Chapter 13
The Construction of a Chinese Semantic Dependency Graph Bank

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Abstract Semantic dependency parsing is a deep semantic analysis task based on large-scale and canonically annotated corpora. This chapter will present a new Chinese semantic dependency scheme using solid linguistic knowledge of Chinese. Chinese is a meaning-combined language with flexible syntactic structures and complex modifying relations among words. Thus, we used dependency graphs instead of dependency trees as target representations to allow nodes to have more than one incoming arc and crosses among dependency arcs. We annotated the dependency structures of 30,161 sentences, with 570,403 words, using this scheme. This chapter will describe the semantic dependency scheme in detail, including its specifications and the process involved in creating the corpus. Using Fleiss' kappa, the inner-annotated agreement evaluation results were 0.835 for non-labeled arcs and 0.686 for labeled arcs as assignments. This chapter will also provide the statistics of the annotated corpus.

Keywords Semantic analysis · Dependency tree · Dependency graph · Semantic corpus

13.1 Introduction

Sentence analysis based on dependency grammar has recently become a hot issue in natural language processing. This task has been extensively studied and has proven to be useful in several applications, including question answering (Cui et al. 2005; Punyakanok et al. 2004), semantic structure extraction (Johansson and Nugues 2007), and semantic role labeling (Hacioglu 2004; Pradhan et al. 2005).

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Much work has focused on constructing dependency parsers. So far, all the dependency parsing technologies have been data driven, and large-scale corpora have been annotated to construct automatic dependency parsers. The Prague Dependency Treebank (Böhmová et al. 2003), the first dependency structure annotation work, has been influential. Dependency treebanks have been built for at least 30 languages, on a large or small scale, by hand or via algorithms to automatically convert available phrase structure treebanks to dependency structure notations (Marimon and Bel 2014), such as Chatterji et al. (2014), Haverinen et al. (2014), and Marneffe and Manning (2008). Liu et al. (2006) created a Chinese syntactic dependency treebank (CDT) consisting of 60,000 sentences from the *People's Daily* in the 1990s. Several studies have been conducted on Chinese dependency parsing using this corpus, such as Niu et al. (2009) and Li et al. (2012). Most studies on dependency analysis have been syntax-oriented. Semantic dependencies were seldom studied until the share tasks in the SemEval-2012 (Che et al. 2012) and SemEval-2014 (Oepen et al. 2014), where semantic dependencies annotated in Chinese and English were provided for participants to build dependency parsing systems.

Distinct from English, Chinese is an ideographic language belonging to the Sino-Tibetan family (Lu 2001) that organizes sentences based on logical connections among lexical meanings and the semantics of sub-sentences, so no formal meanings or fixed syntactic structures are available. Because rich latent information is hidden in facial words, the semantic analysis of Chinese is specialized. Conversely, English is a hypotaxis language that organizes sentences by linguistically formal meanings, wherein grammar prioritizes syntax and even disengages from semantics.

Semantic dependency parsing aims to determine all the word pairs with exact semantic relations and connect each word pair to a dependency arc with a relation label, indicating their semantic relations. Semantic dependency has similarities with and differences from syntactic dependency. Both are based on dependency grammar (Robinson 1970) and annotate each word in a sentence. Syntactic dependency gives a transparent encoding of the predicate-argument structure, while semantic dependency explicitly displays semantics hidden behind predicate-argument structures.

The number of semantic dependency labels is more than five times higher than syntactic dependency labels[1], which allows them to express different information of sentences. Syntactic dependency analyzes syntactic functions from the perspective of grammar systems (e.g., subjective, predicate, and objective), and for this task, dependency tree structures are sufficient. By contrast, semantic dependency involves semantic relations (e.g., agent, patient, and experiencer) between each pair of words. According to the above analysis of the Chinese language, semantic relations between word pairs do not always generate tree structures, and graphs describe semantics

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[1]CDT and Malt syntactic dependency have 13 and 12 labels, respectively. The Malt dependency corpus was acquired via automatic conversion from Penn Chinese Treebank phrase structure trees using Penn2Malt. Semantic dependency labels exceed 50, including those produced by Li et al. (2003) and Chen et al. (1999). Hundreds of labels are available in our BLCU-HIT Semantic Dependency Parsing (BH-SDP) system.
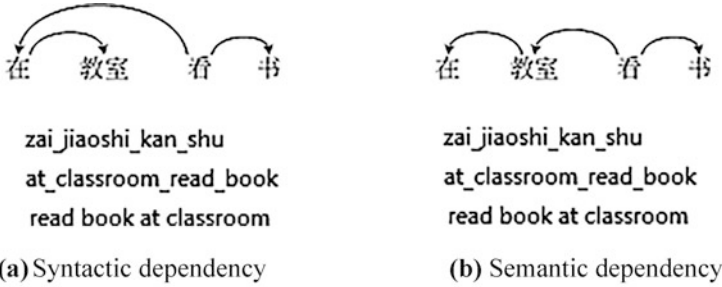
Fig. 13.1 Difference between syntactic and semantic dependency for prepositions. (**a**) Syntactic dependency. (**b**) Semantic dependency

better than trees. These findings coincide with the meaning-text theory (MTT), a theoretical framework for the description of natural languages (Žolkovskij and Mel'čuk 1967). MTT considered that trees are not sufficient to express the complete meaning of sentences in some cases, which has been proven undoubted in our practice of corpus annotation.

Comparing word pairs connected by dependency arcs, semantic dependency seeks to depict the relations among content words, whereas syntactic dependency mostly relies on functional words (e.g., coordinating conjunctions and prepositions). Figure 13.1 presents an example of this difference. In the prepositional phrase 在教室 *zai jiaoshi* "at the classroom," the preposition 在 *zai* "at" is the head word in (a), whereas the headword in (b) is the content word 教室 *jiaoshi* "classroom."

The rest of this chapter is organized as follows. Section 13.2 will describe the details of our dependency scheme, while Sect. 13.3 will introduce the origin of our corpus and the design of our annotation tool. Then, an evaluation of the inner-annotator agreement of our annotated corpus will be given, concretely describing the assessment method, in Sect. 13.4. Section 13.5 will present some statistics of our annotated corpus, followed by the conclusion in Sect. 13.6.

13.2   Annotation Scheme of the Semantic Dependency Graph

Dependency tree structures are traditionally prerequisites for syntactic dependency analysis. However, dependency trees are not suited for meaning representation because of some distortion in or omission of the dependency arcs needed to preserve a legal dependency structure. According to large-scale real corpus and parataxis characteristics, a word may be the argument of more than one predicate, resulting in multiple incoming arcs. Therefore, we extended dependency tree structures to graphs.

13.2.1 Graph Structure of Semantic Dependency

Semantic dependency graphs (SDGs) are directed acyclic graphs. Nodes refer to words, while edges refer to semantic relations between labeled words. There is only one node without a head, which is the root of the entire graph. Graphs overcome the limitations of dependency trees by allowing more than one head on certain nodes and crosses of arcs. Figure 13.2 shows that the node 杯子 *beizi* "cup" has semantic relations with both 打 *da* "break" and 破 *po* "damaged," which means that 杯子 *beizi* "cup" has two heads, and the arcs connecting 杯子 *beizi* "cup" and 破 *po* "damaged" as well as 他 *ta* "he" and 打 *da* "break" cross.

The dependency structure in traditional dependency grammar must be single-headed, connective, acyclic, and projective. Since dependency graphs do not include single-headed and projective relations, only connective and acyclic relations, they are considered extensions of dependency grammar.

13.2.2 Semantic Relation Set

Lu (2001) explained the parataxis network of Chinese grammar. We applied this semantic unit classification and semantic combination, as well as integrated the semantic characteristics, to construct a clear semantic relation scheme. At the same time, we also considered some of the semantic relation tags in HowNet (Dong and Dong 2006).

Semantic units are divided from high to low into event chains, events, arguments, concepts, and marks. Arguments refer to noun phrases related to certain predicates. Concepts are simple elements in basic human thought or content words in syntax. Marks represent the meaning attached to the entity information conveyed by speakers (e.g., speakers' tones or moods). These semantic units correspond to compound sentences, simple sentences, chunks, content words, and function words. The meanings of sentences are expressed by event chains, which consist of multiple simple sentences. The meanings of simple sentences are expressed by arguments, while arguments are reflected by predicate, referential, or defining concepts. Marks are attached to concepts.

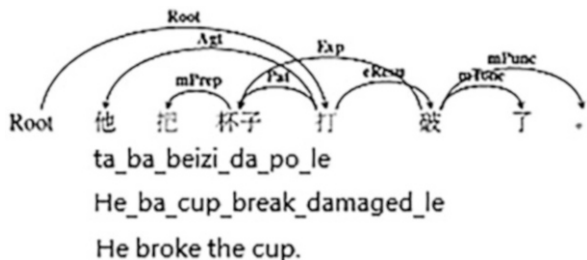**Fig. 13.2** Sample sentence annotated with the SDG scheme

Table 13.1 Label set of semantic relations

Semantic roles	
Subject roles	Agt (agent), Exp (experiencer), Aft (affection), Poss (possessor)
Object roles	Pat (patient), Cont (content), Prod (product), Orig (origin), Datv (dative), Comp (comparison)
Copula roles	Belg (belongings), Clas (classification), Accd (according)
Cause roles	Reas (reason), Int (intention), Cons (consequence)
Condition roles	Mann (manner), tool, Matl (material)
Space-time roles	Time, Loc (location), Dir (direction), Proc (process), Sco (scope)
Measurement roles	Quan (quantity), Qp (quantity phrase), Freq (frequency), Seq (sequence)
Special attribute roles	Desc (description), host, Nmod (name modifier), Tmod (time modifier)
Reverse relations	r + semantic roles, e.g., r-Agt, r-pat, etc.
Nested relations	d + semantic roles, e.g., d-Agt, d-pat, etc.
Event relations	
Symmetric relations	eCoo (coordination), eSelt (selection), eEqu (equivalent)
Consecutive relations	ePrec (precedent), eSucc (successor), eProg (progression), eCau (cause), eAdvt (adversative), eResueResu (Resutl), eInf (inference), eCond (condition), eSupp (supposition), eConc (concession), eSum (summary), eRect (recount)
Semantic marks	
Relation marks	mConj (conjection), mAux (auxiliary), mPrep (preposition)
Attachment marks	mTone, mTime, mRang (range), mDegr (degree), mMod (modal), mFreq (frequency), mDir (directon), mPars (parenthesis), mNeg (negation)
Auxiliary marks	mMaj (majority), mSepa (separation), mRept (repetition), mVain, mPunc (punctuation)

The meaning of a sentence consists of the meanings of the semantic units and their combinations, including semantic relations and attachments. Semantic attachments refer to marks on semantic units which are listed in Table 13.1 as "semantic marks" such as prepositions, mood words, punctuations, and so on. Semantic relations are classified into symmetric and asymmetric types. Symmetric relations include coordination, selection, and equivalence relations, while asymmetric relations include the following:

1. Cooperative relations occur between core and non-core roles. For example, in 工人修理管道 *gongren_xiuli_guandao* "workers repair the pipeline," 管道 *guandao* "pipeline" serves as a non-core role and is the patient of 修理 *xiuli* "repair," which is a verb that serves as a core role. Relations between predicates and nouns belong to cooperative relations. Semantic roles usually refer to cooperative relations. Table 13.1 presents the 32 semantic roles we defined, divided into 8 small categories.

2. Additional relations refer to the modifying relations among concepts within an argument, in which all semantic roles are available; for example, in 地下的管道 *dixia_de_guandao* "underground pipeline," 地下 *dixia* "underground" is the modifier of 管道 *guandao* "pipeline," which refers to a location relation.
3. Connectional relations are bridging relations between two events that are neither symmetric nor nested relations. For example, for the sentence "如果天气好, 我会去颐和园 *ruguo_tianqi_hao, wo_hui_qu_yiheyuan* 'If the weather is good, I will go to the Summer Palace'," the former event is the hypothesis of the latter. Fifteen event relations were defined by our scheme.

We analyzed how the elements of each sentence constitute the entire meaning of the sentence and used the results as the theoretical basis in designing the SDG corpus. Table 13.1 shows the entire semantic relations set, which includes five types of semantic relations, i.e., semantic roles, reverse relations, nested relations, event relations, and semantic marks.

13.2.3   Special Situations

1. Reverse relations. When a verb modifies a noun, a reverse relation is applied with the label r-XX (XX refers to a single-level semantic relation). A reverse relation is generated when a word pair with the same semantic relation appears in different sentences with different modifying orders. A reverse relation distinguishes different modifying orders (i.e., they have arcs with reverse directions in the two situations). For example, the semantic relation between the head word 男孩 *nanhai* "boy" and the kernel word 打 *da* "play" in Fig. 13.3 is the r-agent, and the label agent is labeled the kernel word 打 *da* "play" and its modifier 男孩 *nanhai* "boy." The expression of the semantic tri-tuple of this pair of words in Fig. 13.3a is 男孩 *nanhai* "boy," 打 *da* "play," r-agent, and in Fig. 13.3b, it is 打 *da* "play," 男孩 *nanhai* "boy," agent. Here, the first word in the tri-tuple is the head word, and the second one is a modified or dependency word, while the last one has asemantic role.
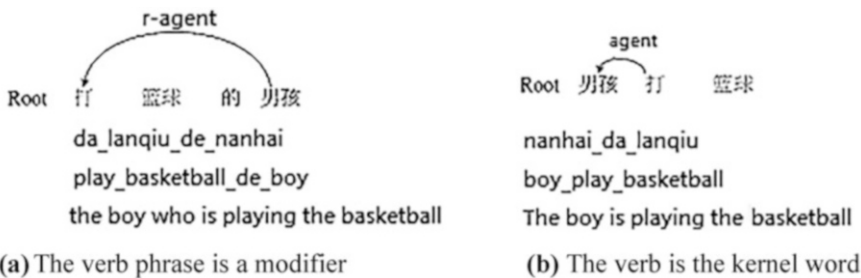

Fig. 13.3 Sample of reverse relations. (**a**) The verb phrase is a modifier. (**b**) The verb is the kernel word
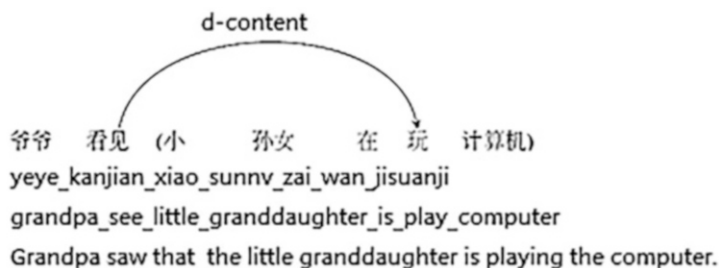
Fig. 13.4 Sample nested relation; the event within the round bracket serves as a nested constituent

2. Nested events. Two events have a nested relation (i.e., one event is regarded as a grammatical item of the other), which belongs to two semantic hierarchies. For example, in the sentence in Fig. 13.4, the event 小孙女在玩计算机 *xiao_sunnv_zai_wan_jisuanji* "little granddaughter is playing the computer" is regarded as the content of the action 看见 *kanjian* "see." A prefix "d" is added to single-level semantic relations as a "distinctive" label. The tri-tuple of this sentence is labeled 看见 *kanjian* "see," 玩 *wan* "play," d-content.

3. Quantitative phrases. There are no English quantifiers such as 个 *ge*, 本 *ben*, 只 *zhi*, etc. in Chinese. Here, a "quantitative word" refers to the combination of one numeral and one quantifier, such as 十个 *shi_ge* "ten," and a "quantitative phrase" represents the combination of a quantitative word and a noun, such as 十个人 *shi_ge_ren* "ten persons." In our scheme, considering that sometimes numerals can be omitted, such as 这本书 *zhe_ben_shu* "this book," the quantifier of the quantitative word was labeled the head word, and the numeral was the dependency word, while the semantic relation between them was labeled "Quan" (quantity), a measurement role. When a quantitative word modified a noun, the noun was labeled the head word of the whole quantitative phrase, and the quantifier was the dependency word. The semantic relation between the noun and the quantitative word was labeled "Qp" (quantity phrase). For example, for the quantitative phrase 五本书 *wubenshu* "five books," the semantic tri-tuples were 本 *ben* "ben," 五 *wu* "five," Quan and 书 *shu* "book," 本 *ben* "ben," Qp.

4. Serial verb sentences. When several verbs occur in one sentence and there is neither a pause punctuation nor a conjunction sub-sentence, these kinds of sentences are called serial verb sentences or compressed sentences, which in fact includes more than two events in one sentence. Mostly, the front verb of the serial verb sentence is selected as the head word, and in rare cases such as manner serial verb sentences, the head word is the rear verb. According to the relations between different verbs, the semantic relations of serial verb sentences are classified as succession, purpose, manner, result, and soon. For instance, the head word of the Chinese sentence "他穿衣服走了。 *ta_chuan_yifu_zou_le* 'He wore his cloth and left'." is the front verb 穿 *chuan* "wear," and the relation between the two events is labeled "eSucc" (successor event). The tri-tuple of the two verbs in this sentence is 穿 *chuan* "wear," 走 *zou* "leave," eSucc. In fact, the

subject word 他 *ta* "he" has two parent nodes—one is the verb 穿 *chuan* "wear" and the other is the verb 走 *zou* "leave."

5. "De" structures with the omission of the head word. The Chinese word 的 *de* "De" is always used as an auxiliary word, and it is often taken as a dependency mark. However, sometimes the head word of the De structure is omitted. In this head word deletion situation, 的 *de* "De" was labeled the head word in our scheme. For example, in the Chinese sentence "卖菜的走了。 *mai_cai_de_zou_le* 'The man who sold vegetables left'.", the head word 人 *ren* "person" of the De structure was omitted. Different from the Abstract Meaning Representation (AMR) semantic labeling system (Li et al. 2016), our scheme did not add the omitted component to the sentence, so the auxiliary word 的 *de* "De" was considered the head word of the De structure, and the tri-tuples were expressed as 走 *zou* "leave," 的 *de* "De," agent and 的 *de* "De," 卖 *mai* "sell," r-agent. Because 的 *de* "De" is often labeled as an auxiliary mark, if it is not annotated as a mark, it will mean that the situation of omission has occurred.

6. Predicate-complement structures. The semantic relations between verbs in verb serial sentences can also be applied to the predicate-complement structure. For example, for the Chinese sentence "他走累了。 ta_zou_lei_le 'He got tired of walking'.", the semantic relation between the predicate 走 zou "walk" and the complement 累 lei "tired" was labeled "eResu" (result event), which means that the complement was the "result" of the verb.

7. Separable words. In Chinese, some words can be separated into two parts, which are called "separable words." For example, the word 洗澡 *xizao* "take a bath" can be split into 洗个澡 *xi_ge_zao* "take a bath" by inserting the Chinese quantifier word 个 *ge* "Ge" into the word 洗澡 *xizao* "take a bath." In this case, the semantic relation between the two Chinese characters 洗 *xi* "take" and 澡 zao "bath" can be labeled "mSepa" (separation mark).

13.3 Corpus

13.3.1 Corpus Origin

Our corpus contained more than 30,000 sentences. The sentences were chosen from newspapers, spoken sentences, and Sina Weibo microblogs. We selected 10,068 newspaper sentences and labeled the word segmentation and part-of-speech (POS) information using Chinese PropBank 6.01 (Xue and Palmer 2003). Of the remaining sentences, 10,038 spoken and 10,055 Sina Weibo sentences had no annotated tags. Thus, we annotated the morphological information first before annotating semantic dependency. Chinese Treebank (CTB)-style POS tags were derived from the Penn English Treebank, which belongs to the Indo-European word class system that includes 33 POS tags.

Table 13.2 Raw corpus details

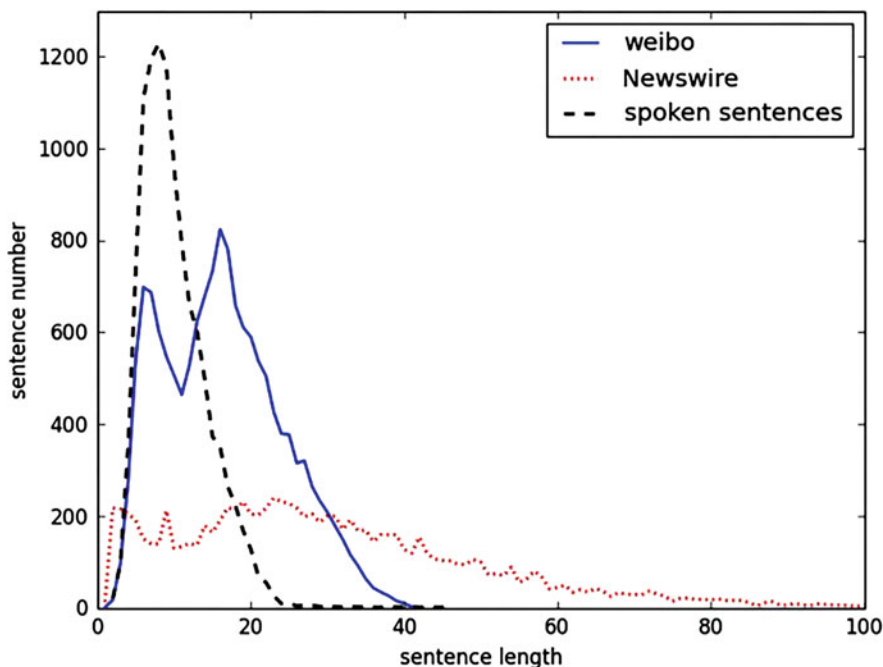|	Sentence number	Word number	Average length
News sentences	10,068	308,383	30.63
Spoken sentences	10,038	101,140	13.44
Microblog sentences	10,055	160,880	16.00

Fig. 13.5 Number of sentences relative to sentence length

Table 13.2 presents additional details on our annotated corpus, while Fig. 13.5 shows the curve of the number of sentences relative to sentence lengths. Spoken sentences refer to sentences with rich expressions (e.g., dialogues, dialogue sentences, Chinese-English bilingual sentences, and primary school texts). The sentences in the primary school texts were not all colloquial, as some of them exploited luxuriant expressions. Differences and the diversification of resources resulted in rich linguistic phenomena. Fan (1998) and Huang and Liao (2003) reduced sentence patterns into single and compound sentences from a linguistic perspective. In our annotated corpus, single sentences were categorized into 8 patterns, while compound sentences were categorized into 12 patterns, and each sentence pattern had corresponding sentences.

13.3.2 Annotation Tool

We developed an online annotation tool to enable annotators to conveniently search, annotate, and revise. Figure 13.6 shows the annotation interface of the tool. On the annotation page, two buttons are used to switch to the word segmentation and POS tagging sub-pages. On the history page, sentences are displayed with dependency labels and relations. Annotators can click on a sentence, which will take them to a page to revise the annotation. On the search page, different keywords and their combinations can be used to search for sentences and corresponding annotation results. When annotators are confused about certain words or relations, they can search and learn from other labeling results. This online tool provides helpful functions for those involved in the annotation process.

13.4 Evaluation of the Corpus

The quality of an annotated corpus is crucial for automatic dependency parsing. We measured the consistency degree of the inner-annotators' agreement to evaluate the quality of our annotated corpus, wherein the same linguistic phenomena were labeled with the same dependency structures and relation labels. We employed three linguistics master's students to annotate the same smaller corpus blindly. The smaller corpus included 422 randomly selected sentences from the 30,000 sentences collected. We evaluated the agreements on the dependency arcs level and both the arc and relation levels, respectively. The average agreements among the three pairs of annotators were 88.78% for arcs only and 72.15% for both arcs and relations. The latter result was lower than the former because only when both the
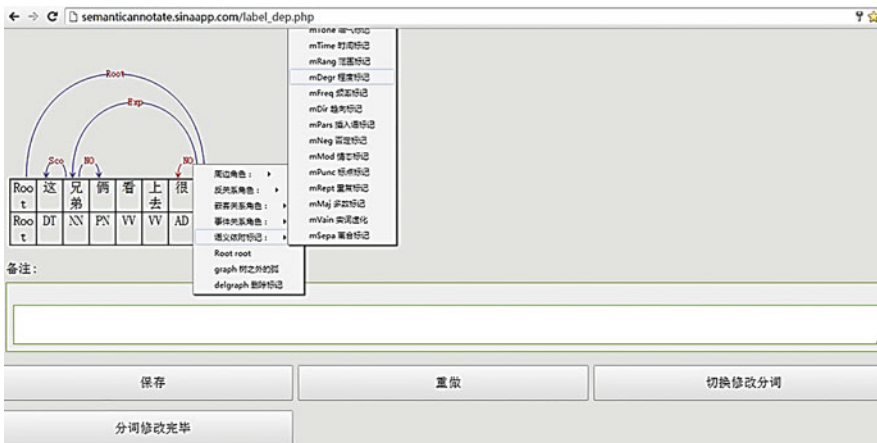

Fig. 13.6 Interface of the online annotation tool

Table 13.3 Agreement results of three separate annotator pairs

	A1 and A2 (%)	A1 and A3 (%)	A2 and A3 (%)	Average (%)
Arcs only	87.48	91.14	87.71	88.78
Both arcs and relations	69.45	74.78	72.21	72.15

dependency arcs and corresponding relations were consistent could an agreement item be obtained. Hundreds of relations were defined, so this low result was conceivable. Table 13.3 shows the agreement results.

In addition, we evaluated the agreement using Fleiss' kappa discussed in Fleiss (1971). The degree of agreement between all annotators was computed in terms of Fleiss' kappa (κ), as shown in Eq. (13.1):

$$\kappa = \frac{\overline{P} - \overline{P}_e}{1 - \overline{P}_e} \tag{13.1}$$

The proportion of all assignments used for assigning the *jth* assignment was defined using Eq. (13.2), where N is the total number of words, n is the number of annotators for our resource building work, K is the total number of assignment types conducted by the annotators, and $N \times n$ is the total number of assignments made by all the annotators, while the mean proportion of assignments for all assignments was defined using Eq. (13.3):

$$P_j = \frac{1}{N \times n} \sum_{i=1}^{N} n_{ij} \tag{13.2}$$

$$\overline{P}_e = \sum_{j=1}^{K} P_j^2 \tag{13.3}$$

The extent of the annotator pairs' agreement for the *ith* word was defined using Eq. (13.4), where subscript i (1, ..., N) represents the words and subscript j (1, ..., K) represents the assignments; thus, *nij* is the number of annotators who assigned the *ith* word to the *jth* assignment, and $n(n - 1)/2$ represents the pairs of annotators, while the mean of agreements for all words was defined using Eq. (13.5):

$$P_i = \frac{1}{n(n-1)} \sum_{j=1}^{K} n_{ij}(n_{ij} - 1) \tag{13.4}$$

$$\overline{P} = \frac{1}{N} \sum_{i=1}^{N} P_i \tag{13.5}$$

In this case, n is equal to 3 (i.e., the three annotators that participated in this experiment). The total number of sentences annotated was 422, which included 6634

words. We calculated two Fleiss' kappa scores, one using arcs as assignments and the other using both arc and relation labels. For the two criteria, we had 48 and 1638 assignments, respectively. We achieved kappa scores of 0.835 and 0.686, respectively, for the two criteria. If all three annotators agreed on all the assignments, then the kappa score would be 1. Generally, when the kappa score is above 0.7, agreement is good, and when the kappa score is below 0.7 but above 0.4, agreement is reasonable. The kappa scores indicated that the three annotators mostly agreed when annotating the semantic dependency graph corpus.

13.5   Corpus Statistics

We performed statistics on our annotated corpus. Table 13.4 illustrates the highest and lowest frequent labels in the annotated corpus. The bottom five labels with the least occurrence were reverse or nested relations, which are uncommon kinds of linguistic phenomena. By contrast, the labels with the most frequent appearances are shown in the third and fourth columns. The mPunc (punctuation) label was excluded. Each sentence had at least one punctuation mark, and the total occurrence of mPunc exceeded 30,161. Both Exp (experiencer) and Agt (agent) appeared in the top 5 label list because they belong to the subject-predicate structure, which frequently appears in languages, at the syntactic level. Two relation marks—mAux (auxiliary mark) and mMod (modal mark)—had the highest frequencies. Desc (description) appeared the most frequently as it was used between most adjectives and nouns.

Figure 13.7 shows the relation numbers and frequencies by relation groups. The frequencies of each group were added. We recorded 27 nested relations and 28 reverse relations in our annotated corpus. Reverse relations appeared the least among all groups, followed by nested relations. These two kinds of linguistic phenomena are not common in the Chinese language. The occurrence of event relations was directly related to the number of sub-sentences.

Table 13.5 shows the arc proportions that caused crossed arcs and nodes with multiple heads. Statistical analysis was performed on the entire annotated corpus, including 30,161 sentences. The proportion of sentences with cross arcs was 24.31%, while sentences with multiple heads accounted for 30.59%. Figure 13.8a shows an example of the sentence with crossed arcs, and Fig. 13.8b is an example of

Table 13.4 Sample of semantic relations with the least and most occurrences

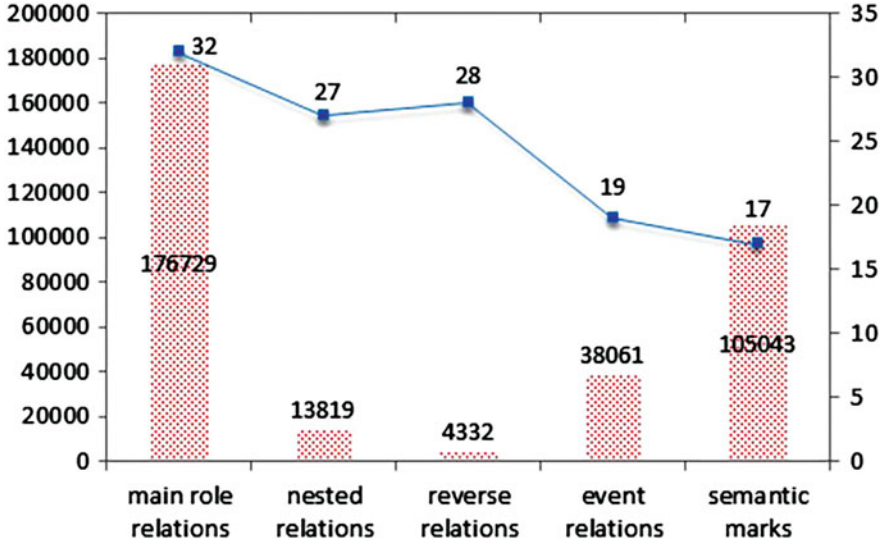| No. of occurrence	Bottom labels	No. of occurrence	Top labels
1	dQuan, dAft	22,585	Desc
1	rComp, rMalt, rSco, rSeq	22,273	mAux
3	dFreq, rQp	20,529	Exp
4	rAccd	18,151	Agt
6	rInt	15,189	mMod

Fig. 13.7 The number and occurrence of labels in each relation category

Table 13.5 Proportion of crossed arcs and sentences, including nodes with multiple heads

	Number	Proportion
Sentences with crossed arcs	7332	24.31%
Sentences with multiple heads	9226	30.59%
Total sentences	30,161	–

ta_yanjing_ku_zhong_le

she_eye_cry_swollen_le

Her eyes were swollen with tears.

(a) Example of sentences with crossed arc

wo_you_ge_meimei_hen_nenggan

I_have_a_sister_very_competent

I hace a sister who is very competent

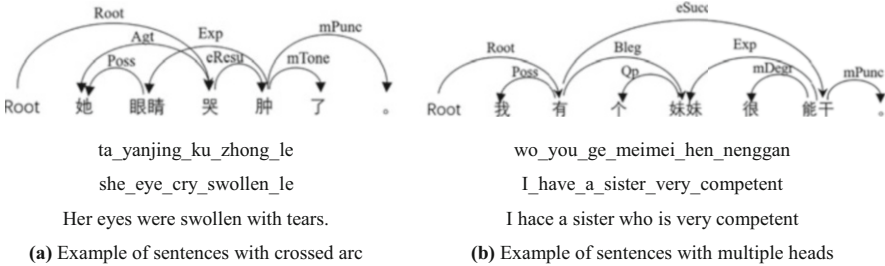**(b)** Example of sentences with multiple heads

Fig. 13.8 Examples of crossed arcs and nodes with multiple heads. (**a**) Example of sentences with crossed arcs. (**b**) Example of sentences with multiple heads

sentence with multiple heads. Example (a) shows the Agt arc from 哭 *ku* "cry," 她 *ta* "she," and the Exp arc from 肿 *Zhong* "swollen," to 眼睛 *yanjing* "eye" cross, while (b) shows the node 妹妹 *meimei* "sister," which has two parent nodes—有 *you* "have" and 能干 *nenggan* "competent." As can be seen, the structure of quite a few sentences in Chinese highlights the limitations of dependency trees, so using semantic dependency graphs to describe semantic structures is quite necessary.

13.6　Conclusion

The current chapter proposed a scheme for Chinese semantic dependency, and each label in this scheme reflected concrete semantic information. The SDG is a human-understandable semantic representation both visually and logically. The semantic relations were designed from the perspective of linguistics to adapt to the characteristics of the Chinese language. Very little abstraction of semantic information exists, which distinguishes this proposed scheme from existing dependency schemes. Inducing semantics directly, we employed more relation labels than syntactic dependencies. To clarify the boundaries of relation labels, we classified them into several hierarchies that represented different types of information, namely, main semantic roles, event relations, and semantic marks.

We annotated more than 30,000 sentences based on this scheme. The sentences were chosen from spoken sentences, newswires, and Sina Weibo microblogs, covering both the common core of the language and more specialized domains. In the process of constructing this corpus, we obtained the utmost out of other gold standard information labeled in the sentences to generate pre-annotation results by rules or by machine learning tools. Triple-blinded annotation experiments were conducted to measure the inner-annotators' agreement by calculating the widely used Fleiss' kappa. We achieved kappa scores of 0.835 and 0.686 for non-labeled arcs and labeled arcs as assignments, respectively. These results indicate that the three annotators had a great majority of agreements while annotating the corpus, although the semantic dependency scheme was slightly complicated.

According to the statistics and analysis of the annotated corpus, we arrived at the conclusion that although most sentences constitute projective dependency trees in Chinese, non-projective trees and dependency graphs do exist but in a smaller proportion. Thus, using semantic dependency graphs to describe semantic information is quite necessary and reasonable.

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