SEMANTIC DISAMBIGUATION FOR PP-ATTACHMENT

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1. Abstract

Prepositional Phrases, adverbs and subordinate clauses express the same semantic value, even though they are obviously tied to different restrictions which are language specific. If we are concerned with computational systems, MT or generation systems, we are compeled to express the same semantic content in different syntactic structures depending on the verb selection or on language specific stylistic means. The main reasons for this are the following:

* they have syntactically the same distribution
* semantically there is a hierarchy of periphrasis between adverbs, prepositionals and subordinate clauses.
* different languages make different structural choices for the same adverbial meaning.

For this reason the head of the adverbials, prepositions and connectors(Subordinating conjunctions) together with the semantics of the controlled NP get a final semantic value, while keeping the same syntactic function.

2. Functional Typology of the Prepositionals

PPs as any adverbial may have 3 different functions:

* valency bounded. The verb demands the adverbial role
  a) with any preposition in this adverbial value
  b) with a specific preposition
* free adverbial in a sentential role
* nominal modifier

Any system working with verb framing will be able to detect any verb role, arguments or complements. Verbs like "live" or "go" demand adverbials. Any PP accepting this role must be local or directional respectively. However other verbs may demand a very specific preposition as the head of the adverbial. That is the case for:

alejarse **de** (move **away**)
llegar **a** (arrive **in**)
esperar **a** (wait **for**)

Such examples are no further problematic, because these adverbials are **marked** and as such easily detected by the verb framing module. On the contrary, unmarked adverbials can belong to the sentence level, or either to any nominal in the sentence.

Adverbials modifying a noun can belong to the following types:

* incremental restrictions of a modifier
* logical causal connection
* modifiers bounded to a genitive (part-of or possessive)

The only means to achieve the right PP-attachment is to get the right **semantic value of the PP** and afterwards try to follow the right nominal and verbal framing strategy.
A reasonable strategy supporting parsing is to combine nominal and verbal framing in the following way:

** first do NP framing with additional PP-attachment
** mark the attachment as provisional
** do verbal framing
** undo PP-attachment if necessary.

The core of the PP-attachment strategy is to obtain the semantics of the PP through a calculus of the PP-series, and finally to map this semantic-syntactic role to the nominal and verbal framing.

3. Semantic typology of PPs

The semantic value of a PP is a calculus of the semantics of the preposition and that of the controlled NP. However, at first glance if we consider the following examples we could conclude that there is no means to know the "real" semantics of prepositionals. This will be very critical with prepositions that neutralised many functions . A typical case is "of" ("de" Sp. ; "von" Ger.), which can assign many roles according to the semantics of the NP . The PP can be "agent", "deep direct object", specification of material, modal, etc...

(1) "aus Holz" (1a) sp. "de madera" (1b) "wooden"
(2) "aus Angst" (2a) sp. "por miedo" (2b) "for fear of"
(3) "aus Madrid" (3a) sp. "de Madrid" (3b) "from Madrid"
(4) "in der Bluete"(4a) sp. "en la flor" (4b) "in the flower" **local**
(5) "in der Bluete seiner Jahre" **temporal**
(5a) sp. "en la flor de su juventud" **temporal**
(5b) "in the prime of life"

From these examples we conclude:

* prepositions have so many different semantic values as the semantic value of the controlled NP they combine with. A fine grounded prepositional semantics could not help in disambiguating, if there is no good NP semantics available.

* an NP controlled by a preposition can itself be the controller of a further PP (or genitive NP in german . See example (5, 5a).

From this we can conclude that prepositions are functions taking a tuple the controlled NP and eventually (if before hand) the controller NP to its left.
A preposition is a multifunctional head. It takes the semantic value of the NO and delivers a final semantic value. If both, preposition and nominal are polysemic the value of the function is the intersection of their possible semantic values.

Compare the case of : aus (SOURCE, CAUSAL, MATERIAL) that gets its semantics within the semantics of the controlled NP. This semantics are again restricted by the controller NO.

If we are concerned with Machine Translation purposes the final "semantic meaning" of a bare or complex PP relies on the facts mentioned above and on distributional phenomena. The transfer of a preposition will be accurate if we can restrict the translation according to the semantic features obtained during analysis and obviously percolated to that preposition.

A preposition is temporal if the following NP is temporal; a preposition is local or whatever only once the whole semantic value of the controlled NP to its right is calculated. Let us take the following examples to make clear that prepositions have no inherent semantic value:

(6a) "**con** la caida de la noche" temporal
(6b) "**at** the fall of night"
(6c) "**bei** der Einbruch der Nacht
(7a) "**con** la caida del dollar" causal
(7b) "**with** the fall of the dollar"

The Spanish preposition "con" gets different translations not only depending on the semantic type of the controlled NO, but also on the whole NP complex that subsumes the genitive. According to the semantic type of the genitive we obtain the final PP value.

This phenomena is mirrored by these verbs and nouns that are "framed" with an **obligatory** preposition. These verbs or nouns get different translations (= readings) according to the semantics of the whole PP, even though they concur with a concrete preposition.

(8a) "er beschaeftigt sich mit Logik"
(8b) "se dedica a la lógica"
(8c) "he is concerned with logic"
(9a) "er beschaeftigt sich mit seiner Schwester"
(9b) "se dedica a su hermana"
(9c) "he is devoted to his sister"
(10a)"er beschaeftigt sich mit Dummheiten"
(l0b)"se entretiene con tonterias"
(10c)"he spends time with silly things"

The different semantics underlying the collocations of the verb "beschaeftigen mit" is reflected not only in the different lexical correspondences in another language but also in the preposition selected.

Another relevant factor is the grammatical information. A preposition can also have different "meanings" according to the semantics of the controlled NP. That is according to the additional information about definiteness and quantification.

(11a) "mit diesem habe ich 5 gegessen"

(11b) "con este he comido 5"
(11e) "with this one I've eaten 5"
(12a) "ich male dich mit Schlagsahne"
(12b) "te pinto con nata"
(12c) "I'll cover you with whipped cream"
(13a) "ich mag den Mann mit Bart"
(13b) "me gusta el hombre con barba"
(13c) "I like the man with beard"
(14a) "ich mag den Mann mit dem Bart"
(14b) "me gusta el hombre con la barba"
(14c) "I like the man with the beard"

The only difference between sentences 13 and 14 is the referentiality. If sentence 13 would be a generical then the complement could not be referential.

*(15) Me gustan los hombres con la barba (?)

The relevant fact is the semantics of the different sortals. In a second stage the system has to state the final value of the PP. This value is a recursive function for the cases of complex NPs. Nouns that are processes accomplishments or achievements they become Locals or Temporals if they control another PP of that type.

(15a) "Am Anfang der Strasse LOC
(15b) "Al principio de la calle LOC
(15c) "At the beginnig of the street" LOC
(16a) "Bei Beginn der Vorstellung" TMP
(16b) "al principio de la representación"
(16c) "at the start of the presentation"

From these Spanish examples, while considering the PP-attachment we have discovered that the right attachment going through the semantic calculus of a complex NP has a double repercussion:

* the right meaning (=transfer) of the preposition
* the right translation of the Head NO.

The Spanish noun "principio" gets different translation into German or English according to the fact that the whole NP is a local or a temporal (after the percolation of the PP semantics.

The system knows the semantics of the NP from the semantic information of the NO together with that of its complement. The final NO in its "collocation" gets assigned during analysis its semantic feature that overwrites the initial one. The system does
not need to store all the possible semantic entities corresponding to the different collocations of "principio".

Such a "linguistic oriented" semantics gets the same semantics as an Artificial Intelligence approach working with world knowledge and making explicit *a* large amount of "contextual" possibilities. The main difference relies on the approach, not on the results. A knowledge based system contains a lot of information that must be matched during a process of navigation.

The linguistic oriented approach is procedural, where predicates and nouns have coded the inherent demanded "roles" (arguments and complements) . Other information not committed to the inherence of the predicate, or to that of the noun is calculated during analysis, and finally attached to the verb, noun, or sentence.

It is obvious that there *is* no advantage of doing a lot of work in subcategorising fine grounded the prepositions, because the final decisive fact is the collocation to be asked in transfer. I think this strategy mirrors in a wide sense that of "terms" and "complex nominal expressions" as we do in presently in METAL.

The main effort should concentrate in very accurate transfer tests about the controlled NO with the following points of view:

* semantic calculus of embedded PP (usually genitives)
* access in transfer of the semantic type of the NO
* access to the grammatical information of the controlled NP

4. Percolation of semantic values in complex PPs

In an internal representation of a sentence structure a system must be able to access all the information of the collocations of a noun. This will enhance the system with the possibility of giving **one semantic value for clusters of complex PPs.**

Nouns that select certain prepositions must be coded as such. For example : "output", or "flight". However, the final value of the preposition is, as already mentioned, the one obtained during analysis.
There follows some coding proposals, the analysis changes and the transfer for the German preposition "ueber".

```
Output           : (OPT ($DIR Prep to))
Flug (Flight)    : (OPT ($DIR Prep von)($DIR Prep nach)($DIR
                   ueber) ($LOC ueber))
```

(17) Der Flug ueber Muenchen LOC
(18) Der Flug von Madrid nach Muenchen ueber Barcelona (DIR)

Example 18 contains *a* series of directionals, so that the local reading of "ueber" is excluded. This value obtained during analysis is percolated both to the controller and to the preposition. Now let us have a look on the transfer of the preposition "ueber".

```
ueber                    -- > sobre
(REQ TYN LOC)

ueber                    -- > via
(REQ TYN DIR)
```

Other grammatical features can be decisive for transfer. These will be other "requirements" about the features found in the node.

5. Grammatical distributional universals for prepositional semantics

The semantic value of a PP depends on the following factors:

* semantic type of the NP (bare or complex)
* definiteness of the NP
* quantification type of the NP

Definiteness must be further specified according to the distinction of being a proper noun or not, because prepositions and referentiality behave differently.

For instance Locals in European languages demand the feature definiteness. This fact may, however, be different for other languages.

"aus Wien" — "from Vienna"
"aus der Gegend" — "de las cercanías"

but not

*"aus Kirche" — "de ciudad"
*"aus Heimat" — "de patria"

The "meaning" of the preposition (reflected explicitly in transfer) depends extremely on the definiteness and quantification type. This fact must be captured during analysis and percolated to the preposition for its disambiguation. Let us see some examples:

(19) "mit 20 Jahre" (AMOUNT)
(21) "mit der Zeit" (ABS)
(22) "mit viel Geduld"(ABS)
(23) "mit der Beendigung der ..", "mit der Einbruch der Nacht) TEMPORAL
(24) "mit dem Flugzeug"
(25) "mit der Feder"
(26) "mit Feder","mit Tinte"
(27) "mit uns"
(28) "mit Liebe","mit Interesse"
(29) "mit Verblüffung", "mit Absicht"

"MIT" gets different transfers according to the following requirements:

PREP	sem.Type	Spanish	English	examples
mit.	ABS/ STA	con	with	21,28,29
	TMP	a	at	23
	AMOUNT	con	at	19
	MODAL			
	Concreta +def	con	by	24 (instrument)
	Concreta +def	con	with	25
	Concreta -def	a	with	26
	Human	con	with	27 (commit.)

These grammatical features must be there even if it is not a discriminating factor when mapping this information into a given language. That is the case for the disambiguation between 25 and 26 into Spanish (the definiteness feature) , but with no lexical consequence for the translation into English.

6 Conclusion

PP-attachment can not be relegated to a syntactic strategy. Even more, the attachment is guided by the semantic value of a whole lexical cluster, a NP or a PP.
Once the semantics of a PP is stated the framing mechanism binding arguments or complements to nouns and verbs can be triggered.
The proposed strategy dictates a semantic calculus for the PP-nodes obtained during parsing. This value is copied to the preposition and to the NO. This value is a test condition in the transfer dictionary to restrict the polysemy of prepositions, because the nature of prepositions is relegated to "relational links" almost empty of lexical information.

The semantics of the PPs dictates the role that the PP or the NO is going to actually take in the sentence.
The proposed strategy combines the following modules:

* structural parsing with flat structures
* revision of the PP-attachment guided by the semantics
* triggering of the framing mechanism

7 Literature

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