Identifying Contradictory and Contrastive Relations between Statements to Outline Web Information on a Given Topic

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Abstract

We present a method for producing a bird’s-eye view of statements that are expressed on Web pages on a given topic. This method aggregates statements that are relevant to the topic, and shows contradictory and contrastive relations among them. This view of contradictions and contrasts helps users acquire a top-down understanding of the topic. To realize this, we extract such statements and relations, including cross-document implicit contrastive relations between statements, in an unsupervised manner. Our experimental results indicate the effectiveness of our approach.

1 Introduction

The quantity of information on the Web is increasing explosively. Online information includes news reports, arguments, opinions, and other coverage of innumerable topics. To find useful information from such a mass of information, people generally use conventional search engines such as Yahoo! and Google. They input keywords to a search engine as a query and obtain a list of Web pages that are relevant to the keywords. They then use the list to check several dozen top-ranked Web pages one by one.

This method of information access does not provide a bird’s-eye view of the queried topic; therefore it can be highly time-consuming and difficult for a user to gain an overall understanding of what is written on the topic. Also, browsing only top-ranked Web pages may provide the user with biased information. For example, when a user searches for information on “agaricus,” claimed to be a health food, using a conventional search engine, many commercial pages touting its health benefits appear at the top of the ranks, while other pages remain low-ranked. The user may miss an existing Web page that indicates its unsubstantiated health benefits, and could be unintentionally satisfied by biased or one-sided information.

This paper proposes a method for producing a bird’s-eye view of statements that are expressed on Web pages on a given query (topic). In particular, we focus on presenting contradictory/contrastive relations and statements on the topic. Presenting these relations and statements is thought to facilitate users’ understanding of the topic. This is because people typically think about contradictory and contrastive entities and issues for decision-making in their daily lives.

Our system presents statements and relations that are important and relevant to a given topic, including the statements and relations listed in Table 1. Direct contrastive statements compare two entities or issues in a single sentence. The contrasted entities or issues are also extracted as contrastive keyword pairs. In addition to them, our direct contrastive statement “A is more P than B” contrastive keyword pair (A, B) contrastive relation “A is P” ⇔ “A is not P” contrastive relation “A is P” ↔ “B is P (not P)”

Table 1: Overview of direct contrastive statements, contrastive keyword pairs and contradictory/contrastive relations. Note that “P” is a predicate.
system shows **contradictory and contrastive relations** between statements. Contradictory relations are the relations between statements that are contradictory about an entity or issue. Contrastive relations are the relations between statements in which two entities or issues are contrasted.

In particular, we have the following two novel contributions.

- We identify contrastive relations between statements, which consist of in-document and cross-document implicit relations. These relations complement direct contrastive statements, which are explicitly mentioned in a single sentence.

- We precisely extract direct contrastive statements and contrastive keyword pairs in an unsupervised manner, whereas most previous studies used supervised methods (Jindal and Liu, 2006b; Yang and Ko, 2009).

Our system focuses on the Japanese language. For example, Figure 1 shows examples of extracted statements on the topic “gosei senzai” (synthetic detergent). Rounded rectangles represent statements relevant to this topic. The first statement is a direct contrastive statement, which refers to a contrastive keyword pair, “gosei senzai” (synthetic detergent) and “sekken” (soap). The pairs of statements connected with a broad arrow have contradictory relations. The pairs of statements connected with a thin arrow have contrastive relations. Users not only can see what is written on this topic at a glance, but also can check out the details of a statement by following its links to the original pages.

2 Related Work

Studies have been conducted on automatic extraction of direct contrastive sentences (comparative sentences) for English (Jindal and Liu, 2006b) and for Korean (Yang and Ko, 2009). They prepared a set of keywords that serve as clues to direct contrastive sentences and proposed supervised techniques on the basis of tagged corpora. We propose an unsupervised method for extracting direct contrastive sentences without constructing tagged corpora.

From direct contrastive sentences, Jindal and Liu (2006a) and Satou and Okumura (2007) proposed methods for extracting quadruples of (target, basis, attribute, evaluation). Jindal and Liu (2006a) extracted these quadruples and obtained an F-measure of 70%-80% for the extraction of “target” and “basis.” Since this extraction was
not their main target, they did not perform error analysis on the extracted results. Satou and Okumura (2007) extracted quadruples from blog posts. They provided a pair of named entities for “target” and “basis,” whereas we automatically identify such pairs. Ganapathibhotla and Liu (2008) proposed a method for detecting which entities (“target” and “basis”) in a direct contrastive statement are preferred by its author.

There is also related work that focuses on non-contrastive sentences. Ohshima et al. (2006) extracted coordinated terms, which are semantically broader than our contrastive keyword pairs, using hit counts from a search engine. They made use of syntactic parallelism among coordinated terms. Their task was to input one of coordinated terms as a query, which is different from ours. Somasundaran and Wiebe (2009) presented a method for recognizing a stance in online debates. They formulated this task as debate-side classification and solved it by using automatically learned probabilities of polarity.

To aggregate statements and detect relations between them, one of important modules is recognition of synonymous, entailed, contradictory and contrastive statements. Studies on rhetorical structure theory (Mann and Thompson, 1988) and recognizing textual entailment (RTE) deal with these relations. In particular, evaluative workshops on RTE have been held and this kind of research has been actively studied (Bentivogli et al., 2009). The recent workshops of this series set up a task that recognizes contradictions. Harabagiu et al. (2006), de Marneffe et al. (2008), Voorhees (2008), and Ritter et al. (2008) focused on recognizing contradictions. For example, Harabagiu et al. (2006) used negative expressions, antonyms and contrast discourse relations to recognize contradictions. These methods only detect relations between given sentences, and do not create a bird’s-eye view.

To create a kind of bird’s-eye view, Kawahara et al. (2008), Statement Map (Murakami et al., 2009) and Dispute Finder (Ennals et al., 2010) identified various relations between statements including contradictory relations, but do not handle contrastive relations, which are one of the important relations for taking a bird’s-eye view on a topic. Lerman and McDonald (2009) proposed a method for generating contrastive summaries about given two entities on the basis of KL-divergence. This study is related to ours in the aspect of extracting implicit contrasts, but contrastive summaries are different from contrastive relations between statements in our study.

3 Our Method

We propose a method for grasping overall information on the Web on a given query (topic). This method extracts and presents statements that are relevant to a given topic, including direct contrastive statements and contradictory/contrastive relations between these statements.

As a unit for statements, we use a predicate-argument structure (also known as a case structure and logical form). A predicate-argument structure represents a “who does what” event. Processes such as clustering, summarization, comparison with other knowledge and logical consistency verification, which are required for this study and further analysis, are accurately performed on the basis of predicate-argument structures. The extraction of our target relations and statements is performed via identification and aggregation of synonymous, contrastive, and contradictory relations between predicate-argument structures.

As stated in section 1, we extract direct contrastive statements, contrastive keyword pairs, relevant statements, contrastive relations and contradictory relations. We do this with the following steps:

1. Extraction and aggregation of predicate-argument structures
2. Extraction of contrastive keyword pairs and direct contrastive statements
3. Identification of contradictory relations
4. Identification of contrastive relations

Below, we first describe our method of extracting and aggregating predicate-argument structures. Then, we explain our method of extracting direct contrastive statements with contrastive keyword pairs, and identifying contradictory and contrastive relations in detail.
3.1 Extraction and Aggregation of Predicate-argument Structures

A predicate-argument structure consists of a predicate and one or more arguments that have a dependency relation to the predicate.

We extract predicate-argument structures from automatic parses of Web pages on a given topic by using the method of Kawahara et al. (2008). We apply the following procedure to Web pages that are retrieved from the TSUBAKI (Shinzato et al., 2008) open search engine infrastructure, by inputting the topic as a query.

1. Extract important sentences from each Web page. Important sentences are defined as sentences neighboring the topic word(s).

2. Obtain results of morphological analysis (JUMAN\(^1\)) and dependency parsing (KNP\(^2\)) of the important sentences, and extract predicate-argument structures from them.

3. Filter out functional and meaningless predicate-argument structures, which are not relevant to the topic. Pointwise mutual information between the entire Web and the target Web pages for a topic is used.

Note that the analyses in step 2 are performed beforehand and stored in an XML format (Shinzato et al., 2008).

Acquired predicate-argument structures vary widely in their representations of predicates and arguments. In particular, many separate predicate-argument structures have the same meaning due to spelling variations, transliterations, synonymous expressions and so forth. To cope with this problem, we apply “keyword distillation” (Shibata et al., 2009), which is a process of absorbing spelling variations, synonymous expressions and keywords with part-of relations on a set of Web pages about a given topic. As a knowledge source to merge these expressions, this process uses a knowledge base that is automatically extracted from an ordinary dictionary and the Web. For instance, the following predicate-argument structures are judged to be synonymous\(^3\).

\(^1\)http://nlp.kuee.kyoto-u.ac.jp/nl-resource/juman-e.html
\(^2\)http://nlp.kuee.kyoto-u.ac.jp/nl-resource/knp-e.html
\(^3\)In this paper, we use the following abbreviations:

- NOM (nominative), ACC (accusative), DAT (dative), ABL (ablative), CMI (comitative), GEN (genitive) and TOP (topic marker).

We call the predicate-argument structures that are obtained as the result of the above procedure statement candidates. The final output of our system consists of direct contrastive statements (with contrastive keyword pairs), top-N statements (major statements) in order of frequency of statement candidates, and statements with contradictory/contrastive relations. Contradictory/contrastive relations are identified against major statements by searching statement candidates.

Another outcome of keyword distillation is a resultant set of keywords that are important and relevant to the topic. We call this set of keywords relevant keywords, which also include words or phrases in the query. Relevant keywords are used to extract contrastive keyword pairs.

3.2 Extraction of Contrastive Keyword Pairs and Direct Contrastive Statements

We extract contrastive keyword pairs from contrastive constructs, which are manually specified as patterns of predicate-argument structures. Statements that contain contrastive constructs are defined as direct contrastive statements.

For example, the following sentence is a typical direct contrastive statement, which contains a contrastive verb “chigau” (differ).

\[(1) \text{sekken-wa gosei senzai-to chigai, \ldots} \\
\text{soap-MARK synthetic detergent-ABL differ} \\
\text{(soap differs from synthetic detergent, \ldots)} \]

From this sentence, a contrastive keyword pair, “sekken” (soap) and “gosei senzai” (synthetic detergent), is extracted. The above sentence is extracted as a direct contrastive statement.

We preliminarily evaluated this simple pattern-based method and found that it has the following three problems.
• Keyword pairs that are mentioned in a contrastive construct are occasionally not relevant to the given topic.
• Non-contrastive keyword pairs are erroneously extracted due to omissions of attributes and targets of comparisons.
• Non-contrastive keyword pairs that have an is-a relation are erroneously extracted.

To deal with the first problem, we filter out keyword pairs that are contrastive but that are not relevant to the topic. For this purpose, we apply filtering by using relevant keywords, which are described in section 3.1.

As an example of non-contrastive keyword pairs (the second problem), from the following sentence, a keyword pair, "tokkyo seido” (patent system) and “nihon” (Japan), is incorrectly extracted by the pattern-based method.

(3) amerika-no tokkyo seido-wa nihon-to kotonari, · · ·
different

(patent system of America is different from φ of Japan · · ·)

In this sentence, “nihon” (Japan) has a meaning of “nihon-no tokkyo seido” (patent system of Japan). That is to say, “tokkyo seido” (patent system), which is the attribute of comparison, is omitted.

In this study, in addition to patterns of contrastive constructs, we use checking and filtering on the basis of similarity. The use of similarity is inspired by the semantic parallelism between contrasted keywords. As this similarity, we employ distributional similarity (Lin, 1998), which is calculated using automatic dependency parses of 100 million Japanese Web pages. By searching similar keywords from the above sentence, we successfully extract a contrastive keyword pair, “amerika” (America) and “nihon” (Japan), and the above sentence as a direct contrastive statement.

Similarly, a target of comparison can be omitted as in the following sentence.

(4) nedan-wa gosei senzai-yori takaidesu price-TOP synthetic detergent-ABL high

(price of φ is higher than synthetic detergent)

In this example, the similarity between “nedan” (price) and “gosei senzai” (synthetic detergent) is lower than a threshold, and this sentence and the extracts from it are filtered out.

As for the third problem, we may extract non-contrastive keyword pairs that have an is-a relation. From the following sentence, we incorrectly extract a contrastive keyword pair, “konbini” (convenience store) and “7-Eleven,” which cannot be filtered out due to its high similarity.

(5) 7-Eleven-wa hokano konbini-to 7-Eleven-TOP other convenience store-ABL karabete, · · ·

comepare

(?-Eleven is · · · compared to other convenience stores)

To deal with this problem, we use a filter on the basis of a set of words that indicate the existence of hypernyms, such as “hokano” (other) and ippanno (general). We prepare six words for this purpose.

To sum up, we use the following procedure to identify contrast keyword pairs.

1. Extract predicate-argument structures that do not match the above is-a patterns and match one of the following patterns. They are extracted from the statement candidates.

   • X-wa Y-to \{chigau | kotonaru | kuraberu\} 
     (X differ | vary | compare from/with Y)
   • X-wa Y-yori [adjective] 
     (X is more · · · than Y)

   Note that each of X and Y is a noun phrase in the argument position.

2. Extract (x, y) that satisfies both the following conditions as a contrastive keyword pair. Note that (x, y) is part of a word sequence in (X, Y), respectively.

   • Both x and y are included in a set of relevant keywords.
   • (x, y) has the highest similarity among any other candidates of (x, y), and this similarity is higher than a threshold.

Note that the threshold is determined based on a preliminary experiment using a set of synonyms (Aizawa, 2007). We extract the sentence that contains the predicate-argument structure used in step 1 as a direct contrastive statement.
3.3 Identification of Contradictory Relations

We identify contradictory relations between statement candidates. In this paper, contradictory relations are defined as the following two types (Kawahara et al., 2008).

**negation of predicate**

If the predicate of a candidate statement is negated, its contradiction has the same or synonymous predicate without negation. If not, its contradiction has the same or synonymous predicate with negation.

(6) a. sekken-ga kandyou-ni yoi
    soap-NOM environment-DAT good

b. sekken-ga kandyou-ni yoku-nai
    soap-NOM environment-DAT not good

**antonym of predicate**

The predicate of a contradiction is an antonym of that of a candidate statement. To judge anonymous relations, we use an antonym lexicon extracted from a Japanese dictionary (Shibata et al., 2008). This lexicon consists of approximately 2,000 entries.

(7) a. gosei senzai-ga anzen-da
    synthetic detergent-NOM safe

b. gosei senzai-ga kiken-da
    synthetic detergent-NOM dangerous

To identify contradictory relations between statements in practice, we search statement candidates that satisfy one of the above conditions against major statements.

3.4 Identification of Contrastive Relations

We identify contrastive relations between statement candidates. In this paper, we define a contrastive relation as being between a pair of statement candidates whose arguments are contrastive keyword pairs and whose predicates have synonymous or contradictory relations. Contradictory relations of predicates are defined in the same way as section 3.3.

In the following example, (a, b) and (a, c) have a contrastive relation. Also, (b, c) has a contradictory relation.

(8) a. gosei senzai-de yogore-ga ochiru
    synthetic detergent-CMI stain-NOM wash

b. sekken-de yogyore-ga ochiru
    soap-CMI stain-NOM wash

c. sekken-de yogyore-ga ochi-nai
    soap-CMI stain-NOM not wash

The process of identifying contrastive relations between statements is performed in the same way as the identification of contradictory relations. That is to say, we search statement candidates that satisfy the definition of contrastive relations against major statements.

4 Experiments

We conducted experiments for extracting contrastive keyword pairs, direct contrastive statements and contradictory/contrastive relations on 50 topics, such as age of adulthood, anticancer drug, bio-ethanol, citizen judgment system, patent system and Windows Vista.

We retrieve at most 1,000 Web pages for a topic from the search engine infrastructure, TSUBAKI. As major statements, we extract 10 statement candidates in order of frequency.

Below, we first evaluate the extracted contrastive keyword pairs and direct contrastive statements, and then evaluate the identified contradictory and contrastive relations between statements.

4.1 Evaluation of Contrastive Keyword Pairs and Direct Contrastive Statements

Contrastive keyword pairs and direct contrastive statements were extracted on 30 of 50 topics. 99 direct contrastive statements and 73 unique contrastive keyword pairs were obtained on 30 topics. The average number of obtained contrastive keyword pairs for a topic was approximately 2.4. Ta-
Table 3: Examples of identified direct contrastive statements, contradictory relations and contrastive relations. The sentences with two underlined parts are direct contrastive statements. The arrows “⇔” and “↔” represent a contradictory relation and a contrastive relation, respectively.

| Topic: “tyosakuken hou” (copyright law) |
|----------------------------------------|
| “syouhyouken-wa tyosakuken-yori zaisantekina kachi-wo motsu.” |
| The trademark right has more financial value than the copyright. |
| Tyosakuken hou-de hogo-sare-nai |
| protected by the copyright law |
| Tyosakuken-wo shingai-shi-nai |
| infringe the copyright |
| Tyosakuken-wo shingai-nai |
| not infringe the copyright |
| "syouhyouken-wa shingai-shi-nai" |
| not infringe the trademark right |

| Topic: “genshiryoku hatsuden syo” (nuclear power plant) |
|--------------------------------------------------------|
| “genshiryoku hatsuden syo-wa karyoku hatsuden syo-to chigau.” |
| Nuclear power plants are different from thermoelectric power plants. |
| “CO2-wo hassei-shi-nai” |
| not emit carbon dioxide |
| “CO2-wo hassei-suru” |
| emit carbon dioxide |
| “genpatsu-wo tsukuru” |
| construct a nuclear power plant |
| “karyoku hatsuden syo-wo tsukura-nai” |
| not construct a nuclear power plant |
| “karyoku hatsuden syo-wo tsukuru” |
| construct a thermoelectric power plant |

Contradictory relations were identified on 49 of 50 topics. For 49 topics, 268 contradictory relations were identified. The average number of identified contradictory relations for a topic was 5.5. Contrastive relations were identified on 18 of 30 topics, on which contrastive keyword pairs were extracted. For the 18 topics, 60 contrastive relations were identified. The average number of identified contrastive relations for a topic was 3.3.

4.2 Evaluation of Contradictory and Contrastive Relations

Contradictory relations were identified on 49 of 50 topics. For 49 topics, 268 contradictory relations were identified. The average number of identified contradictory relations for a topic was 5.5. Contrastive relations were identified on 18 of 30 topics, on which contrastive keyword pairs were extracted. For the 18 topics, 60 contrastive relations were identified. The average number of identified contrastive relations for a topic was 3.3.

Table 3 lists examples of the identified contradictory and contrastive relations as well as direct contrastive statements. We manually evaluated the identified contradictory relations and the contrastive relations that were identified for correct contrastive keyword pairs. As a result, we concluded that they completely obey our definitions.

We also classified each of the obtained contradictory and contrastive relations into two classes: “cross-document” and “in-document.”
4.3 Discussions

We successfully identified contradictory relations on almost all the topics. However, out of 50 topics, we extracted contrastive keyword pairs on 30 topics and contrastive relations on 18 topics. To investigate the resultant contrastive relations from the viewpoint of recall, we manually checked whether there were unidentified contrastive relations among 100 statement candidates for each topic. We actually checked 20 topics and found six unidentified contrastive relations in total. Table 4 lists examples of the unidentified contrastive relations. Out of 20 topics, in total, 44 contrastive relations are manually discovered on 13 topics, but out of 13 topics, 38 contrastive relations are identified on eight topics by our method. Therefore, we achieved a recall of 86% (38/44) at relation level and 62% (8/13) at topic level. We can see that many cross-document implicit relations that cannot be retrieved from a single page were successfully identified.

Table 4: Examples of unidentified contrastive relations (translated into English).

| Topic: age of adulthood |
|-------------------------|
| lower the age of adulthood to 18 |
| ↔ lower the voting age to 18 |

| Topic: anticancer drug |
|------------------------|
| anticancer drugs have side effects |
| ↔ anticancer drugs have effects |

document” means that a contradictory/contrastive relation is obtained not from a single page but across multiple pages. If a relation can be obtained from both, we classified it into “indocument.” As a result, 67% (179/268) of contradictory relations and 70% (42/60) of contrastive relations were “cross-document.” We can see that many cross-document implicit relations that cannot be retrieved from a single page were successfully identified.

5 Conclusion

This paper has described a method for producing a bird’s-eye view of statements that are expressed in Web pages on a given topic. This method aggregates statements relevant to the topic and shows the contradictory/contrastive relations and statements among them.

In particular, we successfully extracted direct contrastive statements in an unsupervised manner. We specified only several words for the extraction patterns and the filtering. Therefore, our method for Japanese is thought to be easily adapted to other languages. We also proposed a novel method for identifying contrastive relations between statements, which included cross-document implicit relations. These relations complemented direct contrastive statements.

We have incorporated our proposed method into an information analysis system, WISDOM4 (Akamine et al., 2009), which can show multi-faceted information on a given topic. Now, this system can show contradictory/contrastive relations and statements as well as their contexts as a view of KWIC (keyword in context) (Figure 2). This kind of presentation facilitates users’ understanding of an input topic.

4http://wisdom-nict.jp/
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