Parsing Simplified Chinese and Traditional Chinese with Sentence Structure Grammar

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Abstract

We present a challenge to parse simplified Chinese and traditional Chinese with a same rule-based Chinese grammatical resource—Chinese Sentence Structure Grammar: CSSG, which was developed based on a new grammar formalism idea: Sentence Structure Grammar: SSG. We participate in the simplified Chinese parsing task and the traditional Chinese parsing task of CLP 2012 with a same rule-based chart parser implemented the CSSG. The experiments show that the CSSG that was developed for covering simplified Chinese constructions can also analyze most traditional Chinese constructions.

1 Introduction

Chinese divides into simplified Chinese that is used in the mainland of China and Singapore, and traditional Chinese that is used in Taiwan and Hang Kong. Some treebank resources like Penn Chinese Treebank: CTB, Peking University Treebank: PKU, and Tsinghua Chinese Treebank: TCT had been built for training simplified Chinese parser (Yu, et al. 2010) while Sinica Treebank was developed for parsing traditional Chinese (Chen et al., 1999). Limit to our knowledge, there are still not grammatical resources that analyze both simplified Chinese and traditional Chinese.

Recently, a rule-based Chinese grammatical resource --- Chinese Sentence Structure Gram-
the performance of the latter is lower than the former. We noticed that a few traditional Chinese constructions are different from simplified Chinese.

This paper is organized as bellow: in section 2, we introduce what is CSSG; in section 3, we compare CSSG with TCT and Sinica Treebank; in section 4, we analyze the experimental results of the two tasks; in the last section, we conclude our work.

2 Chinese Sentence Structure Grammar

Chinese Sentence Structure Grammar: CSSG is a rule-based Chinese grammatical resource that was developed based on the idea of Sentence Structure Grammar: SSG.

SSG is a new idea to formalize grammatical rules. Sentence Structure Grammar has 3 main ideas (Wang et al., 2011; Wang et al., 2012):

1) Treat the construction of a sentence as a whole, which consists of a predicate (or more) and its semantic-related constituents.
2) Classify predicate verbs according to their semantic properties.
3) Indicate the semantic relations between predicate and its semantic-related constituents directly on parsing tree.

| Predicate | Ex. | Semantic roles |
|-----------|-----|----------------|
| Vad       | fly | Agent, Direction |
| Vaod      | 扔/throw | Agent, Object, Direction |
| Vaol      | 放/put | Agent, Object, Location |

Table 1: examples of the predicate classification of CSSG

SSG is a kind of context-free grammar, but it differs from Phrase Structure Grammar: PSG: 1) the latter describes a sentence with some context-free phrase rules, but the former treats a sentence as a whole sentential construction, which consists of a predicate (or more) and its semantically-related constituents; 2) the former classify predicate verbs according to their semantic properties. For instance, as shown in figure 1, “停/park” and “飞/fly” have different semantic properties. “停/park” is a kind of verb that needs an agent, an object and a direction. In contrast, “飞/fly” is a kind of verb that needs an agent and a direction. As shown in table 1, predicate verbs can be classified according to their semantic properties; 3) the latter does only syntactic analysis while the former does syntactic analysis and semantic analysis simultaneously. The semantic role set of SSG should be designed based on the idea of the deep cases in Case Grammar, which a linguistic theory proposed by Fillmore (1968).

![Figure 1: the semantic properties of verbs like “停/park” and “飞/fly”](image)

For instance, a) is a passive construction. b) is the PSG rule set while c) is the SSG rule set to analyze a). Figure 2 and figure 3 show the SSG parsing tree and the PSG parsing tree of a). As shown in figure 2, the SSG parsing tree provide not only syntactic information like “np” and “sp” but semantic roles, like “Agent”, “Object” and “Location”, which indicate the semantic relations between the predicate and its semantic-related constituents. Syntactic parsing and semantic parsing can be done simultaneously with the formal grammatical framework SSG.

a. 车/car 被/by 约翰/John 停/park 在/at 停车场/car-park
   The car is parked at the car-park by John
   Rule1: s → np vp
   Rule2: vp → pp vp
   Rule3: vp → v pp
   Rule4: pp → p np
   Rule5: np → n
   Rule6: sp → sq

b. Rule1: s → np vp
   Rule2: Object → np
   Rule3: Agent → np
   Rule4: Location → sp
   Rule5: np → n
   Rule6: sp → sq

c. Rule1: s → Object bei Agent Vaol at Location
   Rule2: Object → np
   Rule3: Agent → np
   Rule4: Location → sp
   Rule5: np → n
   Rule6: sp → sq

![Figure 2: the SSG parsing tree of (a)](image)
In CSSG, predicates are classified into 52 types according to their semantic properties. Table 1 shows some examples of the predicate classification. For instance, the type of verbs like “买/buy” or “拿/take” have same semantic properties. They correspond to the same predicate-argument structure that is shown as figure 4. In CSSG, such semantic relations between a predicate and its arguments are showed on parsing rules directly. For instance, figure 5 shows the CSSG parsing tree of d): “买/buy” is the predicate, “他/he” is the agent case, “书店/bookshop” is the source case, “书/book” is the object case and “家/home” is the goal case. “把/ba” and “回/back” are treated as case-markers.

d. 他/he 从/from 书店/bookshop 把/ba 书/book 买/buy 回/back 家/home

He buys a book at the bookshop and takes it back home.

The CSSG rules cover most constructions of simplified Chinese. Besides most constructions are listed in well-discussed simplified Chinese grammatical literatures (Zhu, 1982; Fan, 1998; Liu et al., 1996; Xue and Xia, 2000), the CSSG rules also cover many phenomena that were not discussed in above literatures but very typical and used frequently. For instance, e) is a ba-construction, f) is a bei-construction, g) is a topic construction, h) is not only a topic construction but a ba-construction and i) is not only a ba-construction but also a bei-construction. We observed many phenomena and found that there is a common feature in these different constructions, it is that one noun phrase “苹果 皮/skin of apples” is split into two parts, which have possessive relation each other but appear different syntactic positions in a sentence. Such constructions are called as “apple-skin constructions” in CSSG, and the possessive relation between the two split parts is indicated on the parsing tree.

The CSSG rules analyze e), f), g), h) and i) as shown in figure 6, 7, 8, 9 and 10. “Object_of0” and “Object_of1” show the possessive relation between “苹果/apple” and “皮/skin”. Apple-skin constructions are used frequently by Chinese native speakers. We can make many sentences with them.

e. 约翰/John 把/ba 苹果/apple 削/peal 了/le 皮/skin
John peeled the apple’s skin

f. 苹果/apple 被/by 约翰/John 削/peal 了/le 皮/skin
The skin of apples was peeled by John

g. 苹果/apple 约翰/John 削/peal 了/le 皮/skin
The apple, John peeled its skin

h. 苹果/apple 约翰/John 把/ba 皮/skin 削/peal 了/le
The apple, John peeled its skin

i. 苹果/apple 被/by 约翰/John 把/ba 皮/skin 削/peal 了/le
The skin of apples was peeled by John

The morphological dictionary of the CSSG includes two kinds of information: the morphology and its POS tag. Table 2 shows a small morphological dictionary for parsing a). The CSSG dictionary contains 45,086 simplified Chinese mor-
phology entries. Table 3 shows the details of the dictionary. The word segmentation criteria and POS tag set of the CSSG were designed originally.

Table 3: the details of the CSSG dictionary

| Word          | POS tag |
|---------------|---------|
| 买回/buy-back | n       |
| 回/after      | at      |
| 桌子/table    | n       |
| 去/park       | Vao     |
| 在/at         | at      |
| 停车场/car-park | sq  |
| 被/by         | bei     |

Table 2: a small dictionary for parsing (a)

| part-of-speech      | amount |
|---------------------|--------|
| verbs               | 6,878  |
| nouns               | 26,191 |
| adverbs             | 1,992  |
| nominal verbs       | 5,028  |
| temporal words      | 865    |
| locative words      | 151    |
| noun-modifier       | 2,439  |
| measure words       | 446    |
| pronouns            | 49     |
| modal verbs         | 23     |
| case markers        | 45     |
| locative localizer  | 15     |
| temporal localizer  | 17     |
| others              | 947    |
| total               | 45,086 |

Figure 11: the CSSG parsing trees of (j) and (k)

Comparing with the existing Chinese treebanks, the design of the POS tag set of CSSG has some distinctive features. The major differences are: 1) verbs are classified according to their semantic properties; 2) some functional words are treated as a part of verbs in the existing treebanks are treated as Case-markers; 3) the localizers are divided into locative localizers and temporal localizers.

For instance, “买回/buy-back” is treated as one word in either TCT or CTB or Sinica Treebank, but in CSSG, as shown in figure 5, “买回/buy-back” is split into two words: “买/buy” and “回/back”. “买/buy” is a predicate verb while “回/back” is a case-maker that marks a goal case.

In every existing Chinese treebank, the words like “前” and “后” are treated as localizers. However, either “前” or “后” contains two notions: a locative notion and a temporal notion. For instance, “后/behind” in j) shows a location while “后/after” in k) indicates a period of time. In CSSG, such words are divided into two kinds of POSs: locative localizers and temporal local-
izers. A locative localizer leads a locative phrase while a temporal localizer leads a temporal phrase (as shown in figure 11).

3 Comparison between TCT, Sinica Treebank and CSSG

3.1 Tsinghua Chinese Treebank and CSSG

Tsinghua Chinese Treebank: TCT (Zhou, 2004) is used as the training data for the simplified Chinese parsing task. TCT and CSSG are very different grammatical resources.

|                         | CSSG     | TCT     |
|-------------------------|----------|---------|
| Formalism               | SSG      | PSG     |
| Form                    | Grammatical rules | Treebank |
| Word segmentation criteria | Original | Original |
| POS tag set             | Original | Original |
| Phrase tag set          | Original | Original |
| Semantic role set       | Original | none    |

Table 4: the differences between CSSG and TCT

Their main differences are: 1) they were developed based on different formal grammatical framework. As shown in figure 2 and 3, the former is based on Context-free Phrase Structure Grammar; PSG while the latter is based on another kind of Context-free grammar formalism idea---Sentence Structure Grammar; SSG. Since PSG parses sentences in syntactic level but SSG analyze sentences more deeply, CSSG provides both syntactic information and semantic roles while TCT shows only syntactic information. Figure 2 is a CSSG parsing tree of a) that represents both phrase information and semantic role information. Figure 3 is a TCT parsing tree that shows only syntactic information; 2) CSSG is a rule-based grammatical resource while TCT is a Treebank. The designers and developers of the treebanks are usually different people. The designers draw up the annotation scheme first, then the developers annotate parsing trees according to the annotation scheme and their own intuition; in contrast, the designer and the developer of CSSG is the same person who designed and developed the CSSG rules introspectively to cover most simplified Chinese constructions; 3) both of them define the word segmentation criteria and POS tag set originally. For instance, as shown in figure 12 and figure 13, TCT treats “来自/come-from” as one verb while CSSG treats “来自/come-from” as two words: “来/come” is a predicate verb and “自/from” is treated as a case-marker that mark a source case for describing semantic roles precisely; 4) they design the phrase tag set originally. As shown in figure 12 and 13, verb phrases appear in TCT while there are no verb phrases in CSSG; their definitions of prepositional phrase are different; as shown in figure 11: CSSG and 14: TCT, both j) and k) are treated as locative phrases in TCT while j) is treated as a locative phrase and k) is treated as a temporal phrase in CSSG. Table 4 shows the differences between TCT and CSSG briefly.

Figure 12: the TCT parsing tree of (l)

1. 约翰/John 来/come 自/from 美国/America
   John comes from America

Figure 13: the CSSG parsing tree of (l)

|                         | CSSG     | TCT     |
|-------------------------|----------|---------|
| Formalism               | SSG      | PSG     |
| Form                    | Grammatical rules | Treebank |
| Word segmentation criteria | Original | Original |
| POS tag set             | Original | Original |
| Phrase tag set          | Original | Original |
| Semantic role set       | Original | none    |

Table 4: the differences between CSSG and TCT

3.2 Sinica Treebank and CSSG

Sinica Treebank (Chen et al., 1999) is used as the training data for the traditional Chinese parsing task. CSSG are quite different from Sinica Treebank.

m. 那个/that 人/person 把/ba 老鼠/rat 带/take 回/back-to 茅屋/cottage
   That man takes the rat back to the cottage
They differ from each other in 6 respects: 1) Sinica Treebank consists of traditional Chinese parsing trees while CSSG is developed for covering simplified Chinese constructions; 2) the former is a rule-based grammatical resource while the latter is a Treebank; 3) both Sinica Treebank and CSSG represent syntactic and semantic information simultaneously, but their formal grammatical framework are different. Sinica Treebank is based on Information-based Case Grammar: ICG, which is a kind of unification-based formalism, and describe syntactic and semantic information in lexical entries (Chen and Huang, 1990); in contrast, CSSG is based on Sentence Structure Grammar: SSG, which is a kind of context-free grammar formalism that indicate both syntactic and semantic constraints in grammatical rules directly; 4) they define the word segmentation criteria and POS tag set originally. For instance, as figure 16 and 17 shown, “那個/that” is treated as one word in Sinica Treebank, but treated as two words in CSSG. “帶回/take-back” is one word in Sinica Treebank while it is split into a verb “帶/take” and a case-marker “回/back” that marks a goal case “茅屋/cottage” in CSSG; 5) they define the phrase tag set originally. For instance, the word “後” can lead not only a locative constituent like j) but a temporal constituent such as k). In Sinica Treebank, Both j) and k) are analyzed as a locative phrase (shown in figure 15); in contrast, the locative constituent is treated as a locative phrase while the temporal constituent is treat a temporal phrase in CSSG (shown in figure 10); 6) they define semantic role set originally. Their designs of the semantic role sets are very different. Figure 16 shows the Sinica-tree while figure 17 represents the CSSG tree of m). “老鼠/rat” is treated as a goal case and “茅屋/cottage” is analyzed as a location case in Sinica Treebank while “老鼠/rat” is regarded as an object case and “茅屋/cottage” is analyzed as a goal case in CSSG. As shown in figure 18 and 19, the source case “從/from 房間/room” in CSSG is treated as a location case in Sinica Treebank. Table 5 shows the differences between these two resources briefly.

|                       | CSSG | Sinica Treebank |
|-----------------------|------|-----------------|
| Character             | Simplified | Traditional     |
| Formalism             | SSG  | ICG             |
| Form                  | Grammatical rules | Treebank |
| Word segmentation     | Original | Original       |
| criteria              |      |                 |
| POS tag set           | Original | Original       |
| Phrase tag set        | Original | Original       |
| Semantic role set     | Original | Original       |

Table 5: the differences between CSSG and Sinica Treebank

Figure 17: the CSSG parsing tree of (m)

Figure 18: the Sinica parsing tree of (n)
4 Experimental Results

4.1 Experimental Setting

There are two parsing tasks in CLP2012: the simplified Chinese parsing task (task 3) and the traditional Chinese parsing task (task 4). Task 3 includes two subtasks: CCG parsing task and PSG parsing task while Task 4 includes two subtasks: sentence parsing task and semantic role labeling task. For each sub-task, there are two tracks: the closed track and the open track. Our tasks are all in the open tracks. We participate in the open tracks of the PSG parsing sub-task of task 3 and both the two sub-tasks of task 4.

CSSG includes the grammatical rules and a simplified Chinese morphological dictionary. For participating in both simplified Chinese parsing task and traditional Chinese parsing task, we transfer the simplified Chinese characters of the dictionary of CSSG to traditional Chinese characters to obtain a traditional Chinese morphological dictionary.

For instance, the simplified Chinese sentence a) can be transferred into a traditional Chinese sentence o). As shown in figure 2 and 20, a) and o) have the same construction. We can parse o) also with CSSG if there was a traditional Chinese morphological dictionary shown in table 6. We can transfer the small dictionary shown in table 1 to traditional Chinese characters to obtain the dictionary shown in table 6.

![Figure 19: the CSSG parsing tree of (n)](image)

**Table 6: some samples of traditional CSSG dictionary**

| Word        | POS tag |
|-------------|---------|
| 車/car       | n       |
| 約翰/John    | n       |
| 停/park     | Vaol    |
| 在/at       |         |
| 停車場/car-park | sq    |
| 約翰/John   |         |
| 停/park     |         |
| 在/at       |         |
| 停車場/car-park |       |

![Figure 20: the CSSG parsing tree of (o)](image)

We parse simplified Chinese test data from task 3 with the parser implemented the grammatical rules and the simplified morphological dictionary while we parse the traditional Chinese test data from task 4 with the parser implemented the same grammatical rules and the traditional morphological dictionary. Since the scale of the dictionaries is not large enough, there are some unknown words for CSSG in both test data of task 3 and task 4. We add the unknown words to CSSG dictionaries before parsing.

![Figure 21: the input and output of (a) of the CSSG parser](image)

As figure 21 shown: 1) the CSSG parser consists of three parts: the grammatical rules, a morphological dictionary and a chart parsing engine; 2) the input is a word-segmented sentence and the output is a CSSG parsing tree; 3) since there is not yet a postager based on CSSG, we have to parse all possible POS tag lists of a sentence with the CSSG parser.
After parsing the test data, we convert the CSSG parsing trees and make them as similar as possible to TCT trees and Sinica-Treebank trees.

4.2 Evaluation Results

Table 7, 8 and 9 summarize the evaluation results of the simplified Chinese parse task 1: PSG parsing evaluation.

Table 7 shows the performance of the POS tag conversion from CSSG to TCT. Table 8 shows the results of the constituent boundary recognition. Table 9 represents the evaluation results of the parsing (both phrase boundaries and phrase labels recognition).

| type   | P    | R    | F1   |
|--------|------|------|------|
| nouns  | 74.4%| 87.9%| 80.6%|
| verbs  | 94.1%| 94.1%| 94.1%|
| others | 62.7%| 56.9%| 59.7%|
| overall| 71.3%| 71.3%| 71.3%|

Table 7: the result for POS tag recognition

| correct | gold | system | P    | R    | F1   |
|---------|------|--------|------|------|------|
| 85      | 92   | 158    | 53.8%| 92.4%| 68.0%|

Table 8: the result for phrase boundary recognition

| correct | gold | system | P    | R    | F1   |
|---------|------|--------|------|------|------|
| 85      | 92   | 158    | 42.4%| 72.8%| 53.6%|

Table 9: the result for both phrase boundary and label recognition

Table 10 and 11 summarize the evaluation results of the two subtasks of the traditional Chinese parsing task. Table 10 presents the results of the parsing sub-task while table 11 shows the results of the semantic labeling sub-task.

| Micro-averaging | Macro-averaging | P   | R   | F1   | P   | R   | F1   |
|-----------------|-----------------|-----|-----|------|-----|-----|------|
|                 |                 | 47.7%| 40.1%| 43.6%| 53.6%| 42.0%| 47.1%|

Table 10: the results of the parsing task

| Micro-averaging | Macro-averaging | P   | R   | F1   | P   | R   | F1   |
|-----------------|-----------------|-----|-----|------|-----|-----|------|
|                 |                 | 20.4%| 22.6%| 21.4%| 23.3%| 24.2%| 23.7%|

Table 11: the results for the semantic labeling task

4.3 Discussion

As we anticipated, the evaluation results are lower than the real performance of the CSSG parser.

There are three reasons should be considered: 1) because of the large differences between the design of CSSG and the two gold data: Sinica Treebank and CSSG, it is impossible to convert some CSSG trees to TCT trees or Sinica-Treebank trees. For instance, k) is treated as a temporal phrase in CSSG, so it does not correspond to any phrase in TCT or Sinica Treebank; 2) there is much inaccuracy in tree-conversion works. As shown in table 7 and 8, the system phrase counts is 158, that is much more than the gold phrase counts 92 so that the recall scores (92.4% and 72.8%) are much higher than the precision scores (68.0% and 53.6%). We checked the evaluation data and found that we converted noun phrases of CSSG like p) to TCT format like q), which might be counted as two noun phrases; 3) As shown in figure 16, 17, 18 and 19, the design of the semantic role set of CSSG are very different from Sinica Treebank, so we can only convert a small number of semantic roles correctly.

As discussed above, the evaluation results do not reflect the real performance of the CSSG parser because of the large differences between CSSG and the two gold data. We expect that more neutral evaluation metrics would be drawn up for the open parsing task.

The experiments show that the evaluation results of the traditional Chinese parsing task are lower than the simplified Chinese parsing task. One of the possible reasons is that there are some differences between the constructions of simplified Chinese and traditional Chinese. We noticed that a few traditional Chinese constructions differ from simplified Chinese. For example, in traditional Chinese sentence r), “食/food” is the direct object that appears at the left side of the indirect object “企鵝寶貝/penguin-baby”. We had ever asked some Chinese native speakers whether they think the construction like r) is grammatical. Only one speaker who comes from Hang Kong thinks r) is a grammatical sentence while other speakers who come from the mainland of China think such constructions are ungrammatical. Therefore simplified Chinese sentence s) is an ungrammatical sentence. For Simplified Chinese native speakers, a function word “给/to” should be used to lead an indirect object, like t) and u), or the indirect object appears at the left side of the direct object, such as v). The CSSG
rules cover the constructions of t), u) and v) but not cover the constructions of r) and s).

r. 工作人員/worker 每天/every-day 仍會/yet 喂/food 企鵝寶貝/penguin-baby
The worker feeds foods to penguin babies everyday

s. *工作人員/worker 每天/every-day 仍會/yet 喂/food 企鵝寶貝/penguin-baby
The worker feeds foods to penguin babies everyday

t. 工作人員/worker 每天/every-day 仍會/yet 喂/food 企鵝寶貝/penguin-baby
The worker feeds foods to penguin babies everyday

u. 工作人員/worker 每天/every-day 仍會/yet 给/to 企鵝寶貝/penguin-baby 喂/food 企鵝寶貝/penguin-baby 喂/food
The worker feeds foods to penguin babies everyday

v. 工作人員/worker 每天/every-day 仍會/yet 喂/food 企鵝寶貝/penguin-baby 喂/food
The worker feeds foods to penguin babies everyday

5 Conclusion and Future work

In this paper, we introduced a broad-coverage rule-based Chinese grammatical resource CSSG, which was developed based on a new grammar formalism idea: Sentence Structure Grammar; we compared briefly CSSG with a simplified Chinese Treebank TCT and a traditional Chinese resource Sinica Treebank; we also introduced our participation of CIPS-SIGHAN-2012 parsing task. We use a same rule-based chart parser implemented CSSG to participate in both simplified Chinese parsing task and traditional Chinese parsing task. The experiment shows that the rule-based grammatical resource CSSG that was developed for covering simplified Chinese constructions can also parse traditional Chinese sentences with a lower performance.

Since the CSSG provide rich information, it is possible to improve the precision and the recall of the evaluation task by optimizing the tree-conversion programs.

We prepare to open this resource to researchers who have an interest in it in the resent future.

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