Detecting Metonymic Expressions with
Associative Information from Words

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Abstract

In natural language processing, metonymic expressions need to be detected and interpreted because sentences including metonymic expressions have different meanings from literal ones. Previous studies focused mainly on interpreting metonymic expressions, but not on detecting ones in sentences. The purposes of this study are to propose an associative approach for detecting them and to evaluate it. By using associative concept dictionaries and Japanese WordNet, we constructed an automatic system that can detect metonymic expressions. We evaluated the system by comparing it with a baseline system that also detects such expressions. As a result, our system showed higher rates of recall (80.0%), precision (72.0%), and F-measure (75.8%) than those of a baseline system.

Keywords: Metonymy, Association Experiment, Associative Concept Dictionary, Verb

1. Introduction

Metonymy is a kind of figure of speech, where one item’s name represents another item that usually has a close relation with the first one. Below is an example Japanese sentence and its English translation:

\begin{quote}
\text{karē-ga isshoubin-wo nomihoshita}
\end{quote}

‘He drank up a large bottle.’

Literally, the Japanese sentence means that he drank up the bottle contents, usually Japanese sake. Of course, it does not mean that he drank or ate the bottle itself. Japanese sake is generally in a large glass bottle of 1.8 liters, where a glass bottle is bin in Japanese and 1.8 liters, isshou. Therefore, the above example means that he drank up Japanese sake in a 1.8-liter bottle. Since a sentence including metonymy is grammatical on a literal level, it is difficult for computers to analyze such metonymy at a surface level.

In natural language processing, metonymy analysis is hard to use for detecting and interpreting the metonymy in a sentence. In previous studies, detecting and interpreting metonymy have been done by...
Table 1. Metonymic expressions of spatial adjacency.

<table>
<thead>
<tr>
<th>Metonymic concept of spatial adjacency</th>
<th>Examples of sentences (metonymic reading)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container for Content</td>
<td>He drank the glass. (the liquid in this glass)</td>
</tr>
<tr>
<td>Producer for Product</td>
<td>He listened to Mahler. (the Mahler’s symphony)</td>
</tr>
<tr>
<td>Means for Agent</td>
<td>The patrol car caught the criminal. (the police man)</td>
</tr>
<tr>
<td>Accessory for Agent</td>
<td>The school uniform is walking. (the student)</td>
</tr>
<tr>
<td>Material for Product</td>
<td>He drank ca eine. (the soft drink with ca eine)</td>
</tr>
<tr>
<td>Others</td>
<td>The theory claimed that. (the proposer of the theory)</td>
</tr>
</tbody>
</table>

Table 2. Metonymic expression of temporal adjacency.

<table>
<thead>
<tr>
<th>Metonymic concept of temporal adjacency</th>
<th>Examples of sentences (metonymic reading)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause for Result</td>
<td>He is tipping the sake cup. (He is drinking the Japanese sake)</td>
</tr>
</tbody>
</table>

Taking computational linguistic or statistical approaches. The former used semantic networks and rules to discriminate metonymy [1, 2, 3, 4]. Metonymic information has many different types, so it was difficult to construct an exhaustive database. The latter used a case frame dictionary and example-based information extracted from newspaper corpora [5, 6]. Thesauri were also used in conventional studies. For example, Goi-Taikai—A Japanese Lexicon [7] was used for detecting metonymic expressions and the associative concept dictionary for nouns (hereinafter referred to as Noun-ACD) [8, 9] was used for interpreting metonymic expressions [10]. However, these studies did not discuss how to detect metonymy and in these evaluations. They presented only sentences containing metonymic expressions, but did not include literal meanings. For these reasons, they mainly focused on interpreting metonymic expressing more precisely. Therefore, in this study, we proposed an associative approach to metonymy detection with our associative concept dictionary for verbs (hereinafter referred to as Verb-ACD). The Verb-ACD has been constructed from large-scale association experiments where stimulus words were basic Japanese verbs [11]. The participants of the experiments associated words from the stimuli with specified semantic relations between them. Each stimulus verb was presented to 40 participants. The total number of the associated words is about 101,000. After all overlapping words were eliminated, there were 24,000 associated words [12]. Finally, the results of experiments with our system and a baseline one using the Japanese Lexicon, our method showed higher measurement rates of recall, precision, and F-measure than those of the baseline.

2. Metonymic Expressions

Metonymic expressions are classified predominantly into two types: spatial adjacency and temporal [10]. In the former type, as shown in Table 1, metonymic patterns are Container-For-Content, Producer-For-Product, Means-For-Agent, Accessory-For-Agent, Material-For-Product, and others. The latter type has, as shown in Table 2, a pattern of Cause-For-Result [13].
From these tables, metonymic expressions of spatial adjacency consist of nouns or noun phrases, but temporal one an event. To express an event, various information is needed; nouns, verbs, and linguistic information e.g., parts of speech, syntactic structures. Using a single sentence to identify whether it includes temporal adjacency metonymy is difficult. We thus focused on detecting only metonymic expressions of the spatial adjacency type.

3. System of Metonymy Detection

To detect metonymic expressions in sentences, we used mainly Verb-ACD and Japanese WordNet. In this chapter, we describe the details of the Verb-ACD construction and our method.

3.1. Verb-ACD Construction

The Verb-ACD consists of the following three elements: stimulus words, i.e., verbs, associated words from the stimulus words with semantic relations, and the word distances among them. The stimulus words were basic verbs and the associated words were from association experiments. These distances were calculated with data of the association words from these experiments. As shown below, we quantified the word distances between stimulus words and associated ones by using a linear programming method.

3.1.1. Association Experiment

To collect associative information on verbs, we conducted large-scale association experiments on the web. The stimulus words were basic verbs with semantic relations that corresponded to deep cases. These verbs were from Japanese elementary school textbooks [14], and we prioritized 200 of them that were entry words in a basic Japanese dictionary [15]. For association purposes, we prepared the 10 semantic relations shown in Table 3: Agent, Object, Source, Goal, Duration, Location, Tool, Aspect, Reason, and Purpose.

3.1.2. Quantification of the Word Distance

By using the linear programming method, we calculated distances between stimulus words and associated ones in the same way as for the Noun-ACD [9]. From the experiments, we obtained three parameters: the inverse of frequency of an associated word \( F(x; y) \), the average of the associated word order \( S(x; y) \), and the response time to generate an association \( T(x; y) \). As shown below, we assumed that a distance \( D(x; y) \) between a stimulus word \( x \) and an associated word \( y \) was expressed by a linear equation using these parameters.

\[
D(x, y) = \alpha F(x, y) + \beta S(x, y) + \gamma T(x, y)
\]  

\[
F(x, y) = \frac{N}{n(x, y) + \delta}
\]  

\[
\delta = \frac{N}{10} - I(N \geq 10)
\]
Let \( N \) denote the number of participants in the experiments, and \( n(x; y) \) denote the number of the experiments participants who replied with the associated word \( y \), to the stimulus word \( x \). If no participant replied, i.e., \( n(x; y) = 0 \), \( y \) is null word. Thus, the minimum value of \( n(x; y) \) is 1 where only one participant replied \( y \). Let denote a factor introduced to limit the maximum value of \( F(x; y) \) to 10 where \( N \) and \( n(x,y) \) are over 10 and 1, respectively. This factor suppresses an abrupt increase of its value if the number of participants becomes larger. Let \( s(x; y) \) denote the order each participant gave the associated word, and let \( t(x; y) \) denote the response time before each participant gave the associated word. In each range of \( t(x; y) \), there are great differences between individuals, so its logarithmic number is used above.

For calculating optimal coefficients, and in Eq. (1), we prepared the following objective function and boundary conditions.

First, the number of participants was 20 when we began to construct the Verb-ACD, so three values \( d_1, d_2, \) and \( d_3 \) in Eq. (6) were average of all participants, i.e., \( N = 20 \), gave in the experiments. One of the boundary conditions meant that the minimum value of the distance among two words was just 1.0 when all participants associated the same word with the shortest time. The other way, another conditions meant that the maximum one was 10:0 when only one participant associated a word with relatively long time. Finally, by using the Simplex Method, the optimum coefficients \( (\alpha; \beta; \gamma) = (7=10; 1=3; 0) \) were obtained where \((d_1; d_2; d_3) = (7:89; 2:82; 2:64), (a_1; b_2; c_3) = (0:95; 1:00; 1:00) \) and \((a_2; b_2; c_2) = (10:00; 9:00; 5:00) \) were presented. As described, the minimization problem of the objective function led two optimal solutions but not one. We used this optimization model because we wanted to use more reliable parameters of the three ones obtained in the experiments. Through the experiments, the values of the response time were highly individual, so it was appropriate that the optimal coefficient of \( T(x; y) \) was 0. Therefore, we showed that \( F(x; y) \) and \( S(x; y) \) were reliable parameters of the three and expressed the word distance \( D(x; y) \) as shown below. We constructed the Verb-ACD with stimulus words, associated words, and distances among these words.

In the Verb-ACD, each semantic relation of two words is expressed by each distance where the smaller the distance is, the closer two words are. For example, when a stimulus verb is the Japanese word, aruku ‘walk’ and the semantic relation is Source, one of the associated words is ie ‘home’ of which the distance is 1:38. Meanwhile, the distance between walk and kaisha ‘o ce’ is 9:92. The number of the stimulus verbs in the Verb-ACD is 252 and the number of all participants is approximately 1; 200. Almost the participants were undergraduate students and graduate students at the Shonan Fujisawa Campus of Keio University. Each stimulus verb was presented to 40 participants. Currently, the total number of the associated words is about 101; 000. In addition, when all of overlapping words are eliminated, the number of the associated words is about 24; 000.

### 3.2. Metonymy Detection System

First, the system analyzes an input sentence morphologically\(^1\) and syntactically\(^2\). The system extracts a predicate verb in the sentence and modification relations of that verb. An associated word from a pair of the

\[ D(x,y) = \frac{7}{10}F(x,y) + \frac{1}{3}S(x,y) \]

\(^1\) Using MeCab 0.98pre3.
\(^2\) Using CaboCha 0.60pre4.
Table 4. Japanese particles corresponding to semantic relations.

<table>
<thead>
<tr>
<th>Case Frame</th>
<th>Semantic Relation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ga</td>
<td>Agent</td>
</tr>
<tr>
<td>wo</td>
<td>Object</td>
</tr>
<tr>
<td>kara, yori</td>
<td>Source</td>
</tr>
<tr>
<td>made, [he/e]</td>
<td>Goal</td>
</tr>
<tr>
<td>de</td>
<td>Location, Tool</td>
</tr>
</tbody>
</table>

predicate verb and a particle which corresponds to the semantic relation shown in Table 4 in the sentence is then extracted from the Verb-ACD. If the sentence has more than one particle, the system extracts each associated word from the noun with the particle, which has the shortest word distance from the stimulus verb. In other words, the system extracts each word which is the most associable from the pair of the predicate verb and a particle. Finally, by comparing the hypernym synset of the associated word with that of nouns in the Japanese WordNet [16], the system detects metonymic expression if these words do not have the same hypernym synset, where the system searches the same synset from these words to the third upper level for the synset hierarchy.

Here we show an example Japanese sentence and its English translation:

shirobai-ga ihansha-wo taiho-shita

‘The police motorcycle arrested the violator.’

For the system to compare the synset of associated words of the past-tense verb taiho-shita ‘arrested’ with that of each noun in the sentence; shirobai ‘police motorcycle’ and ihansha ‘violator’, it must extract associated words from the present-tense taiho-suru ‘arrest’ with each particle in the sentence. As seen in Table 4, ga and wo correspond to Agent and Object. The system then compares the synset and the hypernym of the noun ‘police motorcycle’ with those of words associated with the verb ‘arrest’ with Agent. In the same way, it compares the synset and the hypernym synset of the other noun ‘violator’ with those of associated words from ‘arrest’ with Object. In the former case, there are differences between the synset and the hypernym synset of ‘police motorcycle’ and those of the associated words from ‘arrest’ with Agent. Those associated words with a comparatively short distance from ‘arrest’ with Agent are keisatsukan ‘police man’ and watashi ‘I’, i.e., not vehicles, but humans. On the other hand, in the latter case, there is no difference since the more associable words from ‘arrest’ with Object are ‘violator’ and dorobou ‘thief’, i.e., just humans. The system therefore can judge correctly ‘police motorcycle’ as a metonymic expression and ‘violator’ as a literal meaning.

4. Evaluation

To evaluate our proposed system by comparing it to the previous studies, we prepared a baseline system where the Goi-Taikei—A Japanese Lexicon [7] was used to automatically detect metonymy. We prepared 90 test sentences which consisted of 45 sentences with literal meanings and 45 ones including metonymic expressions. Finally, we compared recall, precision, and F-measure rates of our system with those of the baseline.

4.1. Baseline System

To compare our proposed method with previous studies, we constructed a baseline system. It mainly consisted of syntactic structures and noun properties in the Goi-Taikei—A Japanese Lexicon which was used for detecting metonymic expressions in the previous studies [5, 6]. Syntactic and semantic information of predicate verbs used in test sentences was selected as described below. To automatically detect metonymic expressions, the baseline system uses the highest priority order of syntactic information in each predicate
verb. The order of syntactic information was an order of preference in the Japanese Lexicon and was defined in order to translate from Japanese to English or from English to Japanese [17]. The syntactic information of a verb is a set of syntactic type and noun property and expresses that the verb has noun properties with a part of speech. For example, when a verb is taiho-suru ‘arrest’, one of its syntactic information is the following; “[N1] arrests [N2]” where a noun property of “N1” is shutai ‘agent’ and that of “N2” is hito ‘human’. The noun property consists of some nouns and is expressed by the hypernym and the hyponym of the noun property.

The outline of the baseline system is described below. First, the system selects a syntactic type of the predicate verb from its various syntactic information in the Japanese Lexicon after morphologic and syntactic analysis of an input sentence. Next, the baseline system obtains noun properties in the syntactic information. The baseline system then determines whether an expression is metonymic if each word in the input sentence does not belong to the noun property.

Given that the input sentence is the example shown in 3.2, the system selected syntactic type from present-tense ‘arrest’ and obtained the following noun properties; “[N1] arrests [N2]” where a noun property of “N1” was shutai ‘agent’ and that of “N2” was hito ‘human’. In the Japanese Lexicon, the property of ‘police motorcycle’ was norimono ‘vehicle’ and its hypernym properties did not belong to “N1” property; ‘agent’. The property of ‘violator’ was ‘human’ which was the same as “N2”. The baseline system then judged the former as a metonymic expression and the latter as a literal meaning.

4.2. Test Sentences

For this evaluation, we prepared 90 test sentences which consisted of 45 ones with metonymic expressions and 45 sentences with literal meanings. As shown in Table 5, the former sentences were extracted from the previous studies [5, 10]. The latter ones were extracted in newspaper corpora from 5 years of the Mainichi Newspaper and also included words used in the metonymic sentences. As both our system and the baseline one judged all nouns in each test sentence, the number of the nouns in 90 test sentences was 113.

4.3. Results

Our system detected 50 metonymic expressions in 113 words, the baseline did 49 ones. The number of correct detections in our system was 36, and that in the baseline was 31. As evaluation measurements, we calculated recall, precision, and F-measure rates by using the above numbers of correct detections.

Rates of recall, precision, and F-measure in our system and the baseline are shown in Table 6. As a result, our proposed method expressed higher recall, precision, and F-measure rates than those of the baseline system. The previous studies used syntactic information of predicate verbs from the Goi-Taiki—A Japanese Lexicon, but selected only some of the various syntactic information, which were matched to test sentences [5, 10]. In this evaluation, the baseline system selected the highest priority order of syntactic information in each predicate verb. As described in 4.1, the priority order was defined as preference to translate, so it seemed to express the order of frequency of its usage [17]. The baseline system used the highest frequency of syntactic information of the predicate verb. From the results, we found that using data based on associative information detects metonymic expressions more efficiently than using syntactic information based on the Japanese Lexicon.
Table 6. Results with precision, recall and F-measure rates.

<table>
<thead>
<tr>
<th></th>
<th>Baseline system</th>
<th>Our system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision(%)</td>
<td>63.3(31/49)</td>
<td>72.0(36/50)</td>
</tr>
<tr>
<td>Recall(%)</td>
<td>68.9(31/45)</td>
<td>80.0(36/45)</td>
</tr>
<tr>
<td>F-measure</td>
<td>66.0</td>
<td>75.8</td>
</tr>
</tbody>
</table>

5. Discussion

Compared to the baseline system using the Japanese Lexicon, our system offered improved recall, precision, and F-measure rates. In our method, the proposed system used mainly associative information from the Verb-ACD. There were differences in using knowledge between our system with the associative information and the baseline system with the Japanese Lexicon. For example, when an input Japanese sentence means that ‘The conductor laughed at the clarinet.’ in English in Table 5, our system judged ‘clarinet’ as a metonymic expression, while the baseline system did not. In the Verb-ACD, the associated words whose distances were especially short were hito ‘human’ and telebi-bangumi ‘TV program’, so our system extracted synsets from those associated words and also those hypernyms in Japanese WordNet.

Our system compared extracted words with ‘clarinet’ and its synset expressed by music instruments. Since extracted words did not match ‘clarinet’ and or its synset, our system judged it as a metonymic expression. On the other hand, when the same Japanese sentence was input, the baseline system extracted syntactic type of the following predicate verb ‘laugh’ from the Japanese Lexicon; “[N1] laughs at [N2]” where noun properties of “N1” and “N2” were hito ‘human’ and asterisk ‘all properties’, respectively. Here, the noun property of ‘clarinet’ in the sentence was gakki ‘instrument’ and belongs to “N2” whose property was asterisk ‘all properties’. As a result, the baseline system judged it as a literal meaning, i.e., not metonymy. In general, we usually associate the meaning ‘The conductor laughed at the clarinet player’ when we read the sentence. Of course, it is not wrong syntactically that the conductor laughed at the instrument of clarinet, but it is unnatural in daily conservations and texts. Our system was closer to our associations in daily conservations and texts than the baseline system. That is, the Verb-ACD that our system used was more suited to detecting metonymic expressions than the Japanese Lexicon used by the baseline system.

In a previous study, Murata et al. showed 74.9% precision of detecting metonymic expressions where the number of correct detections in 23 input sentences including metonymic expressions was 17 [5]. In the same situation, our system showed 80.0% precision, i.e., the recall shown in Table 6. Our method had higher precision than the previous study although in this evaluation the number of test sentences was larger than that of the previous study. In addition, those sentences contained not only metonymic expressions, but also literal meanings. Hence, our method was more efficient than the previous method.

However, our system judged some literal meanings as metonymic ones for the following two reasons. One was that some associated words from verbs with semantic relations contained metonymic expressions. In fact, some experiment participants associated metonymic expressions, so detections of our system were wrong when associated words with short word distances were metonymic expressions. The other was that variety of associated words with short word distances was restricted. Less variety within the group of associated words leads to a smaller range of information extracted by our system from Japanese WordNet. This feature provided good detection of metonymic expressions but was weak at judging literal meanings, i.e., not metonymic expressions. As shown in Table 6, this feature means that our system has a greater tendency to judge literal meanings as metonymic expressions than the baseline system does. Meanwhile, the Japanese Lexicon has huge range of noun properties, so the baseline system has a tendency to judge metonymic expressions as literal meanings. From the above, the relation between detecting metonymic expressions and judging literal meanings has a trade, so merging each advantage of our system and the baseline system will improve the ability of our system to detect metonymic...
expressions. Therefore, we concluded that our proposed system was more efficient than the baseline system in detecting metonymic expressions. Additionally, to improve its detection rate, we should integrate it with the Japanese Lexicon.

6. Conclusions

We mainly used the Verb-ACD in an application which detects metonymic expressions in sentences as an approach to association. A Japanese Lexicon used in previous studies, was used to compare our system with the baseline one. Our system was found to have a higher recall, precision and F-measure rates than those of the baseline system. We therefore conclude that the Verb-ACD can be used to efficiently detect metonymic expressions. Our future works are to construct a system for interpreting metonymic expressions and to integrate it with our current detection system for metonymy analysis.

7. Acknowledgements

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References