Abstract

This paper proposes a method of fertilizing a Japanese case frame dictionary to handle complicated expressions: double nominative sentences, non-gapping relation of relative clauses, and case change. Our method is divided into two stages. In the first stage, we parse a large corpus and construct a Japanese case frame dictionary automatically from the parse results. In the second stage, we apply case analysis to the large corpus utilizing the constructed case frame dictionary, and upgrade the case frame dictionary by incorporating newly acquired information.

1 Introduction

To understand a text, it is necessary to find out relations between words in the text. What is required to do so is a case frame dictionary. It describes what kinds of cases each verb has and what kinds of nouns can fill a case slot. Since these relations have millions of combinations, it is difficult to construct a case frame dictionary by hand. We proposed a method to construct a Japanese case frame dictionary automatically by arranging large volumes of parse results by coupling a verb and its closest case component (Kawahara and Kurohashi, 2001). This case frame dictionary, however, could not handle complicated expressions: double nominative sentences, non-gapping relation of relative clauses, and case change.

This paper proposes a method of fertilizing the case frame dictionary to handle these complicated expressions. We take an iterative method which consists of two stages. This means gradual learning of what is understood by an analyzer in each stage. In the first stage, we parse a large raw corpus and construct a Japanese case frame dictionary automatically from the parse results. This is the method proposed by (Kawahara and Kurohashi, 2001). In the second stage, we apply case analysis to the large corpus utilizing the constructed case frame dictionary, and upgrade the case frame dictionary by incorporating newly acquired information.

We conducted a case analysis experiment with the upgraded case frame dictionary, and its evaluation showed effectiveness of the fertilization process.

2 Japanese Grammar

We introduce Japanese grammar briefly in this section.

Japanese is a head-final language. Word order does not play a case-marking role. Instead, postpositions function as case markers (CMs). The basic structure of a Japanese sentence is as follows:

(1) kare ga hon wo kaku

he nom-CM book acc-CM write

(he writes a book)

ga and wo are postpositions which mean nominative and accusative, respectively. kare ga and hon wo are case components, and kaku is a verb.

There are two phenomena that case markers are hidden.

A modifying clause is left to the modified noun in Japanese. In this paper, we call a noun modified by a clause clausal modifiee. A clausal modifiee is usually a case component for the verb of the modifying clause. There is, however, no case marker for their relation.

1In this paper, we call verbs, adjectives, and noun+copulas as verbs for convenience.
In (2), *hito* ‘person’ has *ga* ‘nominative’ relation to *kaita* ‘write’. In (3), *hon* ‘book’ has *wo* ‘accusative’ relation to *kaita* ‘write’.

There are some non case-marking postpositions, such as *wa* and *mo*. They topicalize or emphasize noun phrases. We call them **topic markers (TMs)** and a phrase followed by one of them **TM phrase**.

**3 Construction of the initial case frame dictionary**

This section describes how to construct the initial case frame dictionary. This is the first stage of our two-stage approach, and is performed by the method proposed by (Kawahara and Kurohashi, 2001). In the rest of this section, we describe this approach in detail.

The biggest problem in automatic case frame construction is verb sense ambiguity. Verbs which have different meanings should have different case frames, but it is hard to disambiguate verb senses very precisely. To deal with this problem, we distinguish predicate-argument examples, which are collected from a large corpus, by coupling a verb and its closest case component. That is, examples are not distinguished by verbs such as *naru* ‘make/become’ and *tsumu* ‘load/accumulate’, but by couples such as “*tomodachi ni naru* ‘make a friend’, “*byouki ni naru* ‘become sick’, “*nimotsu wo tsumu* ‘load baggage’, and “*keiken wo tsumu* ‘accumulate experience’.

This process makes separate case frames which have almost the same meaning or usage.

For example, “*nimotsu wo tsumu*” ‘load baggage’ and “*busshi wo tsumu*” ‘load supply’ are separate case frames. To merge these similar case frames and increase coverage of the case frame, we cluster the case frames.

We employ the following procedure for the automatic case frame construction:

1. A large raw corpus is parsed by a Japanese parser, and reliable predicate-argument examples are extracted from the parse results. Nouns with a TM such as *wa* or *mo* and clausal modifiees are discarded, because their case markers cannot be understood by syntactic analysis.

2. The extracted examples are bundled according to the verb and its closest case component, making initial case frames.

3. The initial case frames are clustered using a similarity measure, resulting in the final case frames. The similarity is calculated by using NTT thesaurus.

We constructed a case frame dictionary from newspaper articles of 20 years (about 20,000,000 sentences).

**4 Target expressions**

The following expressions could not be handled with the initial case frame dictionary shown in section 3, because of lack of information in the case frame.

**Non-gapping relation**

This is the case in which the clausal modifiee is not a case component of the verb in the modifying clause, but is semantically associated with the clause.

(6) *kare ga syudoken wo nigiru kaigi*  
he initiative have meeting    
(the meeting in which he has the initiative)

In this example, *kaigi* ‘meeting’ is not a case component of *nigiru* ‘have’, and there is no case relation between *kaigi* and *nigiru*. We call this relation **non-gapping relation**.

**Double nominative sentence**

This is the case in which the verb has two nominatives in sentences such as the following.
(7) kuruma wa engine ga yoi
car TM engine good
(the engine of the car is good)

In this example, wa plays a role of nominative, so yoi ‘good’ subcategorizes two nominatives: kuruma ‘car’ and engine. We call this outer nominative outer ga and this sentence double nominative sentence.

Case change

In Japanese, to express the same meaning, we can use different case markers. We call this phenomenon case change.

(8) Tom ga Mary no shiji wo eta
Tom Mary of support derive
(Tom derived his support from Mary)

In this example, Mary has kara ‘from’ relation to eta ‘derive’. In this paper, we handle case change related to no ‘of’, such as (no, kara).

The following is an example that outer nominative is related to no case.

(9) kuruma no engine ga yoi
   car engine good
   (the engine of the car is good)

The outer nominative of (7) can be nominal modifier of the inner nominative like this example. This is case change of (no, outer ga).

There is a different case from the above that an NP with no modifying a case component does not have a case relation to the verb.

(10) kare ga kaiji no syudoken wo nigiru
he meeting initiative have
    (he has the initiative in the meeting)

In this example, kaiji ‘meeting’ has a no relation to syudoken ‘initiative’, but does not have a case relation to nigiru ‘have’. This example is a transformation of (6), and includes case change of (no, non-gapping).

5 Fertilization of case frame dictionary

We construct a fertilized case frame dictionary from the initial case frame dictionary shown in section 3, to handle the complicated expressions described in section 4.

We apply case analysis to a large corpus using the dictionary, collect information which could not be acquired by a mere parsing, and upgrade the case frame dictionary.

The procedure is as follows (figure 1):

1. The initial case frames are acquired by the method shown in section 3.
2. Case analysis utilizing the case frames acquired in phase 1 is applied to a large corpus, and examples of outer nominative are collected from case analysis results.
3. Case analysis utilizing the case frames acquired in phase 2 is applied to the large corpus, and examples of non-gapping relation are collected similarly.
4. Case similarities are judged to handle case change.

5.1 Case analysis based on the initial case frame dictionary

Case analysis of TM phrases and clausal modifiers is indebted to a case frame dictionary. This section describes an example of case analysis utilizing the initial case frame dictionary.

(11) sono hon wa kare ga
    that book TM he
    tosyokan de yonda
    library in read
    (he read that book in the library)

Case analysis of this example chooses the following case frame “tosyokan de yonda” ‘read in the library’ (‘*’ in the case frame means the closest CM.).

| CM   | examples       | input |
|------|----------------|-------|
| nom  | person, child, book, paper, ... | he    |
| acc  | book           |       |
| loc* | library, house, book, ...       | library |
5.2 Collecting examples of outer nominative

In the initial case frame construction described in section 3, the TM phrase was discarded, because its case marker could not be understood by parsing. In the example (7), “engine ga yoi” ‘the engine is good’ is used to build the initial case frame, but the TM phrase “kuruma wa” ‘the car’ is not used.

Case analysis based on the initial case frame dictionary tells a case of a TM phrase. Correspondence to outer nominative cannot be understood by the case slot matching, but indirectly. If the TM cannot correspond to any case slots of the initial case frame, the TM can be regarded as outer nominative. For example, in the case of (7), since the case frame of “engine ga yoi” ‘the engine is good’ has only nominative which corresponds to “engine”, the TM of “kuruma wa” cannot correspond to any case slots and is recognized as outer nominative. On the other hand, in the case of (11), the TM of hon wa is recognized as accusative, because hon ‘book’ is similar to the examples of the accusative slot. We can distinguish and collect outer nominative examples in this way.

We apply the following procedure to each sentence which has both a TM and ga. To reduce the influence of parsing errors, the collection process of these sentences is done under the condition that a TM phrase has no candidates of its modifying head without its verb.

1. We apply case analysis to a verb which is a head of a TM phrase. If the verb does not have the closest case component and cannot select a case frame, we quit processing this sentence and proceed to the next sentence. In this phase, the TM phrase is not made correspondence with a case of the selected case frame.

2. If the case frame does not have any cases which have no correspondence with the case components in the input, the TM cannot correspond to any case slots and is regarded as outer nominative. This TM phrase is added to outer nominative examples of the case frame.

The following is an example of this process.

(12) nagai sumo wa ashi-koshi ni
long sumo TM legs and loins
futan ga kakaru
burden impose
(long sumo imposes a burden on legs and loins)

Case analysis of this example chooses the following case frame “futan ga kakaru” ‘impose a burden’.

| CM  | examples       | input           |
|-----|----------------|-----------------|
| impose | nom* burden | burden legs loins |
| futan    | ‘burden’  | and ashi-koshi ‘legs and loins’  |

correspond to nominative and dative of the case
frame, respectively, and sumo corresponds to no case marker. Accordingly, the TM of “sumo wa” is recognized as outer nominative, and sumo is added to outer nominative examples of the case frame “futan ga kakaru”.

This process made outer nominative of 15,302 case frames (of 597 verbs).

5.3 Collecting examples of non-gapping relation

Examples of non-gapping relation can be collected in a similar way to outer nominative. When a clausal modifier has non-gapping relation, it should not be similar to any examples of any cases in the case frame, because the constructed case frames have examples of only cases except for non-gapping relation. From this point of view, we apply the following procedure to each example sentence which contains a modifying clause. To reduce the influence of parsing errors, the collection process of example sentences is done under the condition that a verb in a clause has no candidates of its modifying head without its clausal modifier (“·· [modifying verb] N1 no N2” is not collected).

1. We apply case analysis to a verb which is contained by a modifying clause. If the verb does not have the closest case component and cannot select a case frame, we quit processing this sentence and proceed to the next sentence. In this phase, the clausal modifier is not made correspondence with a case of the selected case frame.

2. If the similarity between the clausal modifier and examples of any cases which have no correspondence with input case components does not exceed a threshold, this clausal modifier is added to examples of non-gapping relation in the case frame. We set the threshold 0.3 empirically.

The following is an example of this process.

(13) gyomu wo itonamu
business carry on
menkyo wo syutoku-shita
license get
(φ got a license to carry on business)

Case analysis of this example chooses the following case frame “{gyomu, business} wo itonamu” ‘carry on { work, business }’.

| carry on | CM | examples | input |
|----------|----|----------|-------|
| nom      | acc | bank, company, ··· | business |

Nominative of this case frame has no correspondence with a case component of the input, so the clausal modifier, menkyo ‘license’, is checked whether it can correspond to nominative case examples. In this case, the similarity between menkyo ‘license’ and examples of nominative is not so high. Consequently, the relation of menkyo ‘license’ is recognized as non-gapping relation, and menkyo is added to examples of non-gapping relation in the case frame “{gyomu, business} wo itonamu”.

(14) ihouni denwa gyomu wo
illegally telephone business
itonande-ita utagai
carry on suspect

(suspect that φ carried on telephone business illegally)

In this case, the above case frame is also selected. Since utagai ‘suspect’ is not similar to the nominative case examples, it is added to case examples of non-gapping relation in the case frame.

This process made non-gapping relation of 23,094 case frames (of 637 verbs).

Collecting examples of non-gapping relation for all the case frames

Non-gapping relation words which have wide distribution over verbs can be considered to have non-gapping relation for all the verbs or case frames. We add these words to examples of non-gapping relation of all the case frames. For example, 5 verbs have menkyo ‘license’ (example (13)) in their non-gapping relation, and 381 verbs have utagai ‘suspect’ (example (14)). We, consequently, judge utagai has non-gapping relation for all the case frames. We call such a word global non-gapping word.

We treated words which have non-gapping relation for more than 100 verbs as global non-gapping words. We acquired 128 global non-gapping words, and the following is the examples of them (in English).

possibility, necessity, result, course, case, thought, schedule, outlook, plan, chance, ···
5.4 Case similarity judgement
To deal with case change, we applied the following process to every case frame with outer nominative and non-gapping relation.

1. A similarity of every two cases is calculated. It is the average of similarities between all the combinations of case examples. But similarities of couples of basic cases are not handled, such as (ga, wo), (ga, ni), (wo, ni), and so on.

2. A couple whose similarity exceeds a threshold is judged to be similar, and is merged into one case. We set the threshold 0.8 empirically.

The following example is the case when this process is applied to "{setsumei, syakumei} wo motomeru" 'demand {explanation, excuse}'.

| CM    | examples                      |
|-------|-------------------------------|
| nom   | committee, group, □           |
| acc*  | explanation, excuse          |
| dat   | government, president, □      |
| about | progress, condition, state, □|
| no    | progress, reason, content, □  |

In this case frame, the examples of no ‘of’² are similar to those of ni-itsuite ‘about’, and the similarity between them is very high, 0.94, so these case examples are merged into a new case no/ni-itsuite ‘of/about’.

By this process, 6,461 couples of similar cases are merged. An NP with no modifying a case component can be analyzed by this merging.

6 Case Analysis
To perform case analysis, we basically employ the algorithm proposed by (Kurohashi and Nagao, 1994). In this section, our case analysis method of the complicated expressions shown in section 4 is described.

6.1 Analysis of clausal modifiees
If an clausal modifiee is a function word such as koto ‘(that clause)’ or tame ‘due’, or a time expression such as 3 ji ‘three o’clock’ or saikin ‘recently’, it is analyzed as non-gapping relation.

The other clausal modifiee can correspond to ga ‘nominative’, wo ‘accusative’, ni ‘dative’, outer ga ‘outer nominative’, non-gapping relation, or no ‘of’. We decide a corresponding case which maximizes the score³ of the verb in the clause. If a clausal modifiee corresponds to ga, wo, ni, or outer ga, the relation is decided as it is. If it corresponds to non-gapping relation or no, the relation is decided as non-gapping relation. In the case of corresponding to no, the clausal modifiee has no relation to the closest case component of the verb.

A clausal modifiee can correspond to non-gapping relation or no under the condition that similarity between the clausal modifiee and case examples of non-gapping relation or no is the maximum value (which means two nouns locate in the same node in a thesaurus). This is because a noun which is a little similar to case examples of non-gapping relation may not have non-gapping relation.

6.2 Analysis of TM phrases
If a TM phrase is a time expression, it is analyzed as time case. The other TM phrase can correspond to ga ‘nominative’, wo ‘accusative’, or outer ga ‘outer nominative’. We decide a corresponding case which maximizes the score of the verb modified by the TM phrase. When the verb has both a case component with ga and a TM phrase, the case component with ga responds to ga in the selected case frame, and its TM phrase corresponds to wo or outer ga. If the correspondence between the TM phrase and outer ga case components gets the best similarity, the input sentence is recognized as a double nominative sentence.

6.3 Analysis of case change
If the selected case frame of the input verb has merged cases which include no ‘of’, no case in the input sentence is interpreted as the counterpart of no between the merged cases. If not, the no case is considered not to have a case relation to the verb and has no corresponding case in the case frame.

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²In no case in case frames, every noun which modifies the closest case component of the verb is collected.

³This score is the sum of each similarity between an input case component and examples of the corresponding case in the case frame.
Table 1: Case analysis accuracy

|            | clausal modifiee | TM          |
|------------|------------------|-------------|
| our method | 301/358          | 307/345     |
|            | 84.0%            | 88.9%       |
| baseline   | 287/358          | 305/345     |
|            | 80.1%            | 88.4%       |

Table 2: Non-gapping relation accuracy

|            | precision | recall | F     |
|------------|-----------|--------|-------|
| our method | 82/116    | 82/92  | 78.8% |
|            | 70.7%     | 89.1%  |       |
| baseline   | 88/148    | 88/92  | 73.3% |
|            | 59.5%     | 95.7%  |       |

7 Experiment

We made a case analysis experiment on Japanese relevance-tagged corpus (Kawahara et al., 2002). This corpus has correct tags of predicate-argument relations. We conducted case analysis on an open test set which consists of 500 sentences, and evaluated clausal modifiees and TM phrases in these sentences. To evaluate the real case analysis without influence of parsing errors, we input the correct structure of the corpus sentences to the analyzer.

The accuracy of clausal modifiees and TM phrases is shown in table 1, and the accuracy of non-gapping relation is shown in table 2. The baseline of these tables is that if a clausal modifiee belongs to a non-gapping noun dictionary in which nouns always having non-gapping relation as clausal modifiees are written, it is analyzed as non-gapping relation.

The accuracy of clausal modifiees increased by 4%. This shows effectiveness of our fertilization process. However, the accuracy of TM phrases did not increase. This is because the accuracy of TM phrases which were analyzed using added outer nominative examples was 4/6, and its frequency was too low. The accuracy of case change was 2/4.

8 Related work

There has been some related work analyzing clausal modifiees and TM phrases. Baldwin et al. analyzed clausal modifiees with heuristic rules or decision trees considering various linguistic features (Baldwin et al., 1999). Its accuracy was about 89%. Torisawa analyzed TM phrases using predicate-argument cooccurences and word classifications induced by the EM algorithm (Torisawa, 2001). Its accuracy was about 88% for wa and 84% for mo.

It is difficult to compare the accuracy because the range of target expressions is different. Unlike related work, it is promising to utilize our resultant case frame dictionary for subsequent analyzes such as ellipsis or discourse analysis.

9 Conclusion

This paper proposed a method of fertilizing the case frame dictionary to realize an analysis of the complicated expressions, such as double nominative sentences, non-gapping relation, and case change. We can analyze these expressions accurately using the fertilized case frame dictionary. So far, accuracy of subsequent analyzes such as ellipsis or discourse analysis has not been so high, because double nominative sentences and non-gapping relation cannot be analyzed accurately. It is promising to improve the accuracy of these analyzes utilizing the fertilized case frame dictionary.

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