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状況を用いた名詞句照応解析のための試論

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概 要

通常、名詞句はその発話により指示対象と結びつけられるが、特に量化や否定の表現を伴う文章中では名詞句の指示対象は存在しない場合がある。これらの名詞句の働きは発話者が言及している指示対象を推論するための重要な役割をになう。本論文では、談話のテキスト状況を各名詞句から抽出し、状況理論の考え方に基づき、その状況のもとでの制約を名詞句照応解決の一手段として適用する。そしてその結果から名詞句が指示対象を持つか否かの機能を推論し、指示対象が存在する場合にはそれを同定することで、否定詞、量化子のスコープ、その他の非明示的な情報を推測する。

Analyses of Nominal Anaphora using Situations — A Trial

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Abstract

When one utters a noun phrase, the referent of the noun phrase usually exists. However, in a sentence with quantification or negation, it may not exist. In such utterances, it is important to determine if the noun phrase has its referent when we infer what the utterer describes. In this paper, we extract "textual situation" from noun phrases in discourse, then, following situation theory, use constraints to automatically dissolve nominal anaphoric mechanisms. Moreover, we infer the scope of negation or quantification, and some other implicit information surrounding the discourse by applying the anaphoric relation.

1 Introduction

In natural language understanding, various ambiguities cause difficulties in determining the meaning of sentences. In this paper, we focus on nominal anaphoric mechanisms, one of the ambiguities observed in written and spoken discourse. To dissolve the anaphoric mechanisms, it is necessary to understand the information carried by the sentence but not explicitly specified by the written/spoken sentence itself. To represent the cognitive mechanism of human being, we adopt the Situation Theoretic idea. In particular, the idea of "constraint" plays the major role.

Our aim is to reduce ambiguity in a sentence to a minimum by dissolving anaphoric relations and identifying referents.

2 Varieties of Ambiguity

There are many kinds of ambiguities in discourse analysis. We will show that some of them are related to nominal anaphora, quantification, and negation, following Westerståhl[1].

- *absorption ambiguity*:
  In the case of utterance[1] of an indefinite noun phrase, particular in a sentence with negation or quantification, the noun phrase may not have a referent. In this case, the noun phrase is absorbed, otherwise, it is anchored.
- *linking ambiguity*: This is the ambiguity where which antecedent the pronoun links with.
- *quantifier scope ambiguity*: This is the well-known ambiguity in quantification.
- *polarity ambiguity*: This is the ambiguity which occurs in a sentence with negation.

3 On Situation Semantics and Situation Theory

Situation semantics was first proposed by J.Barwise and J.Perry in 1980's. In situation semantics, efficiency of information , that is the features that one utterance is interpreted in different ways depending on situations, is important, and it constitutes the key concept([6]).

Situation theory is a theory to be used to construct mathematical tools to fix such situations above[3]. Though there have been some attempts to explain anaphora in the framework of situation semantics or situation theory ([4, 1]), few of these have been implemented for computer processing([5]).

Constraints would provide the basis for a naturalistic theory of meaning and information ([2, 6]). In developing a computer-processing system on the basis of situation theory, constraints can be exploited to give the system various kinds of real world knowledge. While Barwise and Perry presented four kinds of constraints[2], we simply classify those into two kinds: *unconditional constraints* which hold in any situations; and *conditional constraints* which hold or do not hold depending on the situation. Some of these constraints are violable and others are inviolable.

3.1 Situation Theoretic Account of NPs

According to [4, 8], when a noun phrase is uttered, either (a)the parameter is newly introduced or (b)the parameter is already provided, or (c)the parameter is absorbed. The function of indefinites is likely to be (a), definites and pronoun to be (b), and the function of indefinites in a scope of quantification or negation to be (c).

The treatment of definite and indefinite noun phrases here is different from the traditional account in formal semantics which treats them as quantified noun phrases.

4 Tools to Build the System

4.1 Textual Situation

4.1.1 Basic Concept

As one of the means to dissolve anaphoric mechanisms, we adopt the idea of Textual Situation which infers the utterer's implied presumption in expressing the current fragment from the text itself. It can be accounted as

[1]We use expressions "utterer' and "utterance" for both written and spoken fragments.

a part of the *utterance situation* in situation theory. We use this situation as a "condition" of constraints.

4.1.2 Method to Extract "Textual Situation"

In our system, most common nouns are respectively given some textual features in the dictionary; for example, nouns which are related to a school, such as teacher, student, blackboard, etc., have a feature "*school*". Next, we evaluate "textual situations" for each sentence based on those features carried by the nouns in the sentence.

A formula of "exponential smoothing" is applied to evaluate textual situations so that the expression nearer to the sentence under consideration will put greater influence on the situation and exponentially smaller influences on the farther situations. The formulae are as follows.

forward evaluation

$$\hat{y}_t = \alpha y_t + (1-\alpha)\hat{y}_{t-1},$$

where

$0 \leq \alpha \leq 1$,

$y_t = \frac{m}{n}\alpha \sum_{i=1}^{n}(1-\alpha)^{i-1}$,

n = number of nouns having some textual features in the sentence under consideration

m = number of nouns having the textual features under consideration

t = the index of sentence in the order of utterances, $0 \leq t \leq T$,
t=1 for the first sentence
t=T for the current sentence

$\hat{y}_0 = 0$.

backward evaluation

$$\hat{z}_t = \alpha z_t + (1-\alpha)\hat{z}_{t+1},$$

where

z_t is defined likewise as y_t,

$\hat{z}_{T'+1} = 0$,

T' = the index of the last sentence of current paragraph.

forward + backward evaluation

$$\hat{x}_t = \beta\hat{y}_t + (1-\beta)\hat{z}_t,$$

where $1/2 \leq \beta \leq 1$.

4.2 Constraint System

Our constraint system which represents linking relations is built in accordance with the Text Rules in [1]. However, since those text rules are basic, we add some other rules. Some rules are built based on traditional accounts of pronouns, i.e. "a reflexive pronoun must co-refer with its S" (*rule3*) or "a personal pronoun must not co-refer within its S" (*rule4*).

4.2.1 Text Rules

Let LP_i be a list of parameters in sentence i, LP_i^j be a list of parameters in sentence i to j, and CS_i be a list of constraint system in sentence $1 \cdots i$.

AN stands for anchor, AB for absorb, L (note[2]) for link_with, CP for co-parametric.

If $ANx \rightarrow yLx$, then $yCPx$ (note[3]).

CS_i is formed by adding linking constraint to CS_{i-1}, i.e., $CS_{i-1} \bigcup CS_i$ as follows:

rule1: If a parameter $x \in LP_i$ does not match a parameter $y \in LP_1^{i-1}$ with respect to person, gender or number , add $\neg xLy$.

rule2: For every pronoun parameter $z \in LP_i$, let X_i be the string of earlier parameters in LPi, and add $AN_z \rightarrow zLX_z$ if this string is non-empty, otherwise add AB_z.

rule3: For every reflexive pronoun parameter $v \in LP_i$, $\exists w \in X_i$, and add $AN_v \rightarrow vLw$, and, for every parameter $y \in LP_1^{i-1}$, add $\neg vLy$.

rule4: For every personal pronoun parameter $p \in LP_i$, and for every parameter $y \in LP_i$ where $y \neq p$, add $\neg pLy$.

rule5: For every pronoun whose case is possessive, only *rule1* is applicable.

4.2.2 Order of the Constraint Systems

In CS_i, if one parameter has more than one constraint system (i.e. has several candidates of antecedents) and the antecedents can not link each other, an order representing the

[2] 2-ary relation L is reflexive, symmetric, and transitive.

[3] in this paper, the term "co-parametric" is applied instead of the term "co-anchored" in [1], since co-parametric anaphora can be non-referential [4].

possibilities of linkedness is given. The ordering methods are as follows:

Let x be a parameter under consideration and Y be the list of possible candidates of antecedents. If x has an attribute and there is a parameter $y \in Y$ which has the same attribute, prioritize the constraint system xLy.

For other parameters in Y, we use several heuristics as follows:

Focus of utterer: In the current system, the simple method is applied, i.e., the focus of utterer may be the subject in a sentence, and when indefinite noun phrase is introduced, the focus may move to the new word, since an indefinite noun phrase can have information that new resource situation is introduced by the utterance([8]). Information about the focus would be a part of resource situation perceived by the speaker([2]).

Recency rule for subject: For this rule, we simplify the rule which is shown in [7]. If the parameter under consideration occurs in the subject position and there is a parameter $y \in Y$ which occurs as the last constituent in the previous sentence, prioritize xLy.

As the default value, an order is given according to recency.

5 Effect of Anaphora Resolution

When the anaphoric mechanisms are dissolved, the result reveals some latent information. Some examples are shown as follows:

• *scope of negation*

Suppose a sentence:

John didn't eat a biscuit. ,

the content is [4]:

$$s \models\ll \mathrm{T1},\ j_{\ll \mathrm{named},j,\text{"John"}\gg} \gg.$$

When some parameter in the text links with the NP "a biscuit", this sentence is read "co-parametric", so that the content of VP is:

$\mathrm{T1}= [x| \ll \mathrm{EATING},$

$$x, y_{r\models\ll \mathrm{BISCUIT},y\gg;0} \gg].$$

While no parameter can be linked with it, this NP is to be absorbed and, therefore, does not have a referent. In this case, the content would be more natural:

$\mathrm{T1}= [z| \ll [x, y| \ll \mathrm{EATING},$

$$x, y_{r\models\ll \mathrm{BISCUIT},y\gg} \gg], z{:}0 \gg].$$

• *meaning of elliptical VP*

Given the following sentence:

John$_i$ loves *his*$_i$ wife and Bill does, too. ,

the content is:

$$s \models\ll \mathrm{T2},\ j \gg \wedge \ll \mathrm{T2},\ b \gg.$$

When some parameters in the text link with NP "his wife", this sentence is read "co-parametric", so that the content of VP is:

$\mathrm{T2}= [x| \ll \mathrm{LOVE}.\ x, y_{r\models\ll \mathrm{WIFE\text{-}OF},y,j\gg} \gg].$

In this case, we can read the sentence "John loves John's wife and Bill loves John's wife."

For the reading of "John loves John's wife and Bill loves Bill's wife", the parameter for "his wife" would be absorbed by the Absorption Principle which rules out absorbed parameters occurring in a restrictions on other parameters ([4]).

The VP content is:

$\mathrm{T2}= [x, y| \ll \mathrm{LOVE},$

$$x, y_{r\models\ll \mathrm{WIFE\text{-}OF},y,x\gg} \gg].$$

We can infer this reading when no parameter is linked with the NP "his wife".

• *scope of quantifiers*

Given a sentence:

Every Japanese loves his mother.,

the content is:

$\ll \mathrm{EVERY},\ [y|s \models\ll \mathrm{Japanese},\ y \gg],\ \mathrm{T3} \gg.$

When some parameter in the text is linked with the NP "his mother", this sentence is read "co-parametric", so that the content of VP is:

$\mathrm{T3}= [y| \ll \mathrm{LOVE},$

$$y, z_{\ll \mathrm{MOTHER\text{-}OF},z,u_{\ll \mathrm{MALE},u\gg}\gg} \gg].$$

In this case, the NP "his mother" is not under the scope of the quantifier.

[4] Notations of contents in this paper follows [4].

Otherwise, if "every" scopes over "his mother" , the content is:
T3= $[y, z| \ll$ LOVE,

$$y, z_{\ll\text{MOTHER-OF},z,y_{\ll\text{MALE},y\gg}\gg} \gg].$$

And no parameter can indicate this NP from sentences following thereafter, since it has been absorbed.

6 Implementation

Algorithms are shown in the following (see figure1);

- step0 *input text*
  Polarity, tense, and textual features are gathered by morphological analysis and syntactical analysis.
- step1 *intra-sentential semantic analysis*
  Information related to anaphora is given by variables at this stage.
- steps 2 through 6 *inter-sentential semantic analysis*

- step 2 Let n be the sentence number under consideration.
- step 3 Let *Fnp* be a collection of nouns in sentence 1 to n, and *Bnp* a collection of nouns in the current paragraph.

  If sentence number $n \geq 2$, and there is a pronoun in sentence n, check features; number, gender etc., and build a constraint system.
- step4 Evaluate the textual situation from *Fnp* and *Bnp*, and if constraints is applicable, attribution of the nouns will be inferred. Add the attributive information to the constraint system.
- step5 Give an order to the constraint system. Then goto step2 for the analysis of the next sentence, or step6 if n = number of the last sentence.
- step6 Constraint systems are displayed and scope of negation and quantification is inferred.

6.1 Sample Fragment

The result of applying our system to some simple text from [1][5] is shown as follows. It

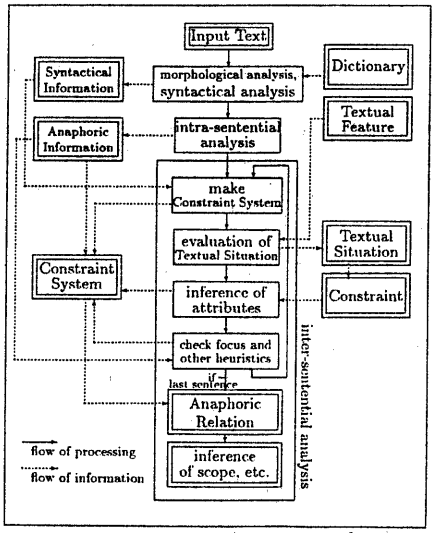

figure 1

shows our method works properly and reduces ambiguities shown in [1].

```
Sample text
     1 John took English.
     2 He didn't talk to a teacher.
     3 He wrote a report.
Constraint System:
     AN sub2 -> sub2 L obj1,[6]
     AN sub3 -> sub3 L sub1,
     AN sub3 -> sub3 L sub2,
     AN sub3 -> sub3 L obj2
Therefore,
CS = sub2 CP sub1 .AND. (sub3 CP sub1
          .OR. sub3 CP obj2)
Constraint from textual situation:
```

$S_{\ll\texttt{uttered-about, utterer, school}\gg} \models$
$[e_1|e_1 \models \ll\texttt{write-a-report},subj \gg] \rightarrow$
$[e_2|e_2 \models \ll\texttt{be-a-student},\ subj \gg]$

$S_{\ll\texttt{uttered-about, utterer, school}\gg} \models$
$[e_3|e_3 \models \ll\texttt{English},\ x \gg] \rightarrow$
$[e_4|e_4 \models \ll\texttt{be-a-course},\ x \gg]$

$S_{\ll\texttt{uttered-about, utterer, school}\gg} \models$
$[e_5|e_5 \models \ll\texttt{took-course},subj \gg] \rightarrow$
$[e_6|e_6 \models \ll\texttt{be-a-student},\ subj \gg]$

```
Order:
1:  CS = sub2 CP sub1 .AND. sub3 CP sub1
2:  CS = sub2 CP sub1 .AND. sub3 CP obj2
```

[5] To make the fragment more natural, some NPs were changed.

[6] sub2 stands for the subject in the sentence2, and so forth.

From the anaphora relation gained in the first order, we can infer:

```
scope:  sen2 -> neg(a teacher)
focus:  sen1(John) -> sen2(John)
  -> sen3(John),
```

then for the second order:

```
scope:  sen2 -> neg(talk)
focus:  sen1(John) -> sen2(John)
  -> sen3(a teacher).
```

7 Remaining Problems

From a theoretical aspect, some problems still remain.

Look at these sentences:

1 John loves his wife and Bill does, too.

2 She is happy.

For sloppy reading of sentence 1, a parameter "his wife" is absorbed so that we cannot indicate either "John's wife" or "Bill's wife" by the pronoun. However, some native speakers say "she" on sentence 2 above can indicate either one though there are ambiguities. This fact contradicts the feature of pronoun we have proposed before.

Also in [8], some examples to this point are shown. For example,

> John had never read a Russian novel he disliked. But Bill has. It was War and Peace.

where "It" can indicate "a Russian novel that Bill had read" which is absorbed. Much the same as [8] pointed out, these examples show the relation between absorbed parameter and pronoun and cannot be treated by such a simple manner. In this regard, more inspection and classification of the features of pronoun would be needed.

Next, from the point of computer program implementation, though constraints are given manually in our current system, it can be improved so that constraints are generated automatically, and some studies of this point have begun[9].

Furthermore, we prepare to reconstruct our system to embed semantic analysis in a syntactical analysis to simplify the process of analysis and to represent more about the cognitive mechanisms of human being.

8 Conclusion

We propose one means to help to dissolve anaphoric mechanisms by applying "constraints", the situation theoretic concept representing implicit information and implemented in this method. For "conditional constraints", we calculate textual situations i.e. " the condition" for each sentences from common noun phrases surrounding the sentence under consideration. Moreover, when we follow the situation theoretic account of noun phrases, we can infer scope of negation or quantification, or other information via resolved anaphoric information.

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