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Prepositional Phrase Attachment Disambiguation Using Preference Rules and Conceptual Information

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1. Introduction

The disambiguation of prepositional phrase(PP) modifiers in unrestricted text is a difficult problem to resolve in NLP. In this paper, we describe an method which use preference rule and conceptual information from a machine-readable dictionary to disambiguate PP attachment. In case of an unique attachment can't be determined, probability from an annotated corpus is calculated to determine the attachment.

As other work do, we use four head words of verb(v), head noun(n1) ahead of preposition, preposition(p) and head noun(n2) of the object of preposition to simplify the context we use in disambiguation.

2. Disambiguation Using Conceptual Information

Our way for disambiguating PP modifiers by use of conceptual information is based on the following observations on PP:

1. In many cases, lexical properties or features of v, n1, or n2 supply crucial clue for making decision on PP attachment. When v is passivized, for example, the PP is attached to the VP as in sentence: *He is* **named** *after his father.*
2. For many prepositions, PP is attached to the VP if there is some co-occurrent or conceptual relationship between v and n1. In sentence: *Tom* **mended** *his* **bicycle with** *a* **wrench**,for instance, the PP *with a wrench* is attached to the VP since *wrench* is an instrument for *mend*.
3. For many prepositions, PP is attached to the NP when n1 and n2 show certain conceptual relationship. For example, knowing that a *lock* typically has some *key*, we select the NP attachment as its interpretation in the sentence: *I took the lock with the key.*

Conceptual information about conceptual class and conceptual relation can be extracted from *EDR Concept Dictionary*(EDR 93). We introduce conceptual classes (such as place, time, etc) based on features needed for disambiguation, each class is defined on some upper level concept (as its root) in *concept classification*[1] of Concept Dictionary.

In EDR Concept Dictionary, The concept relations between two concepts are defined by a set of concept relation labels, each lable represents a kind of relation. In an example, the relation between *fix* and *wrench* is defined as: {*object, implement, source, goal, scope, a-object, basis*}, in which **implement** means that *wrench* plays the role of instrument for *fix*, and so on.

3. Preference Rule

We use a set of preference rules to choose an appropriate attachment for PPs. These rules are derived intuitively by reviewing a large amount of PPs extracted from dictionaries, grammar books and randomly selected texts.

The preference rules are classified into two groups: global and local. Global rules apply to all prepositions where local rules only apply to related prepositions.

There are nine global rules used in common to all prepositions, four of them are listed below.

1. (lexical(v + PP) OR lexical(v + Adverb + PP)) – > vp_attach(PP)
2. lexical(passivized(v) + PP) AND prep ≠ 'by' – > vp_attach(PP)
3. is_a(n1, Pronoun) – > vp_attach(PP)
4. (prep ≠ 'of' AND prep ≠ 'for') AND (time(n2) OR date(n2)) – > vp_attach(PP)

Local rules for twelve prepositions with the highest occurrence frequencies are introduced. Here, we lists two of them as example:

for-rules:
  goal(v, n2) OR implement(v, n2) OR

[1]Concept classification consists of nearly 400,000 concepts where related concepts are organized in hierarchical architecture by kind-of relation.

purpose(v, n2) − > vp_attach(PP)

abstract(n1) − > vp_attach(PP)

Default − > np_attach(PP)

with-rules:

implement(v, n2) − > vp_attach(PP)

(a-object(n1, n2) OR possessor(n1, n2)) AND NOT(implement(v, n2)) − > np_attach(PP)

Default − > vp_attach(PP)

4. Algorithm

The following is the algorithm we devised for PP attachment:

1: Try the global rules for attachment, if some rule succeeds, attach the PP to the assigned constituency and then exit.

2: Map each of v, n1, n2 used by local rules into its concept set. If any of them is not in dictionary, goto step 4.

3: Try the local rules relevant to the preposition *one by one*. If only one rule succeeds, apply it to determine the PP attachment, and then exit.

4: use the following formula to compute lra-score (Likelihood Ratio on Attachment). If the score is bigger than 1.0, attach the PP to the VP, else to the NP.

$$lra(v,p)=\frac{count(p|vp\_attach)}{count(p|np\_attach)}+log_2\frac{count(v|p)*\Sigma count(prep)}{\Sigma count(v|prep)*count(p)}$$

$$(prep \subset \text{all preposition})$$

In the formula, data for each item comes from EDR English Corpus. The first term is the ratio between VP attachments and NP attachments for the preposition. The second term estimates the possibility of the VP attachment by judging the co-occurrence frequency between the verb and the preposition.

We show a few examples to illustrate how the algorithm works.

(1) He is flattered to his ruin.

Global rules are tried and the second one succeed, according to this rule the PP **to his ruin** is attached to the VP.

(2) Tom fixed his car with a wrench.

First, global rules are tried. As no global rule applies to the sentence, the local rules related to the preposition *with* are accessed one by one. The first one succeed because in EDR concept dictionary there is **implement** relation between **fix** and **wrench**. As the second rule fails, the PP **with a wrench** is then attached to the VP.

Stage	Total Number	Number Correct	Success rate
global rules	1527	1507	98.7%
local rules	1906	1608	84.4%
iscr-scores	342	252	73.7%
Total	3775	3367	89.2%

Table 3: Results of the test in PP attachment

5. Experimental Results

Table 1 shows the test results on 3775 PPs, corresponding to twelve prepositions which were taken from newspaper articles and two books.

We achieved an overall success rate of 89.2%, which is rather encouraging compared with other approaches.

6. Conclusion

Our experiments show that a new rule-based approach to attachment decision on PP modifiers is both feasible and promising. By using preferential rules which employ hybrid information from an electronic dictionary and an annotated corpus, we avoided laborious, manual work of producing a large training data. Our model has the merits of being conceptually simple, easy to implement and domain-independent.

References

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[3] Japan Electronic Dictionary Research Institute, Ltd. (1993). EDR electronic dictionary specifications guide.