Answering Questions of IAD Task using Reference Resolution of Follow-up Questions

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Abstract

In this paper, we will propose reference resolution method for follow-up questions in IAD task. In this method, our system classifies reference pattern of question sentences into three types and recognize antecedent using reference resolution algorithm for each type. In the evaluation, performance of our methods was not better results than our expectation. In Formal Run, our system got correct answers in 13 questions among 71 questions which our system got correct answer in Reference Run. However, according to the analysis of evaluation results, the main reason of low performance was lack of word information for recognition of referential elements. If our system can recognize word meanings correctly, some errors will not occur and reference resolution works well.

1 Introduction

Several approaches to handle follow-up questions have been proposed in the previous evaluation of QAC2 subtask3. One system uses a document set which is retrieved using the first question information and extracts answers of its follow-up questions from the document set[5]. The other system put keywords extracted from the previous questions to keyword list of the follow-up question for document retrieval[4]. On the other hand, our approach was to handle reference resolution including zero anaphora of follow-up questions of a series of questions and apply the processed question to our main QA system called *core QA system*. The core QA system is a system to process ordinal questions and is used for previous QA evaluations such as the subtask1 and 2. In the previous QACs, we submitted our systems using the above approach and had evaluations[2] [3]. However, the evaluation results were not enough level of our satisfaction.

In our previous reference resolution approach, we assumed that a question sentence consisted of three parts: topicalized element, its modifier phrase and inquiring expression. We proposed reference resolution method which determined referential element using information of topic presentation and topicalized element of follow-up question. However, there are many cases that our approach could not work correctly and we found that the main reason is luck of handling semantic information according to the results of evaluation.

For QAC3 evaluation, we have proposed our new reference resolution method for follow-up questions using semantic information. Based on the analysis of evaluation results of QAC2, we classified reference patterns of a follow-up question into three types. The first type is reference of pronoun of follow-up question. We will determine referential element using information of pronoun. The second type is zero anaphora of main verb case of a follow-up question. We will calculate semantic distance between case element and referential candidates of the previous question. The last type is zero anaphora element which modifies a topicalized element or is modified by a topicalized element. In order to determine referential element of zero anaphora, we will calculate semantic distance between topicalized element and referential candidates of the previous question. In order to handle semantic information of the above three reference types, we utilized concept hierarchy of EDR Japanese Word Dictionary and EDR Japanese Cooccurrence Dictionary dictionary[1].

As for core QA system, we integrated previous systems modules which have been developed for QAC2. One module is to handle numeric type questions. In this module, system analyzes co-occurrence data of unit expressions and their object names. This system provided better performance than another one in numeric type questions. Another module uses detailed classification of Named Entity for non numerical type questions such as person name, organization name and so on. With this integration, the core QA system had a little improvement according to our local test. Therefore, our core QA system has still space to improve its performance.

In the following sections, we will show overall results of this evaluation and explain detail of analysis

Table 1. Evaluation Results of Our system

	all	first	rest
Formal Run	0.050	0.166	0.031
Reference Run	0.102	0.166	0.092

of elliptical sentences of question and our new method of reference resolution of follow-up question. We will also discuss our system evaluation.

2 Overview of Evaluation Results

As the official scores of our system is shown in Table 1, the scores of the average of all question, the first questions of each series, and the rest of questions are 0.050, 0.166, 0.031, respectively in Formal Run. Our system provides output which include correct answers in 45 questions in Formal Run and 90 questions in Reference Run. Compared with QAC2, overall performance of our system got a little bit worse. We think the main reason of this slip is caused by evaluation method of F-measure. In QAC3 test set, there are many questions which have only one answer (questions of subtask2 of QAC2 have several answers) and our system provided many answers to questions (5 answers in max) because of some system design mistakes and bugs.

In the score of the rest of question, the score of Formal Run is 0.031 and the one of Reference Run is 0.092. There are 71 questions in which our system have succeeded to answer in the rest of questions. Among 71, our system got correct answers in 13 questions. If our reference resolution method works well, these score will be almost the same one. But the scores of such difference shows that there will be more space to do more research on reference resolution in follow-up questions. The details of evaluation of reference resolution will be discussed in the following sections.

3 Reference resolution

In this section, we explain what kinds of reference patterns exist in the follow-up questions of a series of questions and how to resolve each reference to apply them to core QA system.

3.1 Reference patterns in question sentences

We have analyzed 319 questions (46sets) which were used in subtask3 of QAC1 and QAC2 and then, classified reference patterns into 3 types as follows:

(1) Reference of pronoun

In this pattern, a pronoun of a follow-up question refers to a word used in the previous question or an answer of the previous question. The following example shows that a pronoun in the follow-up question refers to a word of the previous question.

Ex1-1 アメリカの大統領は誰ですか。
Ex1-2 そこが独立したのはいつですか。

“ そこ ” of **Ex1-2** refers to “ アメリカ ” of **Ex1-1**. Therefore, **Ex1-2** should be “ アメリカが独立したのはいつですか。 ”.

In the following example, a pronoun in the follow-up question refers to an answer of the previous question.

Ex2-1 アメリカの大統領は誰ですか。
Ex2-2 彼の出身地はどこですか。

Pronoun “ 彼 ” of **Ex2-2** refers to an answer of **Ex2-1**(ブッシュ). Therefore, **Ex2-2** should be “ ブッシュの出身地はどこですか。 ”.

(2) An obligatory case element of verb is zero anaphora

In this pattern, an obligatory case element of verb of the follow-up question is omitted, and the omitted element is a zero anaphora which refers to a word used in the previous question or an answer of the previous question. An example of this pattern is as follows:

Ex3-1 アメリカの大統領は誰ですか。
Ex3-2 いつ就任しましたか。

Verb “ 就任する ” has two obligatory case frames *agent* and *goal*, and the elements of each case frame are omitted. The element of *agent* is the answer of **Ex3-1**, and the element of *goal* is “ 大統領 ” of **Ex3-1**. Therefore, **Ex3-2** should be “ (the answer of **Ex3-1**) はいつ大統領に就任しましたか。 ”.

(3) Modifier or modificand is zero anaphora

When two words are in modification relation in a follow-up question and they includes topicalized element of the question, the modifying element or the modified element used in a previous question is omitted, and the omitted element is zero anaphora. We call the modifying element modifier and we call the modified element modificand. The following example shows that modifier is zero anaphora.

Ex4-1 アメリカの大統領は誰ですか。
Ex4-2 国務長官は誰ですか。

Ex4-2 should be “ アメリカの国務長官は誰ですか。 ”. Then, “ アメリカ ” is modifier of “ 国務長官 ”, and “ アメリカ ” is used in **Ex4-1**. Therefore, “ アメリカ ” of **Ex4-1** is omitted in **Ex4-2**.

The following example shows that modificand is zero anaphora.

Ex5-1 アメリカの大統領は誰ですか。
Ex5-2 フランスは誰ですか。

Ex5-2 should be “ フランスの大統領は誰ですか。 ”. Then, “ 大統領 ” is modificand of “ フランス ”, and

“ 大統領 ” is used in **Ex5-1**. Therefore, “ 大統領 ” of **Ex5-1** is omitted in **Ex5-2**.

3.2 How to resolve references

3.2.1 Overview of the method

We will show our method which resolves references of these patterns. For the first pattern, we replace the pronoun with a word which referred by it. For the second pattern, we try to fill up obligatory case frames of the verb. For the third pattern, we take a word from the previous question based on co-occurrence frequency. We assumed that the antecedent of anaphora of follow-up question exists in a question which appears just before, so the “previous question” indicates immediately previous question in our method. We show the process as follows:

Step1 Recognition of reference pattern:

When a follow-up question has some pronoun, we will recognize it is in the first pattern. When a follow-up question has a verb, it is in the second pattern. When a follow-up question does not have pronoun and verb, it is in the third pattern.

Step2 Recognition of antecedent type:

- In the case of the first pattern:
  We will recognize antecedent type from pronoun type. For example, if pronoun is personal one such as “ 彼 ”, the type is person. If pronoun is *rentaishi* such as “ その ” and modifies its next noun, we will recognize antecedent type using the noun information.
- In the case of the second pattern:
  We will recognize antecedent type from information of omitted obligatory cases of the verb. This verb information is from EDR Japanese Cooccurrence Dictionary.
- In the case of the third pattern:
  We will firstly extract topicalized element with Japanese particle “ は ” and check co-occurrence of antecedent candidates and the topicalized element using EDR Japanese Cooccurrence Dictionary. If there is co-occurrence in the dictionary, the rightmost position word in the candidate list will be antecedent element. If not, the major concept type in the set of co-occurred words will be antecedent type.

Step3 Selection of the antecedent:

If an antecedent is not determined in Step2, we will select antecedent from the candidate list using the chosen antecedent type. An answer word of the previous question is included in the candidate list (as rightmost position). In this selection, we will use EDR Japanese Word Dictionary. If there are many elements, we will choose the rightmost position word. Then, we will determine position of this antecedent in follow-up question.

If the system fail to match the above conditions, the following exception rules will be applied:

a) When there is no topicalized element in follow-up question, system recognize topicalized element of the previous question will be antecedent.

b) When there is a topicalized element in follow-up question, system recognize modifier of topicalized element of the previous question will be antecedent.

3.2.2 The details of type recognition using EDR dictionaries

In reference resolution method, we have to recognize antecedent type, in Step2 and 3. For this purpose, we have used EDR dictionaries: Japanese Word Dictionary, Concept Dictionary and Japanese Cooccurrence Dictionary. We will show how EDR dictionaries are used to recognize antecedent type, omitted case of verb and position in follow-up question as follows:

Recognition of antecedent type

We have used EDR Japanese Word Dictionary and EDR Concept Dictionary. Japanese Word Dictionary records Japanese words and its detailed concept as Concept Code. Concept Dictionary records each Concept Code and its upper concept. We will use concept type as antecedent type. When a word is found in Japanese Word Dictionary, its upper concept will be selected as antecedent type using Concept Dictionary. In our current implementation, we used the second or third level concept from root one (about 10 concepts).

For example, Concept Code of a word “ 会社 ” is 3ce735 (a group of people combined together for business or trade). According to the Concept Dictionary, 3ce735 belongs to 3aa912 which means *agent* (self-functioning entity). Then, type of “ 会社 ” is an *agent*.

Recognition of omitted case of verb

In EDR Japanese Cooccurrence Dictionary, there are co-occurrence data which consist of verb, concept code of case and case marker of Japanese particles. If co-occurrence data is found by a verb information, its case markers of the data will be recognize as omitted case and upper case of its concept code will used for antecedent types. All the data whose case marker

did not appear in follow-up question are used for this recognition.

For example, according to the Japanese Cooccurrence Dictionary, a verb " 就任する " has two case frames, *agent* (30f6b0) and *goal* (3f98cb or 3aa938), and *agent* is used with particle " が ", *goal* is used with particle " に ". If question does not have any " が " or " に " (ex: " いつ就任しましたか。 "), we found that *agent* and *goal* are omitted.

Recognition of position in follow-up question

There are two ways to put the selected antecedent to topicalized element of follow-up question. One is to modify topicalized element and the other is to be modified by topicalized element. That is, antecedent will be modifier (A) and modificand (B) of " A の (no) B " pattern in the first and second case, respectively. In order to recognize it, we used co-occurrence data of " A の (no) B " pattern extracted from Japanese Cooccurrence Dictionary. If antecedent exists in the slot of " A " of the data, it will be modifier. If antecedent exists in the slot of " B " of the data, it will be modificand. If both case or no case, it will be determined by the number of data.

3.2.3 Examples of reference resolution

We will show above examples again as example of reference resolution as follows:

Example of reference resolution of first pattern[1]

Ex1-1 アメリカの大統領は誰ですか。
Ex1-2 そこが独立したのはいつですか。
Ex1-2' アメリカ が独立したのはいつですか。

In the above example, **Ex1-2** has a pronoun " そこ ", so we classified reference pattern of **Ex1-2** into the first pattern as step1. Next, we recognize that the pronoun " そこ " refers organization or location as step2. Then, we select the antecedent from the answer and the words of **Ex1-1** as step3. The answer type of **Ex1-1** and " 大統領 " are not organization or location, " アメリカ " is location. Therefore we determine that the antecedent is " アメリカ " and replace " そこ " of **Ex1-2** with " アメリカ " . Then **Ex1-2** becomes " アメリカの大統領は誰ですか。 " .

Example of reference resolution of second pattern

Ex3-1 アメリカの大統領は誰ですか。
Ex3-2 いつ就任しましたか。
Ex3-2' (answer of **Ex3-1**) は いつ 大統領に 就任しましたか。

In the above example, **Ex3-2** has a verb " 就任する ", so we classified reference pattern of **Ex3-2** into the second pattern. We recognize that " 就任する " has two obligatory case frame *agent* (human) and *goal* (managerial position). **Ex3-2** does not have word which is suitable for obligatory cases of " 就任する ". Therefore we recognize that the *agent* and the *goal* are omitted and they are zero anaphora. Then, we select the antecedents of each case from the candidates of **Ex3-1**. The answer type of **Ex3-1** is human, so it is suitable for the *agent*. The type of " 大統領 " is managerial position, so it is suitable for the *goal*. Finally, we take the answer of **Ex3-1** and " 大統領 " to **Ex3-2** and **Ex3-2** becomes " (answer of **Ex3-1**) はいつ大統領に就任しましたか。 " .

Example of reference resolution of third pattern

Ex4-1 アメリカの大統領は誰ですか。
Ex4-2 国務長官は誰ですか。
Ex4-2' アメリカの 国務長官は誰ですか。

In the above example, **Ex4-2** does not have any pronoun and verb, so we classified reference pattern of **Ex4-2** into the third pattern. Then we search " noun の国務長官 " and " 国務長官の noun " pattern from the Japanese Cooccurrence Dictionary. In the Japanese Cooccurrence Dictionary, we can find " アメリカの国務長官 " pattern. " アメリカ " is used in **Ex4-1**, so we take " アメリカ " to **Ex4-2** and **Ex4-2** becomes " アメリカの国務長官は誰ですか。 ".

4 Evaluation

4.1 Evaluation method

The following examples show question sets of the Formal Run and Reference Run. In **Qm-n**, m and n indicates series ID and its question number which we gave and **Rm-n** indicates a question which correspond to **Qm-n**.

Questions of Formal Run

Q1-1 富士山レーダーはいつ設置されましたか。 (QAC3-30038-01)
Q1-2 どういう目的で設置されましたか。 (QAC3-30038-02)
Q1-3 富士山の何処にありましたか。 (QAC3-30038-03)
Q1-4 どのような表彰を受けましたか。 (QAC3-30038-04)

Questions of Reference Run

R1-1 富士山レーダーはいつ設置されましたか。 (QAC3-31267-01)
R1-2 富士山レーダーはどういう目的で設置されましたか。(QAC3-31268-01)
R1-3 富士山レーダーは富士山の何処にありましたか。(QAC3-31269-01)
R1-4 富士山レーダーはどのような表彰を受けましたか。(QAC3-31270-01)

[1] **Exm-n'** indicates complemented question of **Exm-n**

In IAD task, there were several questions of one series, and follow-up questions have anaphora. In our method, we assumed that the antecedent of anaphora exists in its just before question. For example, the antecedent of **Q1-2** is " 富士山レーダー " of **Q1-1**. The antecedent of **Q1-4** is " 富士山レーダー " of **Q1-1** actually, however, if **Q1-3** is completed correctly (as **R1-3**), " 富士山レーダー " exists in **Q1-3**. We prepared 310 pairs of evaluation data each of which consists of a question of Reference Run and a question of Formal Run. For example, **R1-1** and **Q1-2** is one pair of the evaluation data. Correctness have been judged by human. When the system must take an answer of previous question, we have used " <ANS> ". In the Formal Run, we have replace " <ANS> " with the 1st answer of core QA. In the evaluation, considering core QA's failure, we have left " <ANS> " and considered as correct.

4.2 Results

Our system could resolve 52 references correctly in 310 questions. There are 24 of them were processed by our reference resolution method only and 28 of them were processed by exception handling. The following list shows evaluation results of each reference pattern.

- Reference of pronoun:
  System classified 88 of 310 questions in this pattern. The classification was 100% correct and reference resolution succeeded in 13.6% (12 questions).
- An obligatory case element of verb is zero anaphora:
  System classified 158 of 310 questions in this pattern. The classification was 66.5% (105 questions) correct and reference resolution succeeded in 7.6% (8 questions).
- Modifier or modificand is zero anaphora:
  System classified 64 of 310 questions in this pattern. The classification was 68.8% (44 questions) correct and reference resolution succeeded in 9.1% (4 questions).

We will show the major failing reasons of each step and their numbers of cases. The detail will be discussed later.

Failure of classification of reference pattern

- System used wrong verbs · · · 29
- All obligatory cases of verb was filled and other element was omitted · · · 22
- Failure of morphological analysis · · · 8
- An adjective phrase was zero anaphora · · · 1

Failure of recognition of antecedent type

- The verb was not in the Japanese Cooccurrence Dictionary · · · 35
- Lack of rule for reference of pronoun · · · 17
- System filled up to case already filled · · · 15
- Any modifier or modificand did not exist in the Japanese Cooccurrence Dictionary · · · 10
- Case frame element was omitted and system overlooked it · · · 7
- A modifier or modificand which had lower co-occurrence frequency should be taken · · · 7
- Verb was passive · · · 6
- Zero anaphora was not in the modification relation which included the topicalized element · · · 6
- Omitted obligatory case was not zero anaphora · · · 2

Failure of selection of antecedent

- System failed to recognize type of candidate of antecedent of previous question · · · 79
- System failed to decide to range of taken word · · · 21
- System took a word in inquiring expression · · · 6
- The antecedent was not the rightmost position · · · 3

4.3 Discussions

Our system could work well for some reference resolutions of questions. We will discuss the major failing reasons with examples[2] as follows:

System used wrong verbs

Fq1 インドネシアの津波で家屋は何件倒壊しましたか。(QAC3-31228-01)
Oq1 津波発生の原因となった地震のマグニチュードはいくつですか。(QAC3-30032-05)
Sq1 津波が 津波発生の原因となった地震のマグニチュードはいくつですか。

In the above example, system found a verb " なる " of **Oq1** and tried to fill up its obligatory case. The

[2] **Fqx** and **Oqx** are pair of questions. **Fqx** indicates question of Reference Run as former question. **Oqx** indicates original question of Formal Run as follow-up question. **Sqx** indicates system output of **Qqx**.

agent of “ なる ” was omitted and the system recognized that “ 津波 ” of **Fq1** was suitable to the case, so the system took it as antecedent. However, system should have taken “ インドネシア ” of **Fq1**. It was referred by zero anaphora modifier of “ 津波 ” of **Oq1**. The reason of this failure was to handle general verbs for reference resolution. In Japanese, very general verbs may be used accessorily. For example, “ どのくらいいますか ” has “ いる ”, “ 何という人ですか ” has “ いう ”, etc... These verbs is not used as central element of questions, so we should not have used them for reference resolution even if their obligatory case element have been omitted. If we do not use these verbs, this failure will not occur.

All obligatory cases of verb was filled and other element was omitted

Fq2 ＵＳＪの最寄りの駅はどこですか。(QAC3-31166-01)
Oq2 オープン初日のフィルムカット式に出席した俳優は誰でしたか。(QAC3-30024-03)
Sq2 オープン初日のフィルムカット式に出席した俳優は誰でしたか。

In the above example, system found a verb “ 出席する ” of **Oq1** and tried to fill up its obligatory case. All obligatory cases of “ 出席する ” was already filled, so the system did not take any antecedent. However, system should have taken “ ＵＳＪ ” of **Fq2** which is modifier of “ オープン初日 ” of **Oq2**. We supposed that when a follow-up question has some verb, zero anaphora was only the case of verb, so system could not resolve reference. If the case frame of verb is already filled, we should search other zero anaphora.

Failure of morphological analysis

Fq3 海遊館にはこれまでにどれくらいの人が訪れましたか。(QAC3-31277-01)
Oq3 そこで人気なのはどんな魚ですか。(QAC3-30039-05)
Sq3 人の そこで人気なのはどんな魚ですか。

In the above example, **Oq3** had a pronoun “ そこ ”, so system had to replace it with its referring word, but system did not it. The cause was that morphological analyzer ChaSen recognized that “ そこで ” is conjunction, but it was pronoun “ そこ ” + particle “ で ”. Therefore we could not find the pronoun. If ChaSen works well, we can use the information that “ そこ ” refers some location or organization. Then, system will replace “ そこ ” with “ 海遊館 ” of **Fq3**, because “ 海遊館 ” indicates location.

An adjective phrase was zero anaphora

Fq4 スヌーピーをイメージキャラクターにしているホテルはどこですか。(QAC3-31101-01)
Oq4 銀行はどこですか。(QAC3-30015-03)
Sq4 <ANS> の 銀行はどこですか。

In the above example, System recognized that the answer of **Fq4** was antecedent of zero anaphora modifier of “ 銀行 ”. However, the actual antecedent was an adjective phrase “ スヌーピーをイメージキャラクターにしている ” of **Fq4**. In the current implementation, system can not handle adjective phrases as elliptical element.

The verb was not in the Japanese Cooccurrence Dictionary

Fq5 チャールズ皇太子は何歳ですか。(QAC3-31031-01)
Oq5 ダイアナ妃とはいつ結婚しましたか。(QAC3-30005-02)
Sq5 何歳の ダイアナ妃とはいつ結婚しましたか。

In the above example, system found a verb “ 結婚する ” of **Oq5** and tried to fill up its obligatory case. However, the verb information of “ 結婚する ” was not in EDR dictionary, so system took “ 何歳 ” of **Fq5** as antecedent by the exception routine.

Lack of rule for reference of pronoun

Fq6 宇宙ステーション「ミール」で研究を行った日本人には誰がいますか。(QAC3-31214-01)
Oq6 この宇宙ステーションはいつ廃棄されましたか。(QAC3-30030-06)
Sq6 No output

In the above example, system tried to replace “ この ” with its referring word. However, we did not have rule for some pronoun (ex: ここ, この), so the system did not output anything. We have to expand reference resolution rule for pronoun.

System filled up to case already filled

Fq7 阿川佐和子がキャスターをしていたのはどこのテレビ局ですか。(QAC3-31206-01)
Oq7 初めて書いた長編小説は何ですか。(QAC3-30029-05)
Sq7 阿川佐和子が キャスターを キャスターに 初めて書いた長編小説は何ですか。

In the above example, system found a verb “ 書く ” of **Oq7** and tried to fill up its obligatory case. “ 書く ” has three obligatory cases: *agent*, *object* and *goal*. System recognized that every obligatory case element were omitted, and took “ 阿川佐和子 ”, “ キャスター ”, “ キャスター ” as antecedents respectively. However the *object* of “ 書く ” was not omitted. “ 長編小説 ” of **Oq7** was the *object*. According to EDR dictionary, the case marker of *object* of “ 書く ” is “ を ”, but “ 長編小説 ” of **Oq7** appeared with “ は ”, so system could not recognize that “ 長編小説 ” was *object* of “ 書く ”. If we add case marker patterns for recognition of omitted case element, we can recognize the omitted case correctly. In passing, system tried to fill up the *goal* and take “ キャスター ” to it. It is other failure. We will show it at following **Fq12**, **Oq12**, **Sq12**.

Any modifier or modificand did not exist in the Japanese Cooccurrence Dictionary

Fq8 日光東照宮の例大祭は毎年
いつ行われるのですか。(QAC3-31235-01)
Oq8 ハイライトは何ですか。(QAC3-30033-06)
Sq8 日光東照宮の ハイライトは何ですか。

In the above example, system checked co-occurrence of antecedent candidates and the topicalized element " ハイライト " of **Oq8**. However, no co-occurred word with " ハイライト " was recorded in EDR dictionary, so we could not use co-occurrence data. Then system took " 日光東照宮 " of **Fq8** as antecedent by the exception routine, but the actual antecedent was " 例大祭 " of **Oq8**. We can solve this problem by using corpus which has more information.

Case frame element was omitted and system overlooked it

Fq9 コリン・パウエルのレーガン政権での
役職は何ですか。(QAC3-31090-01)
Oq9 ベトナム戦争当時はどこに所属して
いましたか。
(QAC3-30013-06)
Sq9 ベトナム戦争当時はどこに所属して
いましたか。

In the above example, system found a verb " 所属する " of **Oq9**, and tried to fill up its obligatory cases. In this case, the *agent* of " 所属する " of **Oq9** (" コリン・パウエル " of **Fq9**) was omitted and we had to take it. However, because " ベトナム戦争当時 " appeared with case marker " は ", system mistook " ベトナム戦争当時 " for *agent*, and recognized that any case frame element were not omitted. " ベトナム戦争当時 " indicates *time* information, and it was not suitable to obligatory case of the verb. We should have ignored *time* information for obligatory case of verb.

A modifier or modificand which had lower co-occurrence frequency should be taken

Fq10 破壊されたバーミヤン遺跡の大石仏像は
何体でしたか。(QAC3-31048-01)
Oq10 大きさはどのくらいですか。
(QAC3-30007-05)
Sq10 破壊の 大きさはどのくらいですか。

In the above example, because the words which was same type as " 破壊 " co-occurred with " 大きさ " at highest frequency, system recognized that " 破壊 " of **Fq10** was antecedent of **Oq10** and system took " 破壊 ". However, in this case, we have to take " 大石仏像 ". The words which was same type as " 大石仏像 " co-occurred with " 大きさ " at lower frequency than " 破壊 ", so the system failed to select taken word. If we allow taking a modifier or modificand which does not have highest co-occurrence frequency, we can handle these case.

Verb was passive

Fq11 バーミヤン遺跡の仏像などが
破壊されたのはいつですか。(QAC3-31047-01)
Oq11 破壊された大石仏像は何体でしたか。
(QAC3-30007-04)
Sq11 0 が 破壊された大石仏像は何体でしたか。

In the above example, system output an error code " 0 ". Because the verb " 破壊される " of **Oq11** was passive and we did not have a rule for passive verb. If we analyze the case that verb is passive, we can cope with it.

Zero anaphora was not in the modification relation which included the topicalized element

Fq12 「Ｈ２Ａ」ロケットは何に
利用されるのですか。(QAC3-31243-01)
Oq12 一回の打ち上げ費用はいくらですか。
(QAC3-30034-07)
Sq12 利用の 一回の打ち上げ費用はいくらですか。

In the above example, system took " 利用 " of **Fq12** as antecedent of zero anaphora modifier of topicalized element " 費用 " of **Oq12**. However, in this case, " 費用 " did not have zero anaphora modifier actually, and the " 打ち上げ " of **Oq12** had zero anaphora modifier. The antecedent of zero anaphora was " 「Ｈ２Ａ」ロケット ". We supposed that a zero anaphora is in the modification relation which included the topicalized element, it was cause of failure. If we handle zero anaphora modifier and modificand in modification relation which does not include topicalized element of follow-up question, we will resolve this problem.

Omitted obligatory case was not zero anaphora

Fq13 阿川佐和子がキャスターをしていたのは
どこのテレビ局ですか。(QAC3-31206-01)
Oq13 初めて書いた長編小説は何ですか。
(QAC3-30029-05)
Sq13 阿川佐和子がキャスターを キャスターに
初めて書いた長編小説は何ですか。

The above example is same as **Fq7**, **Oq7**, **Sq7**. System tried to fill up the obligatory cases of " 書く " of **Oq13**. " 書く " has three obligatory cases: *agent*, *object* and *goal*, and the *agent* and the *goal* were omitted (and we have explained about *object* case). Then, system tried to fill up the *agent* and the *goal* of " 書く ", and took " 阿川佐和子 " and " キャスター " respectively. However, the *goal* was not zero anaphora, we did not have to take any word to *goal*. We supposed that the every omitted case is zero anaphora, it was the cause of failure.

System failed to recognize type of candidate of antecedent of previous question

Fq14 静岡スタジアム「エコパ」の
こけら落としで清水エスパルスと対戦したのは
どこですか。(QAC3-31133-01)
Oq14 そのチームの設立はいつですか。
(QAC3-30019-04)
Sq14 エスパルス の設立はいつですか。

In the above example, system tried to replace " そのチーム " of **Oq14** with its antecedent. Then system recognized that the antecedent is " エスパルス " of **Fq14**. However " そのチーム " refers the answer of the **Fq14** actually. System failed to recognize the answer type of **Fq14** so the system could not resolve reference of **Oq14**. If the recognition of type of antecedent is improved, it will be solved.

System failed to decide to range of taken word

Fq15 岐阜県長良川の鵜飼いは何時代に
始まったものですか。(QAC3-31296-01)
Oq15 それに訪れた年間観光客がピークと
なったのは何年ですか。(QAC3-30042-04)
Sq15 鵜飼い に訪れた年間観光客が
ピークとなったのは何年ですか。

In the above example, system replaced " それ " of **Oq15** with " 鵜飼い " **Fq15**, and it was correct. However, in this case, we have to take the modifier of " 鵜飼い " (" 岐阜県長良川の ") too. We supposed that the antecedent is only a word, it was cause of failure. Then we should consider that the antecedent is not only a word but also including its modifier.

System took a word in inquiring expression

Fq16 アラビア石油はどんな会社ですか。
(QAC3-31117-01)
Oq16 そこが何という油田の採掘権を
失ったのですか。(QAC3-30017-02)
Sq16 会社 が何という油田の採掘権を
失ったのですか。

In the above example, system replaced " そこ " of **Oq16** with " 会社 " of **Fq16**. " そこ " refers some organization or location, and " 会社 " indicates organization, so system recognized that " 会社 " is antecedent of " そこ ". However, in this case, " 会社 " was a part of an inquiring expression of **Oq16**. A word of inquiring expression is not proper for an antecedent of reference in question sentences, so we should have ignored it.

The antecedent was not the rightmost position

Fq17 コリン・パウエルは誰に国務長官に
指名されたのですか。(QAC3-31087-01)
Oq17 彼の政治的な立場はどのような
ものですか。(QAC3-30013-03)
Sq17 <ANS> の政治的な立場はどのような
ものですか。

In the above example, system replaced " 彼 " of **Oq17** with the answer of **Fq17**, because " 彼 " refers human and the answer type of **Fq17** is human and the answer of **Fq17** was rightmost candidate of antecedent. However, " 彼 " referred " コリン・パウエル ". In this case, " コリン・パウエル " was the topic of **Fq17**, so " コリン・パウエル " should be preferred to the answer of **Fq17**. If we improve the rule which decides priority of antecedent candidates, this problem will be solved.

5 Conclusion

In this paper, we have presented reference resolution method for follow-up questions in IAD task. We have classified reference pattern of question sentences into three types and proposed reference resolution method for each type. In the evaluation of Formal and Reference Runs, performance of our method was not better results than our expectation. However, according to the analysis of evaluation results, the main reason of not enough performance was lack of word information for recognition of referential elements. If our system could recognize word meanings correctly, reference resolution would work well.

We are now improving our reference resolution method based on statistical measurement of word meaning using co-occurrence data extracted from corpus. We have already integrated recognition mechanism of target question into our method. Then, our system can search antecedent from the previous questions. However, we have not tested this new algorithm using test correction. In future work, we will test this algorithm and apply it for other QA application.

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