Some issues on the Treatment of Temporal Modifiers in Machine Translation

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This paper reports on the research that we have conducted concerning temporal modifiers in an NLP environment. In our research group we have concentrated on contrastive phenomena, investigating the translational difficulties that arise from the differences between Dutch, English and Spanish. We will discuss two main issues in this area. Section 1 will discuss the proper translation of temporal modifiers, especially prepositional phrases. This section starts of with the treatment suggested by Bree (1990), followed by the alternative approach we would like to suggest. Section 2 deals with the problem of tense translation, where ambiguities can be solved when temporal modifiers are present. Van Eynde's (1988) classification of temporal modifiers is introduced, then an ammended version of this classification is proposed in which semantic features are shown to play an important role in tense disambiguation.

1. The Translation of Temporal Prepositions

1.2 Using Selection Trees

The research described in Bree et al. (1990) concentrates on the translation of temporal prepositions and connectives and aims at establishing "a description of the meaning of the temporal function words in such a way that these meanings can be included as part of the semantics of any natural language computer programme". This meaning description is considered necessary since the usage and translation of temporal function words is difficult to predict, not just for NLP systems but also for non-native speakers. This is illustrated in the examples below.

1. He woke up
   a) at 5 o'clock   om vijf uur   a las cinco
   b) at night   's nachts   por la noche
   c) at the weekend   in het weekend   durante el fin de semana

2. We played football
   a) on Monday   (op) maandag   el lunes

3. They discussed it
   a) in the evening   's avonds   por la noche
   b) in the summer   in de zomer   en el verano
   c) in the meeting   in de vergadering durante la reunión

The method used by Bree et al. makes usage of so-called selection trees, a variation on conventional decision trees. These selection trees, which they establish for English and Dutch should reflect the usage of almost all the temporal connectives and prepositions.

The overall result of this research is a rather concise description of combinatorial behavior of temporal function words, represented in an organizational structure, the selection tree. Nevertheless, some doubts with regard to the adequacy of the selection trees in the field of MT arise. These doubts are based on the following problems:

i) The selection trees are incomplete.
The selection tree in Bree(1990) misses out on the following English prepositions: *over, around, about, near, towards, through, throughout and under*. Some, but not all of them, have been included in Bree(1991). Furthermore, although the selection trees predict to a certain degree the right translational equivalent of a temporal function word, translation problems still exist, e.g. for *in, on* and *at*. We will illustrate this with the following examples:

English	Dutch	Spanish
at 3 o'clock	om 3 uur	a las 3
at that moment	op dat moment	en ese momento
at the beginning	aan het begin	al principio
at dawn	bij het ochtendgloren	al amanecer
at night	's nachts	por la noche
at the weekend	in het weekend	durante el fin de semana
at Christmas	met Kerst	en Navidad

The Dutch selection tree only suggests the prepositions *om, em, op* and *aan* as possible translation for "punctual" *at*. As a consequence, they only can deal with the first 3 examples. Thus we have to conclude that the selection trees are incomplete.

ii) Too ambitious for current MT.

The selection trees are built so that they can be incorporated in "any natural language translation program that is based on the principle of first "comprehending" the original text before producing the translation" (Bree 1990). Most existing MT systems however have little or no understanding of input texts, and some of the distinctions used in the selection trees are tricky, even for advanced text understanding systems.

iii) Formalization too strong.

Looking at temporal prepositions only we can determine about 29 prepositions in English. The majority of these prepositions cause no real problems in translation. As a matter of fact most problems (when translating into Dutch or Spanish at least) are caused by about 4 out of these 29: *at, in, on* and *for*. Finding a meaning description of all temporal function words therefore seems a matter of overkill. (It is certainly elegant to have a treatment that includes all these words, but if the majority of these words do not display translation problems it is not necessary. It is the efficiency of a system that comes into question here, and there is no doubt that the selection tree approach will cause an increase in processing times, also in cases where this is not necessary.

1.3 Using Semantic Features

Of course, some of the distinctions identified by Bree et al. can be found back in a different form in the approach we chose to pursue. The treatment however is quite different, one major difference being that we make use of semantic features to assign the distinctions we need.

When we look again at the examples given in the previous section, we notice that the translation of prepositions is very much dependent on the noun which follows. Therefore, we should provide more specific temporal information on the noun and make it accessible for the preposition. A first step is to distinguish three types of nouns:

1. Unambiguously temporal nouns (e.g. Monday, January)
2. Nouns which can be used temporally (e.g. event nouns: meeting, lecture, etc.)
3. Nouns which can not be used temporally (e.g. location or concrete nouns: John, a dog, etc.)

In a MT system these distinctions are already present in the form of semantic features on the lexical entries of the noun (e.g. semtype=temporal). This is a first step towards explaining differences in preposition selection. The preposition {*on*} e.g. will get different Dutch translations in *on the table* (location) and *on Monday* (temporal). A further specification is needed to deal with the other translation problems. For this purpose we have introduced the feature *tempval*. This feature should be present on all the lexical entries of temporal nouns and can take the following values:

tempval = hour_of_day, part_of_day, weekday, name_of_month, name_of_season, name_of_year, name_of_century, unit.

hour_of_day:	3 o'clock, midnight, noon, etc.

hour_of_day: 3 o'clock, midnight, noon, etc.
part_of_day: morning, afternoon, evening, night
weekday: Sunday,   Monday,   Tuesday,   Wednesday,   Thursday,   Friday,   Saturday
name_of_month: January, February, etc.
name_of_season: winter, spring, summer, autumn
name_of_year: 1991, 1492, 1964, etc.
name_of_century: nineteenth century, etc.
unit: hour, week, month, year, etc.

Using these distinctions we can generalize over nouns with the same feature, a generalization with useful consequences for translation.

There are two different ways in which we can profit from the extra feature. A first possible approach is to translate the preposition to all its possible translations. Thus the English *at* would get four different Spanish translations: *{a}, {por}, {durante}, {en}*. The translation process however requires that the output of transfer be consolidated by the Interface Structure (IS) Grammar of Spanish. In this IS grammar we would then specify that if a preposition *{a}, {por}, {durante}* or *{en}* is followed by a temporal noun of the type *{hour_of_day}*, then only the translation *{a}* can be consolidated. A filter rule doing this work should look as follows:

filter_rule1 =   {e_lu=a/cat=p},{/cat=np}
                              [{/cat=n, role=gov, tempval=hour_of_day},*{}].

Literally this says that the Spanish lexical unit (e_lu) of a preposition is *{a}* if the preposition is followed by a NP and the governor of that NP has the semantic value *{hour_of_day}*. The NP can also contain an unknown number of other elements, indicated by *. (For the case of (on Monday <---> el lunes) we would still need complex transfer, and a rule belonging to the module of determiners calculation to cope with it all.)

The second method is slightly more elegant as the semantic information is directly used in translation in order to keep the number of possible translations down. To achieve this we have to make the tempval feature of the noun known to the preposition. This can be done in analysis by the following rule, which copies the tempval value of the noun to the preposition:

copy_rule2 = {} [{tempval=T/cat=p}, {/cat=np} [{/cat=n, tempval=T}, *{}]].

Now that the *{tempval}* feature is available to the preposition, we can write simple transfer rules that produce just one translation for a temporal preposition. The transfer rule below translates the English preposition *{at}* into Spanish *{a}* as to correctly translate e.g. a PP like *{at midnight}* into *{a medianoche}*:

transfer_rule3 = {gb_lu=at, tempval=hour_of_day} => {e_lu=a}.

Note however that not all temporal prepositions can be dealt with in simple transfer rules. The case of *{on Monday}* is e.g. more complicated: here we are not dealing with a problematic preposition translation, instead the preposition disappears completely when translated to Spanish and the definte article *el* appears. The *{tempval}* feature still allows us though to generalize over such cases and to write a complex transfer rule to deal with all weekdays in one rule:

ctransfer_rule2={cat=pp,role=mod}[~:{gb_lu=on},NP:{role=arg1,cat=np}
                            [N:{cat=n, tempval=weekday, msdefs=msabs}]]

=> NP:{role=mod} <N:{msdefs=msdefs}>.

In this rule the PP node and the governor of this node, the preposition, are deleted (~). The NP is maintained, but the rhs of the rule indicates that it becomes a modifier (the role the PP had previously) instead of the argument of the preposition. The noun is simply translated, but also here

we can see a feature change: the feature value {msabs} which indicates that there is no determiner changes for the target language into {msdefs}, which will generate a definite article.

2. Temporal Modifiers and Tense Translation

2.1 Van Eynde's Approach

In the Eurotra tense and aspect theory, the representation of temporal modifiers is based on the classification given by Van Eynde cite{vaneynde}. The purpose of the classification is not to provide an interlingual analysis for temporal modifiers, but rather to make them useful for the disambiguation of the tense and aspects forms.

Time adverbials:

Relational: *deictic* (the value is determined by the context : tomorrow),
anaphoric (the value is relative to a point of perspective =/= S [speech point]: ten years after, then, etc.)
locational (the value is totally independent: 1492, the 1st of Nov 998)

Aspectual adverbials:
duration: for (compatible with atelic actions and states),
in (compatible with telic actions)
boundary: initial (since + temporal expression)
final (until + temporal expression)

This classification entails the assignment of features to the temporal modifiers; they are used to type the modifiers rather than to provide an interlingual classification for them wich would allow them to be substituted by abstract features. These features allow the disambiguation of tenses, which facilitates the choice of the appropriate trannslation into the target language. How this works can be seen in the following examples:

[Spanish:]
Canta (simul, post) mañana (post) en el Liceo =>
                S=(post)
(He sings tomorrow at the Liceo Opera Hall)

[Dutch:]
Hij is (simul, ante) vorig jaar (ante) zijn baan kwijtgeraakt =>
                S=(ante)
(He lost his job last year)

The disambiguation can be performed in analysis by a rule which, used in a unification grammar, yields a linguistic representation in which the temporal features of the sentence is equivalent to the temporal information conveyed by the temporal modifiers. It is equivalent to saying that the temporal interpretation is the resultant of the interaction of the temporal information conveyed by the temporal morphemes of the verb and the modifiers.

$$verb\_semTENSE= X ==> mod\_semTENSE=X$$

This rule however cannot be applied without discrimination, since it is too general. In practice this means the rule has to be restricted to the case where the temporal modifiers are deictic. It certainl should not apply if the temporal modifier is an aspectual adverbial, like e.g. the boundary adverbial i the following sentence:

Está *(simul)* cantando desde que llegó *(ante)* su novio.
(She is singing since her boyfriend arrived)

This is the reason why this kind of modifier is considered aspectual rather than referential in Van Eynde's theory. But they do have the two values: they somehow locate actions on the temporal axis and also convey the idea of temporal duration. Notice, for instance, that the sentence:

Steve has been working since two o'clock

means that the process of working has started at the last two o'clock before the speech point. It implies, on the one hand, that the action is located in the temporal axis. On the other hand, since there is an indication that the action has been taking place until the speech point, there is also a reference to the duration of the working process.

The grammar rule given above is also problematic in the case of non deictic modifiers. It is argued in Van Eynde's papers that anaphoric temporal modifiers have a temporal value which is also specific. Thus, for instance, according to Van Eynde we must assign the value sTENSE = post to the anaphoric modifier {after}. At a first sight, it seems that the correct sentence

She came (ante) to Barcelona in 1968 and John came (ante) three years later (post).

would be filtered out because the values of the modifier and the verb do not unify. The way to skip this wrong effect is to consider that in the second occurrence the form 'came' is not properly anterior but it conveys transposed future value. This solution entails the treatment of temporal transposition and, therefore, discourse temporal reference which is still very tricky to do in an MT system.

In what concerns the so-called {locative adverbs}, it is argued that they have only two posible values: ante and post.

> At three o'clock she sang.(ante)
> At three o'clock she will sing.(post)

But they can also be simultaneous when they modify iterative sentences:

> She always takes dinner at 8 o'clock.

This implies that temporal quantification has to be treated in combination with temporal reference in order to apply disambiguation correctly. Nevertheless, there is no proper treatment of the temporal quantification in Van Eynde's theory. It is necessary that those elements which convey a quantificational meaning should be classified. This refers not just to all adverbial quantifiers but also to other constituents (NPs, adjectives, etc.) which may convey a quantificational meaning. To illustrate the importance of the temporal quantification, we will concentrate on another particular problem: the interpretation of the dychotomy passé simple/imparfait in Romance languages and simple past in Anglo-Germanic languages.

Simple past in anglo-germanic languages translates into *imparfait* or *passé simple* in French and similarly in other Romance languages. Some factors are supposed to provide the necessary information to achieve the disambiguation.

Aktionsart value, for example, is assumed to be an important element of disambiguation. We may state the following rule:

If (Aktionsart = state; process), then (simple past ---> imparfait)
If (Aktionsart = event), then (simple past ----> passé simple).

This rule generally yields adequate results when the sentence contains no marks of iteration, habituality or temporal quantification. Consider however the following Spanish examples:

a. El mes pasado Juan fue/*iba al cine. (Last month John went to the cinema.)
b. El mes pasado Juan iba/fue al cine todos los domingos. (Last month John went to the cinema every sunday.)

c. El mes pasado Juan *iba/fue al cine todos los domingos menos uno. (Last month John went to the cinema every sunday except for one.)

The classification of temporal quantifiers should be fined-grained enough as to permit to explain the differences in *(imparfait)* and the *(passé simple)* in sentences (1), (2) and (3). Adverbs denoting repetition of an event fall into two classes: cardinal count adverbs (meaning that an event took place a number of times) and frequency adverbials (giving an average over a stretch of time). *(Once)*, *(two times)*, *(every sunday except one)*, etc are examples of the first class. *(Every sunday)*, *(often)*, *(always)*, etc. belong to the second class. Thus, the computation of habituality, iteration and temporal quantification is indispensable for the correct interpretation of the temporal meaning of the English polysemic simple past. Within the class of frequency adverbs two subclasses may be also discerned: those adverbs expressing imprecisely how often a proposition occurs and those which express universal quantification over temporal units. This last distinction will be ignored throughout the rest of the paper since it does not contribute directly to the disambiguation of tense.

2.2 Proposed Features

In order to have a good characterization of the temporal modifiers we adapt the classification given by Van Eynde (see section 2.1 above). The proposed classification includes all the different types of modifiers. Once temporal modifiers have been identified (through the semantic value of the verb, noun, the preposition or the adverb) it is necessary to know to which class they belong. For this purpose we propose the use of the feature tempinf (temporal information) which has the following values:

tempinf =   referential (equivalent to temporal locations),
             aspectual (measure out the temporal duration)
             quant (express any kind of temporal quantification)

Each class can be further subdivided into different groups. Referential adverbs can be attributed a feature indicating the kind of reference they convey:

reftype =   deictic (depending on the context of utterance)
             anaphoric (depending on some previously uttered temporal location)
             indep (independent location, calendar, pysical time,etc.)
             both (can be used as anaphoric or deictic).

As for aspectual modifiers, they have to be subdivided into two groups: those that express duration and those expressing temporal boundary. This subdivision is performed by means of the feature:

asptype = dur, boundary

In view of the disambiguation necessary for the Aktionsart calculation, durative adverbials can b classified using another feature (durtype= in, for).

There is also a subdivision in the case of boundary adverbials. They can be attributed another featu: which indicates whether or no they participate in terminative predications *(boundtype= initial, fina)* With respect to temporal quantifiers there is also a further typing which is relevant for the calculatic of the semantic value of the simple past. The feature quanttype *(quanttype = card, freq)* captures t relevant information. In what follows we are going to present the method we suggest to calculate the features.

2.3 The calculation of the features

Adverbs are typed in the lexicon wrt to the temporal information they provide. Prepositions are a typed for this feature. There are however many cases where the preposition is ambiguous wrt t calculation. For instance, 'in' can form PPs with referential or aspectual value. In this case the value the pp depends on the corresponding NP. Consider, for instance the following two cases:

a. now (deictic) => ahora
   now (ana*phoric) => entonces
b. in two hours (deictic) => dentro de dos horas
   in two hours (anaphoric) => al cabo de dos horas

This feature is even relevant for the translation of some particular adjectives when they form part of a temporal modifier. Notice, for instance, the case of 'last' in the following examples:

   a. LAST week we visited our friends in Paris.
      La semana PASADA visitamos a nuestros amigos en Paris.
   b. THE LAST week we will visit our friends in Paris.
      LA ULTIMA semana visitaremos a nuestros amigos en Paris.

The calculation of this value in case the modifier is ambiguous as in English, is not so simple. There are however some features that can help in the process of disambiguation. First, we can rely on the fact that some tenses are typically relative or anaphoric. Imperfect, pluperfect and conditional in most Romance languages are anaphoric. Consider, for instance, the sentences

a. Now John was a very modest guy. (Entonces Juan era un chico muy modesto.)
b. Now John is a real braggart. (Ahora Juan es un chulito.)

In the first one, *now* is compatible with a past morpheme, because this past morpheme is also anaphoric. We know that it is anaphoric because English past morpheme in stative verbs corresponds to the imperfect morpheme in Romance languages. In the second case, on the contrary, the value of this adverb is typically deictic because the morpheme of the present is also deictic. Notice how the Spanish translation of these two sentences shows clearly the distinction.

The calculation of this feature depends on the syntactic category of the modifiers. Some prepositions can be assigned in the lexicon the feature reftype = deictic, anaphoric, both, indep, nil. This is the case, for instance, for the lexical entries {dentro_de: reftype=deictic} and {al_cabo_de: reftype=anaphoric}. In case the preposition be undefined wrt referential type, the PP is assigned the value of the correponding NP (e.g. after tomorrow's meeting (deicitic), at the following weekend: anaphoric).

As for adverbs, there is also the possibility to featurize them according to their referential value: {tomorrow: reftype=deictic}, {afterwards: reftype=anaphoric}, {ago: both}. NPs are the most difficult case. Different kind of constituents can convey referential information. First, demonstratives are typical marks of deictic or anaphoric information ({this:reftype=deictic; that:reftype=anaphoric}). There are also some adjectives that can be attributed referential properties:

last: reftype=both   following: reftype=anaphoric   next:reftype=both
                                                                  [deictic (last week)
                                                                  or anaphoric (the next week)]

Notice that NPs with temporal value can also contain adverbs with referential information. Consider for instance:

   I give you the paper in the meeting of tomorrow.

The calculation can be represented in the following algorithm:

• If there is a constituent with a deictic or anaphoric referential value, that whole NP is assigned the value of this constituent.

• If there is a constituent which is compatible with anaphoric or deictic expressions then the value of the NP depends on the presence or absence of other features or constituents.

In [two hours] (the NP is a quantified duration) => aspectual
In [summer] (the NP is a location) => referential

The main problem is the calculation of the value corresponding to the NP. It depends on the lexical characteristics of the noun. Nouns expressing temporal information can be subdivided in temporal **designators** and **temporal units**. If the noun contain quantified units, the temporal information is aspectual. On the contrary, if the noun is a temporal designator without quantification, the temporal information conveyed is referential. Quantified temporal designators can refer to both referential and aspectual information. The default case is the referential one. They only acquire aspectual value when they are a part of a pp whose preposition is typically aspectual:

> I visited my mother the first two Sundays of December
> I worked on my Phd for three Sundays

Another factor of diambiguation is the presence of adjectives denoting duration like *{whole}*, *{all}* and *{long}*.

> I worked the whole afternoon
> I worked all day long

As for the recognition of the temporal quantifiers we may take into account certain characteristics of the noun and the quantifiers. There are some nouns which in PLURAL express quantification: time, occasion, etc. The temporal modifiers build with these nouns are cardinal quantifiers.

Some special determiners convey a meaning of frequentative quantifier. This is the case for *{every}* and *{all}*(when combined with plural temporal nouns).

> I saw him three times
> I saw him every day

Whereas the first is a cardinal the second is frequentative. The calculation is not fully compositional. It is very difficult to implement it in a system which is purely based on unification. Notice for instance that in the cases we present below the relevant value of the temporal modifier comes from one of its modifiers:

> Juan visitaba a María tres veces por semana
> Juan estudiaba poesía griega dos horas a la semana

The NP *tres veces,* which apperars in the first sentence, is marked as cardinal when it is analysed in isolation. In this sentence there is another level of intervalization *(por semana)* which is more relevant in order to decide the use of the imperfect (and the frequentative interpretation) opposite to the simple past (cardinal interpretation of the sentence). In the second sentence there is the alternation between durative and frequentative meaning:

> dos horas => duration
> dos horas a la semana => frequentative

Notice that the meaning of the last example is equivalent to that of the temporal modifier in *Juan estudiaba poesía griega durante dos horas todas las semanas.*

As we have mentioned before the distinction deictic/anaphoric is relevant for the calculation of the restrictions we have to impose on the unification of the temporal values of the temporal modifiers and the verb. Furthermore, this distinction is also crucial for the disambiguation of some the temporal modifiers in itself. In English, unlike Spanish, there are some temporal adverbials which can be considered as deictic and anaphoric at the same time. In Spanish, however, only one form corresponds to every of these meanings. Consequently, we need to know this feature to yield the correct translation:

For example, when an ambiguous referential adjective is combined with a definite article then the overall value will be anaphoric (e.g *The last monday*: anaphoric; *Last monday:* deictic). In case the expression has still an ambiguous value, the information the anaphoric value of the verbal morpheme or the context can be used to achieve the disambiguation. As we have said before the imperfect and the conditional are typically anaphoric tenses.

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