Clause-Level Tense, Mood, Voice and Modality Tagging for German

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Abstract

We present a language-independent clausizer (clause splitter) based on Universal Dependencies (Nivre et al., 2016), and a clause-level tagger for grammatical tense, mood, voice and modality in German. The paper recapitulates verbal inflection in German—always juxtaposed with its close relative English—and transforms the linguistic theory into a rule-based algorithm. We achieve state-of-the-art accuracies of 92.6% for tense, 79.0% for mood, 93.8% for voice and 79.8% for modality in the literary domain. Our implementation is available at `https://gitlab.gwdg.de/tillmann.doenicke/tense-tagger`.

1 Introduction

A clause is a syntactic unit within a sentence that contains a verb and all of its arguments (subject, object etc.) and adjuncts (adverbials of time, location etc.), i.e., clauses describe events (or states) and therefore are the core elements of discourse. Several important properties of an event are expressed by inflectional features of the verb alone: Tense and aspect express the relation between event time, speech time and reference time (Reichenbach, 1947; Boogaart and Janssen, 2007), mood expresses the reality status of an event (Elliott, 2000), and voice expresses a mapping between the syntactic arguments of a verb and semantic roles (agent, patient etc.). Modal verbs further mark the modality of an event, such as deonticity and epistemicity (Leiss, 2008). Hence, extracting these features from a clause is a crucial task for discourse analysis. Following previous work (Bögel et al., 2014; Ramm et al., 2017), we address this task with a rule-based approach.

We use parse trees in the Universal Dependencies (UD; Nivre et al. (2016)) format to split sentences into clauses, which makes our clause-splitting method applicable to all languages with a UD treebank. Nevertheless, the morphosyntactic systems for tense, aspect, mood, voice and modality vary greatly between languages (cf. Aronson (1995), Zeitoun et al. (1996), Lin (2005), Keenan and Dryer (2007), Singh et al. (2007) and many others) and do not allow a crosslinguistic approach. We focus on German which shows strong parallels to English.

This paper presents an approach towards tagging morphosyntactic/grammatical features which do not always correspond to semantic features. This is best observable for tense; all of the following examples feature present tense but describe events in the present, past or future:

(1) a. John sees Mary.
b. 44 BC, Caesar is stabbed by a group of senators. (historical present, Wolfson (1978))
c. Tomorrow, we go to the cinema. (future present)

Tagging and normalising temporal expressions such as *44 BC* and *tomorrow* is a separate research task (cf. Strötgen and Gertz (2010), Pustejovsky and Verhagen (2009) and subsequent SemEval tasks) which is not addressed in this paper. In the long run, both temporal expressions and grammatical tense together are helpful for inferring semantic tense.

The difference between syntax and semantics also affects the other features under consideration. The presence of a modal verb, for example, can cause multiple semantic interpretations: *he must work* is ambiguous between *he is required to work* (deontic interpretation) and *he is very likely to work [according to what the speaker knows]* (epistemic interpretation) (Viebahn and Vetter, 2016; Tarvainen, 1976).

Tense + Aspect	Alternate names	Example (indicative, active)
present imperfect	present	*sieht* ‘sees’
present perfect	perfect	*gesehen hat* ‘has seen’
past imperfect	preterite, imperfect	*sah* ‘saw’
past perfect	pluperfect	*gesehen hatte* ‘had seen’
future imperfect	future, future I	*sehen wird* ‘will see’
future perfect	future II	*gesehen haben wird* ‘will have seen’

Table 1: Tense–aspect combinations in German.

Grammatical tense also plays an important role in the analysis of narrative texts which are usually written in the simple past. If the tense changes locally, this marks a potential passage of interest. For example, if the tense changes to the simple present, it could be a passage with gnomic reading (i.e. a passage expressing a general truth) as in (2):

(2) John tried to catch a rabbit. Rabbits are fast, but finally he got it.

This paper is structured as follows: section 2 gives an overview of the inflection of verbs in German; section 3 summarises the previous approaches to tagging tense, mood and voice in German; section 4 contains our algorithms and implementation details; sections 5 and 6 contain the evaluation and discussion of our tool, including comparisons with the previous works; sections 7 and 8 conclude with an outlook on future work and a summary.

2 Inflection and Government in German Clauses

German has three tenses: present, past, future, and two aspects: imperfect (= simple) and perfect, and therefore six tense–aspect combinations (Table 1). The composition of verb forms is very similar to their English counterparts; a main verb is extended by auxiliary verb forms of *haben* ‘have’, *sein* ‘be’ and *werden* ‘will/become/get’. For example, the past perfect form of *sehen* ‘see’ is *(er) hatte gesehen* ‘(he) had seen’. Since tense and aspect are inseparable, they are sometimes simply referred to as “tense”.

German further distinguishes four moods: indicative, present subjunctive (subjunctive I), past subjunctive (subjunctive II) and imperative, as well as three voices: active, dynamic passive and static passive[1]. All of these are expressed by combinations of the three auxiliary verbs mentioned above.

2.1 Word Order

The basic German word order is S-O-V. All verbs are positioned at the end of a clause; starting with the syntactically lowest verb and ending with the syntactically highest verb. However, this ordering is only maintained in subordinate clauses; in main clauses, the finite verb (which is always the syntactically highest verb) moves to verb-second position[2]:

[1]German makes a clear distinction between the dynamic passive using the auxiliary verb *werden* ‘get’ (3a) and the static passive using the auxiliary verb *sein* ‘be’ (3b). In English, on the other side, passives with *be* are ambiguous between a dynamic and a static reading:

(3) a. i. Er wird gefüttert [und verschlingt seinen Fraß].
ii. He is/gets fed [and is devouring his food].
b. i. Er ist gefüttert [und schläft jetzt].
ii. He is/*gets fed [and is now sleeping].

[2]In polar questions, the finite verb moves to sentence-initial position; in subordinate clauses, the finite verb may move to the so-called *Oberfeld* (cf. e.g. Hinrichs (2016)). For this paper, it is enough to say that the finite verb can move to a position preceding the non-finite verbs.

(4) a. i. (dass) er sie gesehen hatte.

ii. (that) he had seen her.

b. i. Er hatte$_1$ sie gesehen t_1.

ii. He had seen her.

English, as an S-V-O language, employs the exact opposite order of verbs. In other words, the direction of verbal government is right-to-left in German, and left-to-right in English:

(5) i. (dass) er sie $\overleftarrow{\text{gesehen haben wird}}$.

ii. (that) he $\overrightarrow{\text{will have seen}}$ her.

The strict ordering makes it possible to derive the syntactic hierarchy of the verbs in a clause without applying a syntactic parser.

2.2 Morphological vs. Clausal Features

As we have seen in (4) and (5), a verb form can consist of several verbs. Each verb has its own morphological features. The features of a composite verb form (= the clausal features) result from the morphological features of the individual verbs. We use feature structures, i.e. sets of FEATURE–value pairs, (see Jurafsky and Martin (2009) for an introduction), to represent morphological and clausal features. Clausal features cannot be derived by unification of the involved morphological features though; this is why we denote the compositional process with a function R which maps a set of morphological features to the features of the clause. For (4) we get:

$$R\left(\left\{\begin{bmatrix}\text{LEMMA} & \textit{sehen}\\ \text{TYPE} & \text{main}\\ \text{FORM} & \text{participle}\\ \text{ASPECT} & \text{perfect}\\ \text{VOICE} & \text{passive}\end{bmatrix}, \begin{bmatrix}\text{LEMMA} & \textit{haben}\\ \text{TYPE} & \text{auxiliary}\\ \text{FORM} & \text{finite}\\ \text{TENSE} & \text{past}\\ \text{MOOD} & \text{indicative}\\ \text{VOICE} & \text{active}\end{bmatrix}\right\}\right) = \begin{bmatrix}\text{FORM} & \text{finite}\\ \text{TENSE} & \text{past}\\ \text{ASPECT} & \text{perfect}\\ \text{MOOD} & \text{indicative}\\ \text{VOICE} & \text{active}\end{bmatrix}$$

2.3 Modal Verbs

Modal verbs are not part of a composite verb form but possibly take over inflectional features. (6a) and (6b) are identical in terms of tense, mood and voice but the modal verb *muss* 'must' in (6b) shows the inflectional features of the auxiliary verb *hat* 'has' in (6a).

(6) a. i. (dass) er sie gesehen$_{[\text{FORM participle}]}$ hat$_{\begin{bmatrix}\text{FORM} & \text{finite}\\ \text{TENSE} & \text{present}\end{bmatrix}}$.

ii. (that) he has$_{\begin{bmatrix}\text{FORM} & \text{finite}\\ \text{TENSE} & \text{present}\end{bmatrix}}$ seen$_{[\text{FORM participle}]}$ her.

b. i. (dass) er sie gesehen$_{[\text{FORM participle}]}$ haben$_{[\text{FORM infinitive}]}$ muss$_{\begin{bmatrix}\text{FORM} & \text{finite}\\ \text{TENSE} & \text{present}\end{bmatrix}}$.

ii. (that) he must$_{\begin{bmatrix}\text{FORM} & \text{finite}\\ \text{TENSE} & \text{present}\end{bmatrix}}$ have$_{[\text{FORM infinitive}]}$ seen$_{[\text{FORM participle}]}$ her.

To obtain the basic verb form without (interfering) modal verbs, one has to shift their features to the next verb in the direction of verbal government.[3]

[3] In English, the shifting of inflectional features is also observable in negation or emphasis with the auxiliary verb *do*:

(7) a. He has$_{\begin{bmatrix}\text{FORM} & \text{finite}\\ \text{TENSE} & \text{present}\end{bmatrix}}$ seen$_{[\text{FORM participle}]}$ her.

b. He does$_{\begin{bmatrix}\text{FORM} & \text{finite}\\ \text{TENSE} & \text{present}\end{bmatrix}}$ (not) have$_{[\text{FORM infinitive}]}$ seen$_{[\text{FORM participle}]}$ her.

2.4 Substitute Infinitives

In German, modal verbs and some other verbs can exhibit a substitute infinitive (*infinitivus pro participio*), i.e. use the infinitive instead of the perfect participle. *Müssen* 'have to' in (8a) and *hören* 'hear' in (8b) (Bausewein, 1991) are substitute infinitives:

(8) a. i. (dass) er sie sehen müssen/*gemusst hat.
   ii. (that) he has had to see her.
  b. i. (dass) er sie singen hören/gehört hat.
   ii. (that) he has heard her sing.

If substitute infinitives are governed by an auxiliary verb, this is always a form of *haben* 'have'.

3 Previous Approaches and Corpora for German

3.1 Bögel et al. (2014)

As part of the heureCLÉA project[4], Bögel et al. (2014) developed a clause-level tagger for five tense–aspect combinations (future imperfect and future perfect are combined into one tag). Their pipeline is implemented in the UIMA framework[5] and makes use of several external resources, such as the TreeTagger (Schmid, 1995) for part-of-speech tagging, the Stanford Parser for constituent parsing and Morphisto (Zielinski et al., 2009) as a morphological analyzer. Clauses ("sub-sentences" in Bögel et al. (2014)) are defined as constituents with an own S root. The final tense is predicted using a small set of rules, e.g.

$$R\left(\left\{\begin{bmatrix}\text{TYPE} & \text{main}\\ \text{FORM} & \text{participle}\end{bmatrix}, \begin{bmatrix}\text{TYPE} & \text{auxiliary}\\ \text{TENSE} & \text{present}\end{bmatrix}\right\}\right) = \begin{bmatrix}\text{TENSE} & \text{present}\\ \text{ASPECT} & \text{perfect}\end{bmatrix},$$

and a heuristic for discontinuities, which copies the tense for a clause from its neighbouring clauses if R does not provide an analysis.

The evaluation corpus consists of twenty narrative texts, and the first 20% of each text (nearly 12k tokens in total) are annotated with tense. In the evaluation, they measured (i) all correctly tagged tokens (all tokens in a clause are assigned the same tense as the main verb), as well as (ii) only the correctly tagged main verbs. The reported accuracies are 94.8% and 93.3%, respectively. Most of the tagging errors are caused by incorrect parser outputs (and thus incorrect clause splitting) or incorrect annotations.

The tense tagger was provided through the annotation tool CATMA[6], version 5. Unfortunately, it was not transferred when moving to CATMA 6 (current version) and the account creation for CATMA 5 has been deactivated, which makes the tense tagger inaccessible. The corpus is still available at `https://github.com/heureclea`.

3.2 Ramm et al. (2017)

The tmv-annotator by Ramm et al. (2017) is a Python tool for tagging preprocessed German, English or French texts with tense mood and voice. For German, the tagsets include all six tenses, three moods (imperative is missing) and two voices (no distinction between static and dynamic passive). To use the tool (available at `https://github.com/aniramm/tmv-annotator`), the texts have to be preprocessed with MATE tools[7]—or another tool providing the same output—which is implemented in Java and includes tokenisation, part-of-speech tagging, lemmatisation, morphological analysis and depedendcy parsing (but no sentence splitting although the text has to be split into sentences before applying the tokeniser). Unlike the Stanford Parser which provides constituent parses, the MATE parser provides dependency parses in the German TIGER/CoNLL format (cf. Buchholz and Marsi (2006), Hajič et al. (2009)). The composite verb form of a clause ("verb cluster" in Ramm et al. (2017)) is extracted by first selecting the main verb and then collecting the dependent auxiliary verbs. The final analysis is predicted with a

[4] `http://heureclea.de/`
[5] `http://uima.apache.org/`
[6] `http://www.catma.de/`
[7] `https://code.google.com/archive/p/mate-tools/`

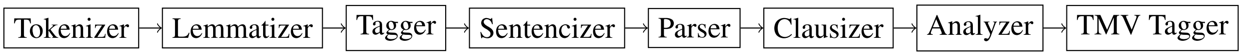


Figure 1: Our processing pipeline: from raw text to clause-level tagging.

rule-set similarly as in Bögel et al. (2014). The output of the tool is a table format providing all main verbs and tense/mood/voice tags as well as the clauses which contain the verbs.

The tool was evaluated on 157 randomly selected clauses from the Europarl corpus (Koehn, 2005) which had been annotated with the respective features. The reported accuracies are 80.8% for tense, 84.0% for mood and 81.5% for voice. Unfortunately, the evaluation corpus is not available anymore.

4 Method/Implementation

We implemented the entire pipeline in spaCy[8], an open-source software library for crosslinguistic natural language processing in Python. The pipeline is shown in Figure 1; its individual components are described below.

4.1 Preprocessing

We used the default tokenizer, lemmatizer, part-of-speech tagger and sentencizer (sentence splitter) from the German spaCy model.[9]

4.2 Universal Dependency Parsing

Universal Dependencies (UD; Nivre et al. (2016))[10] are a crosslinguistic annotation format and also a collection of treebanks from a wide range of languages annotated in that format. An advantage of the universal annotation format, with respect to our need for clause splitting, is that clauses can easily be identified through certain dependency relations (e.g. `nsubj` marks a nominal subject whereas `csubj` marks a clausal subject). This is not the case with, for example, the TIGER annotation scheme for German (here `sb` marks both non-clausal and clausal subjects). We therefore decided to parse our texts with UD relations.

Unfortunately, German and English are the only languages for which the default spaCy parser does not use UD relations. Therefore—and because there is currently no German UD model for spaCy available—, we trained a new parser on the current version of the UD treebanks (Zeman et al., 2020). In contrast to e.g. the Stanford parser which was solely trained on newspaper texts, the German UD treebanks also contain texts from different domains, including a small proportion of texts from literary history (LIT treebank). We held out the test sets of GSD and HDT (9.3% of the sentences) for testing and achieved a labelled attachment score (Zeman et al., 2017) of 85%. We provide our spaCy model along with the rest of our code.

4.3 Crosslinguistic Clause Splitting

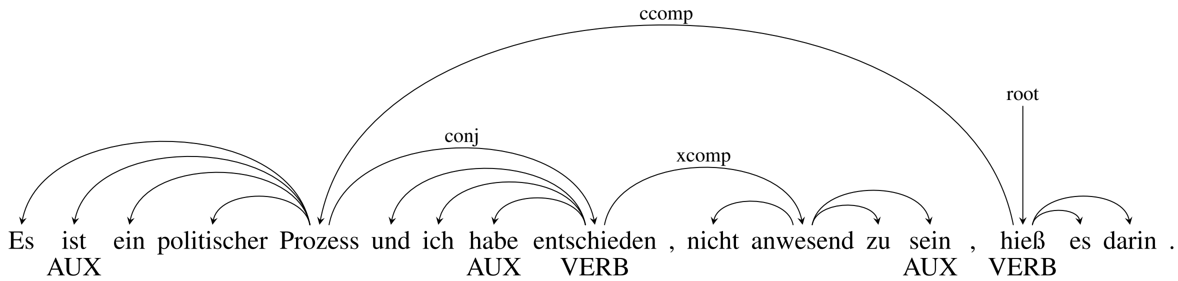
As mentioned above, certain UD relations can be used to split a sentence into clauses. To be more precise, if one of the following relations is encountered in a sentence, the tokens of the corresponding subtree, ignoring punctuation, form a clause: `root` (matrix sentence), `acl` (adjectival clause), `advcl` (adverbial clause), `ccomp` (clausal complement), `csubj` (clausal subject), `discourse` (interjections etc.), `parataxis`, `vocative`, `list`. The relations `xcomp` (open clausal complement) and `conj` (conjunct) sometimes but not always mark clauses. We split at these relations if certain conditions are met: at an `xcomp` if the subtree constists of at least a verb and one additional word which is not a verbal particle (i.e. if the subtree forms an extended infinitive clause); at a `conj` if the label of its head is one of the clause labels listed above (i.e. if the subtree is conjuncted on clause-level). These conditions are hyperparameters in our implementation and can be easily changed if one prefers another handling of open clausal complements or conjuncts.

[8] `https://spacy.io/`

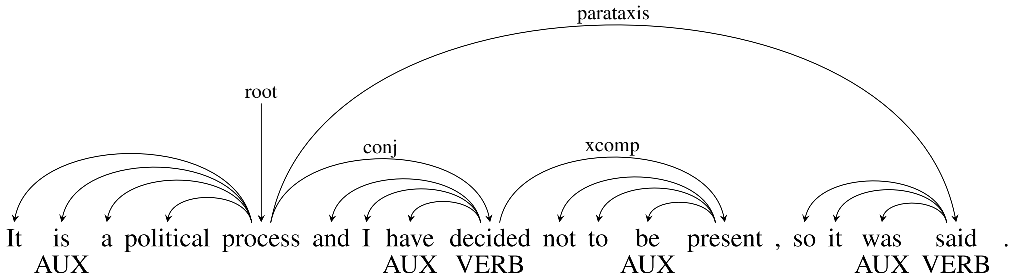
[9] The pre-trained German model is available at `https://spacy.io/models/de#de_core_news_lg`.

[10] `https://universaldependencies.org/`

(i)



(ii)



(iii)

Relation	Clause
`ccomp`	Es ist ein politischer Prozess
`conj`	und ich habe entschieden
`xcomp`	nicht anwesend zu sein
`root`	hieß es darin

(iv)

Relation	Clause
`root`	It is a political process
`conj`	and I have decided
`xcomp`	not to be present
`parataxis`	so it was said

Figure 2: Dependency trees for a sentence in the (i) German and (ii) English PUD treebanks (ID: n02030005). Relations are only labelled if marking a clause. Tables (iii) and (iv) show the extracted clauses; verbs are underlined.

Our clausizer is applicable to all texts with UD parse trees, either after being parsed accordingly (e.g. with spaCy) or after being manually annotated (e.g. within the UD treebanks project). Figure 2 shows a sentence from the German and English PUD treebanks. Each sentence contains four clauses. We implemented the clausizer to recursively detect nested clauses, e.g. two clauses are detected in (9): *Der Mann lacht* 'The man laughs' and *der die Kuh sah* 'who saw the cow'.

(9) i. Der Mann, der die Kuh sah, lacht.
ii. The man who saw the cow laughs.

4.4 Morphological Analysis

SpaCy already assigns some morphological features to words, e.g. the form of a verb, i.e. whether it is finite, an infinitive or a participle. In addition, we use DEMorphy (Altinok, 2018)[11], a morphological analyzer for German. Since DEMorphy outputs all analyses for a word—independent from its context—we filter out unlikely analyses due to case–number–gender congruence. To be more precise, the words within a noun phrase should be congruent in case, number and gender, and a finite verb should be congruent with its subject in number and person.

4.5 TMV Tagging

The algorithm for our tense–mood–voice (TMV) tagger is sketched in Algorithm 1. In the following, numbers in parentheses refer to the corresponding lines in the pseudocode.

Given a clause *C*, the non-finite verbs, i.e. infinitives and participles, are stored in a list *V* (l. 1). In contrast to the procedure of Ramm et al. (2017), this step does not rely on the output of a parser. If the

[11] `https://github.com/DuyguA/DEMorphy`

Algorithm 1: Compute features of a clause C

1 $V \leftarrow$ [non-finite verbs in C]
2 **if** finite verb in C **then**
3     $v_{fin} \leftarrow$ right-most finite verb in C
4     $V \leftarrow [v_1, \ldots, v_{|V|}, v_{fin}]$
5 **if** C is conjunct **then**
6     $V \leftarrow \text{copy\_verbs}(V, C, \text{head}(C))$
7 **if** $|V| = 0$ **then**
8   **return** $[\,]$
9 **else if** main verb **in** V **then**
10     $v_{main} \leftarrow$ right-most main verb in V
11 **else**
12     $v_{main} \leftarrow$ left-most verb in V
13 $V \leftarrow [v_{main}, \ldots, v_{fin}]$
14 $M \leftarrow [\{\text{features}(v_i)\}$ **for** $i = 1$ **to** $|V|]$
15 **if** $[\text{LEMMA } \textit{haben}] \sqsubseteq \text{first}(m_{|V|})$ **and** $[\text{FORM infinitive}] \sqsubseteq \text{first}(m_{|V|-1})$ **then**
16     $m_{|V|-1} \overset{\cup}{\leftarrow} \left\{ \begin{bmatrix} \text{FORM} & \text{participle} \\ \text{ASPECT} & \text{perfect} \end{bmatrix} \right\}$
17 **for** $i = |V|$ **to** 1 **do**
18   **if** v_i is modal verb **then**
19         $m_{i-1} \leftarrow m_i$
20 **while** $|V| > 0$ **do**
21   Set v_1 to be the main verb
22     $F \leftarrow \bigtimes_{\substack{1 \le i \le |V| \\ v_i \text{ is not modal verb}}} m_{|M|-|V|+i}$
23     $A \leftarrow \{\}$
24   **for** $i = 1$ **to** $|F|$ **do**
25   **if** $R(f_i) \neq \text{NULL}$ **then**
26             $A \overset{\cup}{\leftarrow} \{R(f_i)\}$
27   **if** $|A| > 0$ **then**
28         $a \leftarrow \text{first}(\text{filter}(A))$
29         $V_{modal} \leftarrow$ [modal verbs in V]
30         $a \overset{\sqcup}{\leftarrow} [\text{MODALITY } V_{modal}]$
31   **return** a
32     $V \leftarrow [v_2, \ldots, v_{|V|}]$
33 **return** $[\,]$

For a set $S = \{s_1, \ldots, s_{|S|}\}$, first($S$) is identical to s_1.
$\overset{\cup}{\leftarrow}$ and $\overset{\sqcup}{\leftarrow}$ are augmented assignment operators for union and unification, respectively.

clause contains a finite verb, then it is appended to V (ll. 2–4). In that way, the verbs are sorted in basic word order, i.e. as if the clause was a subordinate clause.

If C is a conjunct, the potentially missing verbs are copied from the head clause (ll. 5–6). For example, (10) contains the clauses *er sie gesehen hatte* ‘he had seen her’ and *und gerufen* ‘and called’; *hatte* ‘had’ has to be copied from the first to the second clause to complete the composite verb form *gerufen hatte* ‘had called’.

(10) i. (dass) er sie gesehen und gerufen hatte.
 ii. (that) he had seen and called her.

The next step is to select the clause’s main verb. If there is at least one genuine main verb in V, the right-most (= syntactically highest) one is chosen (ll. 9–10). In (11a), this is *gelernt* ‘learned’. (11b) and (11c) illustrate that auxiliary verbs and modal verbs can function as main verb as well. If there is no genuine main verb in the clause, the left-most (= syntactically lowest) verb is chosen (ll. 11–12). In (11b), this is *gewesen* ‘been’; in (11c), this is *kann* ‘can’. Note that *speak* is the main verb of the English translation since *can* cannot be used alone here; German is much freer in using modal verbs as main verbs.

(11) a. i. (dass) er sprechen gelernt hatte.
 ii. (that) he had learned to speak.
 b. i. (dass) er dort gewesen war.
 ii. (that) he had been there.
 c. i. (dass) er Englisch kann.
 ii. (that) he can [speak] English.

Only the verbs from the main verb to the finite verb are interesting for TMV tagging, because the main verb is the syntactically lowest verb of a composite verb form; all other verbs which precede the main verb are removed from V (l. 13). M contains the feature structures for every word, i.e. m_i ($1 \le i \le |V|$)

is a set of possible morphological analyses for v_i (l. 14). If the second verb from the right $v_{|V|-1}$ is a potential substitute infinitive, the feature structure of a perfect participle is added to $m_{|V|-1}$ (ll. 15–16). Having all verbs of interest together, the features of modal verbs are shifted to their predecessors as described in section 2.3 (ll. 17–19).

The Cartesian product of $m_1, \ldots, m_{|V|}$ (now ignoring modal verbs) yields all possible combinations of morphological analyses of the involved verbs and is stored in F (l. 22). Every combination $f_i \in F$ is then tried to be mapped to the clausal features $R(f_i)$. Instead of using hand-crafted rules like previous work, we created a table of all possible verb forms for the look-up (a table with all verb forms can be found in the appendix). If f_i is in the table, then $R(f_i)$ is saved in the final set of analyses A (ll. 23–26).

If no analysis is found, the first verb in V is removed (l. 32) and the last paragraph is repeated (ll. 20–21). This counteracts tagging and parsing errors and makes it possible to also tag rarely used verb combinations such as sequences of auxiliaries as in (12a) or double perfect constructions (Ammann, 2007) as in (12b).

(12) a. i. (dass) er dort gewesen gewesen ist.
ii. (that) he has been been there.
b. i. (dass) er sie gesehen gehabt hat.
ii. (that) he has had seen her.

As soon as one or more analyses are found, one of them is selected and returned (ll. 27–31). In German, most verbs express the perfect aspect with the auxiliary verb *haben* ‘have’ (e.g. *hat gesehen* ‘has seen’) but some use *sein* ‘be’ (e.g. *ist gegangen* ‘is gone’) and others can use either depending on the context or regional varieties (whereas in English it is almost always *have*). Since forms of *sein* can not only mark perfect aspect but also static passive, this causes ambiguous verb forms. To resolve these ambiguities, we filter the analyses with respect to the main verb’s possible perfect auxiliaries (this is also done by Ramm et al. (2017)). We extracted the possible perfect auxiliaries for every German verb in the German Wiktionary[12].

Before the final analysis is returned, its modality feature is set to the list of modal verbs in the current V (ll. 29–30) (syntactically lower modal verbs are not returned).

5 Evaluation

We compared the performances of our tagger and the tagger from Ramm et al. (2017) on the texts in the heureCLÉA corpus as well as on a text annotated by ourselves.

5.1 Annotation

We annotated the German translation of the preface of *Don Quijote* by Miguel de Cervantes Saavedra[13] (3,200 tokens) which contains a lot of complex (multi-clause) sentences and examples for all six tenses, four moods, three voices and the modal verbs *können* ‘can’, *mögen* ‘may’, *müssen* ‘must’, *sollen* ‘shall’ and *wollen* ‘want’. Two annotators annotated the text with tense. After calculating the inter-annotator agreement ($\kappa = 96\%$, Fleiss et al. (2003)), we combined the two annotations into a gold annotation and extended it with finiteness, mood, voice and the modal verbs involved in a verb form.

We used the official German Duden grammar (Dudenredaktion, 2009, pp. 476 ff.) as reference guide for our annotation of tense, mood and voice. We also annotated non-finite clauses (with infinitive or participle forms) with tense and voice[14]—non-finite forms do not feature mood—, whereas Ramm et al. (2017) only consider finite verb forms and in heureCLÉA non-finite clauses are either not annotated or receive the tense of the corresponding matrix clause.

[12] `https://dumps.wikimedia.org/dewiktionary/`

[13] The text is available at `https://www.projekt-gutenberg.org/cervante/quijote1/quijote1.html`.

[14] It is debatable whether infinitives and participles feature tense or only aspect. This is, however, only a matter of definition. Since we only tag tense–aspect combinations, we use the present imperfect or present perfect for all non-finite verb forms.

	heureCLÉA		*Don Quijote*	
	Tokens	Verbs	Tokens	Verbs
Fleiss' κ	(89.7)	(84.0)	96.3	96.0
Bögel et al. (2014)	(93.3)	(94.8)	–	–
Ramm et al. (2017)	74.9	81.9	55.8	63.7
this work	88.8	90.8	87.2	92.6

Table 2: Inter-annotator agreements and tense tagging accuracies for the heureCLÉA corpus and/or our test text. Numbers in brackets are copied from Bögel et al. (2014). Accuracies are shown for all tokens or only main verbs.

	Fin.	Tense	Mood	Voice	Mod.
Ramm et al. (2017)	82.7	71.5	75.7	82.5	–
this work	88.1	92.9	82.2	93.5	79.8
		92.6	79.0	93.8	79.8

Table 3: Comparison of two taggers for tense, mood, voice and modality on our test text. Accuracies are calculated for main verbs in finite clauses. The first column shows the accuracy distinguishing main verbs in finite clauses from main verbs in non-finite clauses.

5.2 Tense Evaluation

The first evaluation concentrates on tense tagging. Following Bögel et al. (2014), we provide the accuracy for correctly tagged tokens (where each token is assigned the tense of the clause) as well as the accuracy for the correctly tagged main verbs. Table 2 shows the accuracies for testing on the heureCLÉA corpus and our gold annotation of *Don Quijote*.

For heureCLÉA, there is no gold annotation but only the unmerged annotations from two annotators. As in Bögel et al. (2014), we only use those tokens for accuracy calculation which had been annotated with the same tense from both annotators, and we combine future imperfect and future perfect into one tag.

5.3 TMV and Modality Evaluation

For the second evaluation, we used the annotations of finiteness, tense, mood, voice and modality for *Don Quijote*. Since Ramm et al. (2017)'s tagger only tags finite verb forms, we decided to only compare the performances of the taggers on clauses annotated as finite. We further combined indicative and imperative mood as well as static passive and dynamic passive to have the same categories as Ramm et al. (2017). The first column of Table 3 shows the performance of Ramm et al. (2017)'s and our tagger for detecting whether a verb form is finite or non-finite. The other columns show the accuracies for correctly tagged main verbs in finite clauses. The last row shows the accuracies for our tagger when not merging mood and voice to Ramm et al. (2017)'s categories and evaluating on all verbs, including those in non-finite clauses.

5.4 Clause Evaluation

We also tested the sole performance of our clausizer. For the evaluation on *Don Quijote*, we compared the clause boundaries of the annotation B_{gold} with the predicted boundaries B_{pred} (cf. Jurish and Würzner (2013)). We define a clause boundary as a tuple (e_i, s_{i+1}) of character positions, namely the end position e_i of a clause and the start position s_{i+1} of the next clause in the text.[15] Precision, recall and F_1-score are calculated respectively as

$$P = \frac{|B_{gold} \cap B_{pred}|}{|B_{pred}|}, \qquad R = \frac{|B_{gold} \cap B_{pred}|}{|B_{gold}|}, \quad \text{and} \quad F_1 = \frac{2 \cdot P \cdot R}{P + R}.$$

[15] A clause inside another clause produces the same boundaries as three subsequent clauses. It is not possible to distinguish these cases in the calculations, because the annotation format does not distinguish them either.

	Don Quijote	CoNLL-2001	
	clause boundaries	clause starts	clause ends
Gold instances	443	4497	3364
Pred. instances	388	4598	4598
Precision	87.1	72.7	66.4
Recall	76.3	74.3	90.8
F_1-score	81.3	73.5	76.7

Table 4: Clause splitting precisions, recalls and F_1-scores of our clausizer on our test text (German) and the CoNLL-2001 shared task test set (English). The first two rows show the number of gold and predicted instances.

We additionally applied the clausizer to the test set from the CoNLL-2001 shared task on clause identification (in English) (Tjong Kim Sang and Déjean, 2001). The goal in the shared task was the automatic detection of 1) start tokens, 2) end tokens, and 3) entire spans of clauses. The evaluation of our tool on this dataset is somewhat problematic because the concept of what a clause is differs in several aspects. The main difference is that every token belongs to exactly one clause in our concept, namely the syntactically deepest clause where it appears in, whereas a token also belongs to all of its superordinate clauses in the shared task's concept. Therefore, our clausizer would definitely not detect the same spans as in the test set. However, we can evaluate the clausizer on the detection of clause starts and ends; here, the actual number of clauses that start or end on those positions is not considered. For the prediction, we used the sentence boundaries and part-of-speech tags as in the test set, the pre-trained English spaCy model[16] for parsing, and our clausizer in the same configuration as for German, with a small modification: As noted earlier, the English spaCy model does not use UD relations, but instead produces the earlier Stanford relations (de Marneffe and Manning, 2008) which are quite similar to the UD relations. We added `csubjpass`, `intj`, `pcomp`, and `relcl` (which do not appear in the UD inventory) to the list of clause-marking relations.

Table 4 shows the performances of the clausizer on *Don Quijote* and the English test set. We achieve F_1-scores of 81.3% for clause boundaries in *Don Quijote*, and of 73.5% for clause starts and 76.7% for clause ends in the English test set, respectively. Note that the number of predicted starts is identical to the number of predicted ends, since every token is only part of one clause in our system. The number of gold starts and ends varies, since every token can be start and end of several (nested) clauses in the test set. The scores of the systems designed for and submitted to the shared task range between 50% and 92% for clause starts and 60% and 90% for clause ends, respectively.

6 Discussion

Our tagger achieves adequate accuracies for tense, mood and voice on the preface of *Don Quijote*, and outperforms the tagger from Ramm et al. (2017) in every evaluation condition, both on our test text as well as the heureCLÉA corpus. We perform about 4% worse on the heureCLÉA corpus than the original tagger of Bögel et al. (2014). A frequent cause for mismatches is the different treatment of non-finite clauses, which frequently receive the tense of the matrix clause in the heureCLÉA corpus but are standardly tagged with present or perfect tense from our tagger. Clauses are not annotated with finiteness in heureCLÉA and it is therefore neither possible to exclude non-finite clauses from the evaluation, nor to estimate their exact impact. In *Don Quijote*, about 12% of the main verbs are annotated as non-finite, and one can assume that the amount in heureCLÉA is approximately the same.

A manual inspection of the tagger outputs shows that Ramm et al. (2017)'s tagger sometimes leaves entire clauses within complex sentences untagged which is probably an indication of incorrectly split clauses. Our clausizer, on the other hand, is more robust when it comes to these kinds of sentences. Ramm et al. (2017)'s tagger also tags verbs in past subjunctive, e.g. *dächte* 'would think', as present tense (which is usually the semantic tense) although its grammatical tense is the past tense. Again, our

[16]The pre-trained English model is available at `https://spacy.io/models/en#en_core_web_lg`.

complete look-up table is not as prone to errors as a set of rules.

Our comparatively low accuracy for mood mainly results from open clausal complements (`xcomp` in UD) that are not treated as clauses in our annotation but are recognised as such by the clausizer. Such clauses are non-finite and hence not tagged with mood. Mostly, these are cases where the annotators had overlooked an embedded infinitive clause, such as the underlined clause in (13), and then annotated it as part of the finite clause.

(13) i. (Gedichte,) die man den Büchern an den Eingang zu setzen pflegt

ii. (poems) that one uses to place at the beginning of the books

The tagging of modal verbs also leaves room for improvement. The main cause for this are conjuncted clauses in which the modal verb is not correctly copied from a main clause to its conjuncts by our conjunct handling algorithm.

Another type of error are incorrect analyses caused by preprocessing components. An example for this are perfect and pluperfect forms (e.g. *hatte gesehen* 'had seen') which are sometimes tagged as their respective imperfect tenses, present and preterite; e.g. because the morphological analyzer does not recognise the participle as such or the clausizer separates the verbs due to an incorrect parser output. Given parsing and clausizing performances of 85% and 81%, it is encouraging that we reach TMV tagging accuracies of over 90%. The influence of the syntactic preprocessing might be partially alleviated by the fact that our tagger itself does not use dependency information. Nevertheless, improvements in the parser would surely improve the performances of the clausizer and subsequently the tagger.

7 Future Work

As mentioned above, we oriented ourselves to usual German school grammars (Dudenredaktion, 2009) when building our tagsets for tense, mood and voice. However, it might be useful to also include non-canonical, but grammaticalised composite verb forms such as the already mentioned double perfect/pluperfect or the recipient passive (e.g. Ziering et al. (2012)) with the auxiliary verb *bekommen* 'receive'. To do so, nothing more is required than to extend the table of possible verb forms (the look-up function R).

Our approach works for every language with a hierarchically ordered verb structure, such as German and English. To adapt our approach to another language, a morphological analyzer of that language, a table of verb forms and perhaps a list of modal verbs is required. Resources such as Wiktionary provide verb type information and inflection tables for numerous languages and can be used with little effort. Our clausizer, which relies on Universal Dependencies relations, already works language-independently.

Future work could also address the transition from rule-based systems to distributional models. Although mapping morphological features to clausal features is a strictly rule-based process, grouping verbs into verb forms and selecting context-specific analyses for all relevant verbs is not. Since training these models usually requires a certain amount of annotated data, a preliminary step would be the creation of sufficient corpora. For example, clause-level features could be added to the Universal Dependencies treebanks, as they already have the concept of clause-marking dependency relations.

8 Conclusion

In this work, we provide a rule-based method to detect grammatical/morphosyntactic tense, mood, voice and modality on clause level in German. Our algorithm is grounded in linguistic theory and makes use of the hierarchically ordered verb structure in German. We also provide our preprocessing pipeline (implemented in Python/spaCy), including a German parsing model for Universal Dependencies (UD), a language-independent clausizer that splits sentences with UD parses into clauses, and an interface to the morphological analyzer DEMoprhy. We evaluated our approach on literary texts and achieve new state-of-the-art accuracies in all categories. Since our algorithm is rule-based, it does not require any training data and can be used for other text domains as well.

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Appendix A. German verb forms with tense, mood, voice

Aux.	Example	Tense + Aspect	Mood (if finite)	Voice
haben	(zu) sehen	present imperfect	(infinitive)	active
haben	gesehen (zu) werden	present imperfect	(infinitive)	dynamic passive
haben	gesehen (zu) sein	present imperfect	(infinitive)	static passive
haben	gesehen (zu) haben	present perfect	(infinitive)	active
haben	gesehen worden (zu) sein	present perfect	(infinitive)	dynamic passive
haben	gesehen gewesen (zu) sein	present perfect	(infinitive)	static passive
haben	sehend	present imperfect	(participle)	active
haben	gesehen	present perfect	(participle)	passive
haben	sieh	present imperfect	imperative	active
haben	werde gesehen	present imperfect	imperative	dynamic passive
haben	sei gesehen	present imperfect	imperative	static passive
haben	habe gesehen	present perfect	imperative	active
haben	sei gesehen worden	present perfect	imperative	dynamic passive
haben	sei gesehen gewesen	present perfect	imperative	static passive
haben	[er] sieht	present imperfect	indicative	active
haben	[er] sehe	present imperfect	present subjunctive	active
haben	[er] wird gesehen	present imperfect	indicative	dynamic passive
haben	[er] werde gesehen	present imperfect	present subjunctive	dynamic passive
haben	[er] ist gesehen	present imperfect	indicative	static passive
haben	[er] sei gesehen	present imperfect	present subjunctive	static passive
haben	[er] sah	past imperfect	indicative	active
haben	[er] sähe	past imperfect	past subjunctive	active
haben	[er] wurde gesehen	past imperfect	indicative	dynamic passive
haben	[er] würde gesehen	past imperfect	past subjunctive	dynamic passive
haben	[er] war gesehen	past imperfect	indicative	static passive
haben	[er] wäre gesehen	past imperfect	past subjunctive	static passive
haben	[er] hat gesehen	present perfect	indicative	active
haben	[er] habe gesehen	present perfect	present subjunctive	active
haben	[er] ist gesehen worden	present perfect	indicative	dynamic passive
haben	[er] sei gesehen worden	present perfect	present subjunctive	dynamic passive
haben	[er] ist gesehen gewesen	present perfect	indicative	static passive
haben	[er] sei gesehen gewesen	present perfect	present subjunctive	static passive
haben	[er] hatte gesehen	past perfect	indicative	active
haben	[er] hätte gesehen	past perfect	past subjunctive	active
haben	[er] war gesehen worden	past perfect	indicative	dynamic passive
haben	[er] wäre gesehen worden	past perfect	past subjunctive	dynamic passive
haben	[er] war gesehen gewesen	past perfect	indicative	static passive
haben	[er] wäre gesehen gewesen	past perfect	past subjunctive	static passive
haben	[er] wird sehen	future imperfect	indicative	active
haben	[er] werde sehen	future imperfect	present subjunctive	active

Aux.	Example	Tense + Aspect	Mood (if finite)	Voice
haben	[er] würde sehen	future imperfect	past subjunctive	active
haben	[er] wird gesehen werden	future imperfect	indicative	dynamic passive
haben	[er] werde gesehen werden	future imperfect	present subjunctive	dynamic passive
haben	[er] würde gesehen werden	future imperfect	past subjunctive	dynamic passive
haben	[er] wird gesehen sein	future imperfect	indicative	static passive
haben	[er] werde gesehen sein	future imperfect	present subjunctive	static passive
haben	[er] würde gesehen sein	future imperfect	past subjunctive	static passive
haben	[er] wird gesehen haben	future perfect	indicative	active
haben	[er] werde gesehen haben	future perfect	present subjunctive	active
haben	[er] würde gesehen haben	future perfect	past subjunctive	active
haben	[er] wird gesehen worden sein	future perfect	indicative	dynamic passive
haben	[er] werde gesehen worden sein	future perfect	present subjunctive	dynamic passive
haben	[er] würde gesehen worden sein	future perfect	past subjunctive	dynamic passive
haben	[er] wird gesehen gewesen sein	future perfect	indicative	static passive
haben	[er] werde gesehen gewesen sein	future perfect	present subjunctive	static passive
haben	[er] würde gesehen gewesen sein	future perfect	past subjunctive	static passive
sein	(zu) gehen	present imperfect	infinitive	active
sein	gegangen (zu) werden	present imperfect	infinitive	dynamic passive
sein	gegangen (zu) sein	present imperfect	infinitive	static passive
sein	gegangen (zu) sein	present perfect	infinitive	active
sein	gegangen worden (zu) sein	present perfect	infinitive	dynamic passive
sein	gegangen gewesen (zu) sein	present perfect	infinitive	static passive
sein	gehend	present imperfect	participle	active
sein	gegangen	present perfect	participle	pass
sein	geh	present imperfect	imperative	active
sein	werde gegangen	present imperfect	imperative	dynamic passive
sein	sei gegangen	present imperfect	imperative	static passive
sein	sei gegangen	present perfect	imperative	active
sein	sei gegangen worden	present perfect	imperative	dynamic passive
sein	sei gegangen gewesen	present perfect	imperative	static passive
sein	[er] geht	present imperfect	indicative	active
sein	[er] gehe	present imperfect	present subjunctive	active
sein	[er] wird gegangen	present imperfect	indicative	dynamic passive
sein	[er] werde gegangen	present imperfect	present subjunctive	dynamic passive
sein	[er] ist gegangen	present imperfect	indicative	static passive
sein	[er] sei gegangen	present imperfect	present subjunctive	static passive
sein	[er] ging	past imperfect	indicative	active
sein	[er] ginge	past imperfect	past subjunctive	active
sein	[er] wurde gegangen	past imperfect	indicative	dynamic passive
sein	[er] würde gegangen	past imperfect	past subjunctive	dynamic passive
sein	[er] war gegangen	past imperfect	indicative	static passive
sein	[er] wäre gegangen	past imperfect	past subjunctive	static passive
sein	[er] ist gegangen	present perfect	indicative	active
sein	[er] sei gegangen	present perfect	present subjunctive	active
sein	[er] ist gegangen worden	present perfect	indicative	dynamic passive
sein	[er] sei gegangen worden	present perfect	present subjunctive	dynamic passive

Aux.	Example	Tense + Aspect	Mood (if finite)	Voice
sein	[er] ist gegangen gewesen	present perfect	indicative	static passive
sein	[er] sei gegangen gewesen	present perfect	present subjunctive	static passive
sein	[er] war gegangen	past perfect	indicative	active
sein	[er] wäre gegangen	past perfect	past subjunctive	active
sein	[er] war gegangen worden	past perfect	indicative	dynamic passive
sein	[er] wäre gegangen worden	past perfect	past subjunctive	dynamic passive
sein	[er] war gegangen gewesen	past perfect	indicative	static passive
sein	[er] wäre gegangen gewesen	past perfect	past subjunctive	static passive
sein	[er] wird gehen	future imperfect	indicative	active
sein	[er] werde gehen	future imperfect	present subjunctive	active
sein	[er] würde gehen	future imperfect	past subjunctive	active
sein	[er] wird gegangen werden	future imperfect	indicative	dynamic passive
sein	[er] werde gegangen werden	future imperfect	present subjunctive	dynamic passive
sein	[er] würde gegangen werden	future imperfect	past subjunctive	dynamic passive
sein	[er] wird gegangen sein	future imperfect	indicative	static passive
sein	[er] werde gegangen sein	future imperfect	present subjunctive	static passive
sein	[er] würde gegangen sein	future imperfect	past subjunctive	static passive
sein	[er] wird gegangen sein	future perfect	indicative	active
sein	[er] werde gegangen sein	future perfect	present subjunctive	active
sein	[er] würde gegangen sein	future perfect	past subjunctive	active
sein	[er] wird gegangen worden sein	future perfect	indicative	dynamic passive
sein	[er] werde gegangen worden sein	future perfect	present subjunctive	dynamic passive
sein	[er] würde gegangen worden sein	future perfect	past subjunctive	dynamic passive
sein	[er] wird gegangen gewesen sein	future perfect	indicative	static passive
sein	[er] werde gegangen gewesen sein	future perfect	present subjunctive	static passive
sein	[er] würde gegangen gewesen sein	future perfect	past subjunctive	static passive

Table 5: Composite verb forms in German. The first column shows the auxiliary verb used for the perfect aspect. An example for a verb using *haben* ‘have’ is *sehen* ‘see’; an example for a verb using *sein* ‘be’ is *gehen* ‘go’.