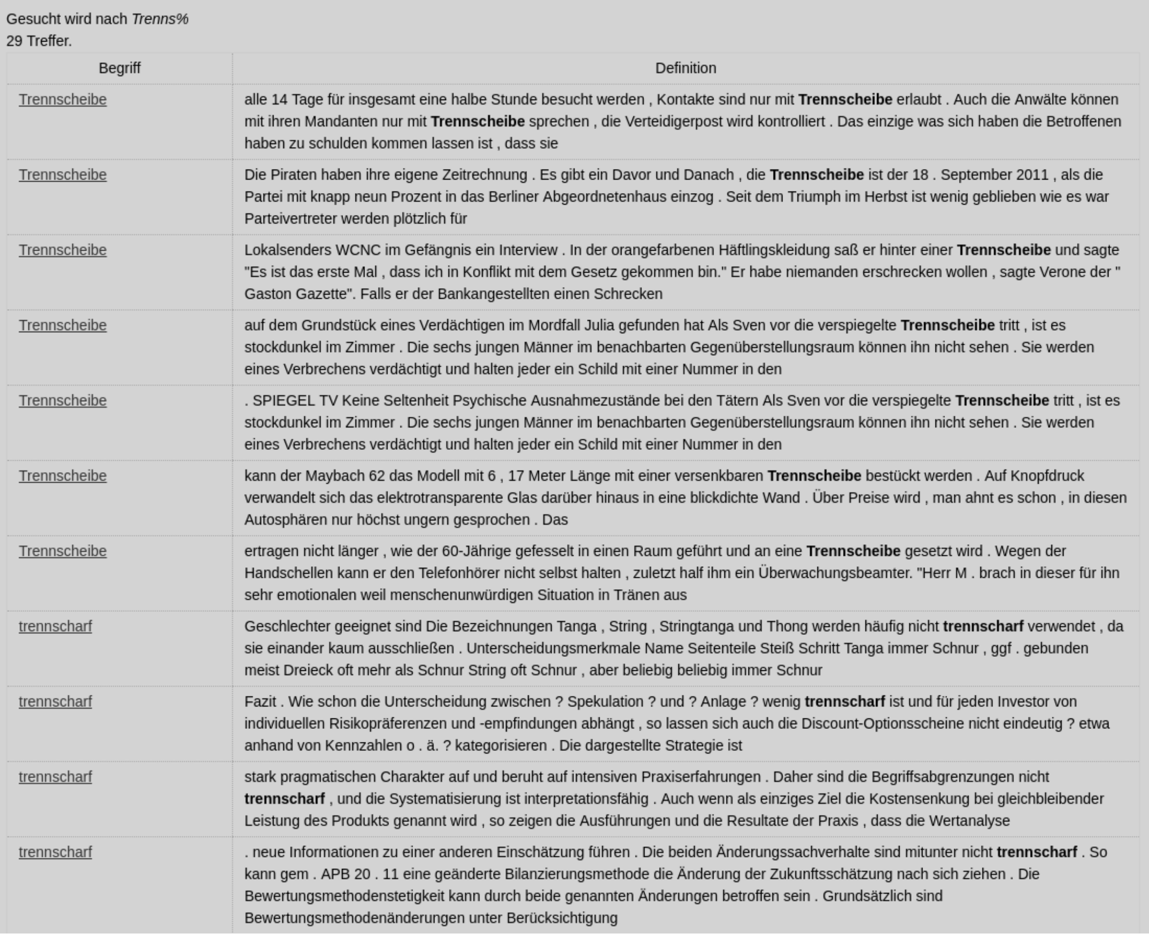
All in all, more than a third of the data proved to be helpful (classes 1 to 3), which considering the specialization degree of the lexemes is already worthwhile. In order to refine the extraction process, we performed an error analysis and listed the most common characteristics that disqualify a text snippet as a good definitory context. We found three main reasons: the *definiendum* could often not be detected correctly; there are many doublets in the data; or the text of the *definiens* is not complete due to markup issues or the definition is split into several sentences.

We assume that our extraction process has to be refined. Contrarily to the expectations raised by the patterns, regular expressions alone do not always perform well in practice on structured data, most notably on tables. The overall quality of the data can be improved with a more in-depth analysis of the structural properties of the resources found online, which involves answering questions relative to the structure of a *definiendum*. Removing doublets would also be beneficial, this issue is directly linked to the extraction which may have to be made less tolerant.

Incomplete contexts could be addressed by a surface analysis of the syntax, although the content is fragmentary on a few webpages or do not lead to full sentences due to HTML extraction; 100 contexts could be properly extracted and proved to be appropriate for presentation on the website (classes 2 and 3).

The opportunistic patterns performed just as well as the "strict" patterns so that we can afford to rely on loose constraints for the extraction. This finding can be explained by the quality of the input data: the URLs of the homepages have been screened manually before download, and the retrieved data seem to confirm that we nearly exclusively deal with explanatory contexts. Thus, we can confirm that the selection of our corpus is optimized for the task at hand since it contains a large number of definitions by its construction principle. The questions we raised are rather of lexicographic nature, concerning the detection we do not need to discriminate patterns based on their efficiency *a priori* and can afford to perform an opportunistic extraction.

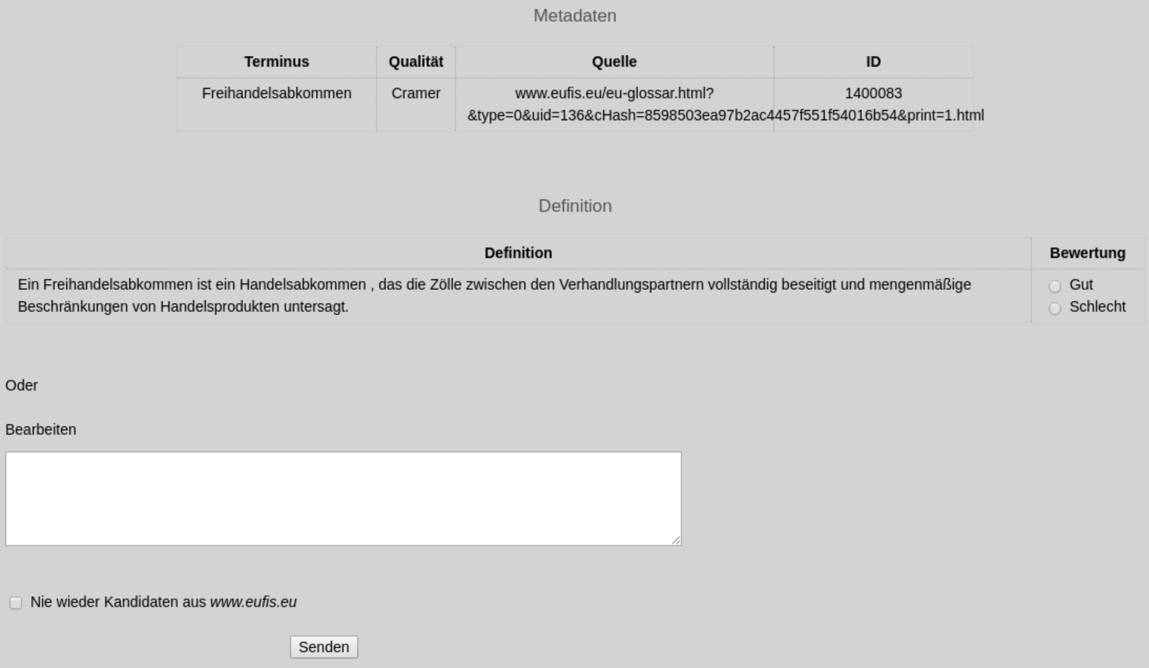
Finally, we started looking for definitions in other web corpora to provide a comparison. We used free texts as input which have no relation to lexicography whatsoever. The extraction results seem to be far worse than in the lexical resources. This confirmed our intuition that it makes sense to acquire a dedicated corpus of lexical resources of all kinds and build a database of definitory contexts based on such a corpus.



Gesucht wird nach *Trenns%*
29 Treffer.

| Begriff | Definition |
|---|---|
| Trennscheibe | alle 14 Tage für insgesamt eine halbe Stunde besucht werden , Kontakte sind nur mit **Trennscheibe** erlaubt . Auch die Anwälte können mit ihren Mandanten nur mit **Trennscheibe** sprechen , die Verteidigerpost wird kontrolliert . Das einzige was sich haben die Betroffenen haben zu schulden kommen lassen ist , dass sie |
| Trennscheibe | Die Piraten haben ihre eigene Zeitrechnung . Es gibt ein Davor und Danach , die **Trennscheibe** ist der 18 . September 2011 , als die Partei mit knapp neun Prozent in das Berliner Abgeordnetenhaus einzog . Seit dem Triumph im Herbst ist wenig geblieben wie es war Parteivertreter werden plötzlich für |
| Trennscheibe | Lokalsenders WCNC im Gefängnis ein Interview . In der orangefarbenen Häftlingskleidung saß er hinter einer **Trennscheibe** und sagte "Es ist das erste Mal , dass ich in Konflikt mit dem Gesetz gekommen bin." Er habe niemanden erschrecken wollen , sagte Verone der " Gaston Gazette". Falls er der Bankangestellten einen Schrecken |
| Trennscheibe | auf dem Grundstück eines Verdächtigen im Mordfall Julia gefunden hat Als Sven vor die verspiegelte **Trennscheibe** tritt , ist es stockdunkel im Zimmer . Die sechs jungen Männer im benachbarten Gegenüberstellungsraum können ihn nicht sehen . Sie werden eines Verbrechens verdächtigt und halten jeder ein Schild mit einer Nummer in den |
| Trennscheibe | . SPIEGEL TV Keine Seltenheit Psychische Ausnahmezustände bei den Tätern Als Sven vor die verspiegelte **Trennscheibe** tritt , ist es stockdunkel im Zimmer . Die sechs jungen Männer im benachbarten Gegenüberstellungsraum können ihn nicht sehen . Sie werden eines Verbrechens verdächtigt und halten jeder ein Schild mit einer Nummer in den |
| Trennscheibe | kann der Maybach 62 das Modell mit 6 , 17 Meter Länge mit einer versenkbaren **Trennscheibe** bestückt werden . Auf Knopfdruck verwandelt sich das elektrotransparente Glas darüber hinaus in eine blickdichte Wand . Über Preise wird , man ahnt es schon , in diesen Autosphären nur höchst ungern gesprochen . Das |
| Trennscheibe | ertragen nicht länger , wie der 60-Jährige gefesselt in einen Raum geführt und an eine **Trennscheibe** gesetzt wird . Wegen der Handschellen kann er den Telefonhörer nicht selbst halten , zuletzt half ihm ein Überwachungsbeamter. "Herr M . brach in dieser für ihn sehr emotionalen weil menschenunwürdigen Situation in Tränen aus |
| trennscharf | Geschlechter geeignet sind Die Bezeichnungen Tanga , String , Stringtanga und Thong werden häufig nicht **trennscharf** verwendet , da sie einander kaum ausschließen . Unterscheidungsmerkmale Name Seitenteile Steiß Schritt Tanga immer Schnur , ggf . gebunden meist Dreieck oft mehr als Schnur String oft Schnur , aber beliebig beliebig immer Schnur |
| trennscharf | Fazit . Wie schon die Unterscheidung zwischen ? Spekulation ? und ? Anlage ? wenig **trennscharf** ist und für jeden Investor von individuellen Risikopräferenzen und -empfindungen abhängt , so lassen sich auch die Discount-Optionsscheine nicht eindeutig ? etwa anhand von Kennzahlen o . ä. ? kategorisieren . Die dargestellte Strategie ist |
| trennscharf | stark pragmatischen Charakter auf und beruht auf intensiven Praxiserfahrungen . Daher sind die Begriffsabgrenzungen nicht **trennscharf** , und die Systematisierung ist interpretationsfähig . Auch wenn als einziges Ziel die Kostensenkung bei gleichbleibender Leistung des Produkts genannt wird , so zeigen die Ausführungen und die Resultate der Praxis , dass die Wertanalyse |
| trennscharf | . neue Informationen zu einer anderen Einschätzung führen . Die beiden Änderungssachverhalte sind mitunter nicht **trennscharf** . So kann gem . APB 20 . 11 eine geänderte Bilanzierungsmethode die Änderung der Zukunftsschätzung nach sich ziehen . Die Bewertungsmethodenstetigkeit kann durch beide genannten Änderungen betroffen sein . Grundsätzlich sind Bewertungsmethodenänderungen unter Berücksichtigung |

Figure 1: Search interface, results of the query *trenns**



Metadaten

| Terminus | Qualität | Quelle | ID |
|---|---|---|---|
| Freihandelsabkommen | Cramer | www.eufis.eu/eu-glossar.html?&type=0&uid=136&cHash=8598503ea97b2ac4457f551f54016b54&print=1.html | 1400083 |

Definition

| Definition | Bewertung |
|---|---|
| Ein Freihandelsabkommen ist ein Handelsabkommen , das die Zölle zwischen den Verhandlungspartnern vollständig beseitigt und mengenmäßige Beschränkungen von Handelsprodukten untersagt. | ○ Gut<br>○ Schlecht |

Oder

Bearbeiten

□ Nie wieder Kandidaten aus *www.eufis.eu*

Figure 2: Definition window with evaluation options

## 5. Conclusions

We introduced work on the detection of definitory contexts which is meant to support lexicographers in writing definitions for a dictionary of contemporary German. We described a specialized web corpus built for this task as well as robust pattern-based extraction processes on bare HTML documents. The resulting database entails about 191,000 candidates taken from about half a million webpages. The corresponding interface displays information for a large range of lexical units which can then be assessed by lexicographers.

Altogether, the definitory contexts in the database can be really helpful in alleviating two key tasks of the lexicographical workflow, firstly because it speeds up the search for the exact meaning(s) of terms – in the present case highly specialized terms – and secondly because it provides usable input for the task of formulating an appropriate meaning paraphrase.

Our method yielded some useful results but can benefit from some improvements, mostly in structural analysis and selection. Given the type of web texts we use, a qualitative review of the extraction patterns does not seem to be very relevant, less constraints lead to more potential definitions, so that it can be said in our case that "looser is better". Beyond an opportunistic setting, future challenges reside in finding the right balance between generic approaches and in-depth analysis.

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