

Aligning Prosody and Syntax in Property Grammars

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Abstract

We propose in this paper a new approach for representing the prosody/syntax interface. We use for this a particular formalism, called *Property Grammars*, in which all information is represented by means of constraints. We show how alignment constraints can implement such an interface. One of the interests of these constraints, in comparison with other approaches such as optimality theory, is the possibility of representing different information at the same level (allowing then a parallel treatment of prosody and syntax). This discussion is illustrated with the example of dislocated constructions.

1. Introduction

The question of the interface between the different levels of linguistic analysis (prosody, phonology, syntax, semantics, etc.) requires on one hand a joint and homogeneous representation of these levels and on the other hand a specification of constraints making it possible to describe such relations. We address more precisely in this paper the question of prosody/syntax interface. This problem was treated on several occasions (cf. for example [Bear90], [Rossi99] or [Mertens01]). It remains however a problem both for knowledge representation and implementation.

We propose in this paper an approach relying on the representation of linguistic information by means of constraints. This formalism, called *Property Grammars* (cf. [Blache00a]), makes it possible to describe each level of linguistic analysis using a set of properties forming a constraints system. We suggest to describe the alignment relations between the different levels in the same way. Insofar as this type of constraint needs to access to the different levels of linguistic description, we propose to use annotation graphs which allows to encode in a same structure various in-

formation (cf. [Bird99]). We present in the first part of the paper the *Property Grammars* and annotation graphs. We illustrate in a second part the notion of alignment constraint with the example of dislocated constructions.

2. Property Grammars

The formalism of *Property Grammars* (noted PG) relies on the idea that any property specified by the description of a language can play the role of a constraint. It is thus a question of collecting and organizing these properties in the form of a constraint system. Such a system plays the role of a grammar in the sense that it describes the structure of a language.

The representation of linguistic knowledge requires various types of properties, each one corresponding to a specific kind of information. In the case of syntax, we propose a limited set of relations representing different types of properties: linearity, dependency, obligation, exclusion, exigency, constituency, unicity. A property is expressed independently from any local structure, but directly between categories. In the following, a predicative representation is given for the constraints, indicating the concerned syntactic unit.

- *Constituency* (*Const*): Defines the maximal set of categories constituting a syntactic unit.

- *Head* (*Head*): Specifies the set of possible heads (compulsory, unique categories) for the *VP*.

- *Unicity* (*Unic*): Set of categories which cannot be repeated in a phrase.

- *Requirement* (\Rightarrow): Cooccurrence between sets of categories.

- *Exclusion* (\nexists): Restriction of cooccurrence between sets of categories.

- *Linearity* (\prec): Linear precedence constraints.

- *Dependency* (\rightsquigarrow): Dependency relations.

These properties contain the basic syntactic information. Other properties can be added if necessary, in particular for integrating knowledge coming from other linguistic domains or for particular devices, for example long distance dependencies.

3. Annotation Graphs

The formalism of Annotation Graphs proposed by [Bird99] provides a satisfactory solution to the annotation of different levels of linguistic analysis (see [Blache00b]). The same input can be annotated by different subsets of arcs corresponding to different levels of annotation (prosodic, syntactic etc.). A specific level of linguistic representation thus corresponds to a subset of the general graph.

Since the representation is a graph and not a tree, there is nothing to stop association lines from crossing, making it possible to represent levels which are not directly superimposable. The only constraint for annotation is that events be describable in terms of a set of discrete linearly ordered (or at least partially ordered) moments which constitute the nodes of the graph. These moments in turn can be indexed by an offset reference to a basic timeline associated, for example, with a physical object such as a speech signal, or to some more abstract specification of linear order.

Figure 1 shows an example of an annotation graph combining information from the phonetic and syntactic level. The acoustic signal provides a common reference for the alignment of the tonal segments M, T, etc. with respect to the phonematic segments or with respect to the more abstract levels of structure (syllables, words, tonal units, intonation units or whatever other higher level prosodic units might be used in the annotation). In this figure, the label *P* stand for phonemes, *W* for words, *Sl* for syllables, *T* for tonla segments and *S* for phrases.

Tonal targets, which unlike the other prosodic and syntactic categories constitute temporal points rather than intervals, are represented in this figure by an arc with identical start and end nodes (cf. node 2). This makes it possible to code this type of information while maintaining the general strategy of encoding content on the arcs rather than on the nodes of the graph. There are of course other ways of encoding this information (cf. [Bird99] for discussion).

Another advantage of this type of annotation is the possibility of specifying information concerning just a part of the input data without necessarily building a complete structural analysis. In

the case of syntax, this means it is possible to associate an arc with a set of properties characterising the corresponding part of the data. This type of syntactic annotation is particularly useful in the case of non-derivational formalisms such as that of PG which have the specificity of providing partial analyses.

Information in *Property Grammars* can be represented in terms of graph. The formalism of annotation graphs is then well adapted to the representation of property grammars. In such a representation, an edge represents a relation between several nodes (i.e. a constraint between categories). One often interprets an edge, as in the figure 1, as a relation between all the dominated nodes: an edge labelled *NP* indicates that the interval dominated by this edge constitutes the *NP*. Formally, it would be necessary to represent all the links between the nodes in the interval and the node corresponding to the label. In such a representation, each label is then interpreted as a node which can be to its turn a source or a target for another relation. In the following, we will represent indifferently these two possible interpretations of the notion of edge thanks to the following notations:

- $\text{Node}_{\langle i, j \rangle}$: the elements of the interval $\langle i, j \rangle$ belong to the relation *Node*.

- $\text{Node}(\text{SubNode1}_{\langle i, j \rangle}, \text{SubNode2}_{\langle k, l \rangle})$: the elements *SubNode1* and *SubNode2* belong to the relation *Node*.

For example, $\text{VP}_{\langle 3, 10 \rangle}$ means that the elements of the interval $\langle 2, 9 \rangle$ belong to the *VP*.

$\text{Dep}(\text{Adv}_{\langle 4, 10 \rangle}, \text{V}_{\langle 3, 4 \rangle})$ represents a dependency relation between $\text{Adv}_{\langle 4, 10 \rangle}$ and $\text{V}_{\langle 3, 4 \rangle}$.

4. The Example of Dislocated Construction

Dislocated construction is a frequent syntactic device as well in spoken or written language. It can in some cases constitute a problem for the analysis. We give in this section a brief description of this construction.

Generally speaking, the dislocation phenomenon makes it possible to realize a syntactic unit (generally a noun phrase¹) before or after a sentence. The following examples present cases of left dislocations in French.

- (1) *Les livres, elles les avaient envoyés.*
- (2) *Le chocolat, moi, j'adore ça.*

Among the general properties of dislocated,

¹One can also find other types of components in a detached position: adjectives, adverb or completive, for example.

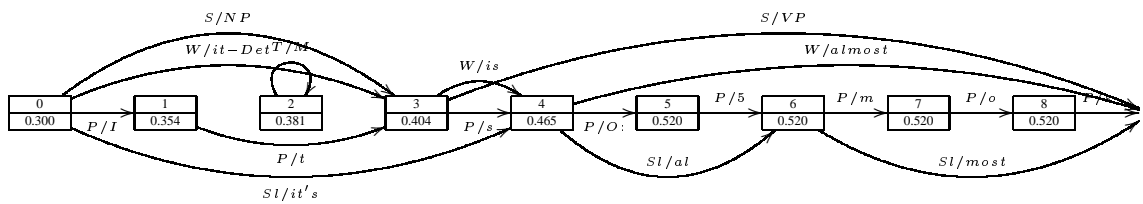


Figure 1: A partial annotation graph

one notes an anaphoric relation between the *NP* and a clitic which precises its function. Thus, the clitic *en* in the example (1) precises an object function for the dislocated *NP*, those in (2) indicate a subject and a complement.

One notices in addition that linear order is rather free between the different dislocated elements when they have a coreferential clitic in the sentence. However, the situation is different whenever the detached part is formed by several phrases that constitute a single unit. The problem in this case comes from the lack of explicit syntactic link, as in the example (3).

- (3) *Ta moto, le guidon, il est cassé.*
 (4) **Le guidon, ta moto, il est cassé.*

In this case, the detached part form a single topic, the relation existing between the two *NP* being at the syntactic level only indicated by linear order. In this case, the referent is in the right-most position, close to the sentence. In this type of construction with one coreferential clitic and a single detached thematic unit, the relative order of the *NPs* cannot be modified as shown in (4).

However, this characteristic can not be generalized: in many cases, one can have a detached constituent with no referential clitic in the sentence without implying a dependency relation between the dislocated *NPs*. This is the case of a multiple detachment in which the anaphoric clitic of one of the dislocated elements is not realized. In the examples (5) and (6), we can consider that two *NPs* have a semantic reference link with the valence of the governing verb. On the other hand, these examples distinguish from (7) in which the first *NP* is governed by the second which is coreferential with the clitic subject.

The problem in this case comes from the fact that no explicit criterion exists to distinguish constructions apart from an analysis of the valence of the governing verb: the *NP* “*ta sœur*” cannot be here complement of “*déchirer*”. On the other hand, in (6), there is an ambiguity: two interpretations are possible (the *NP* “*ta sœur*” is complement of the *NP* “*la robe*” vs. complement of the

verb).

- (5) *Ta sœur, la robe, elle lui va pas.*
 (6) *Ta sœur, la robe, elle va pas.*
 (7) *Ta sœur, la robe, elle est déchirée.*

Fortunately, intonation can play an important role. We describe this point in the next section.

5. Alignment Constraints

The question of alignment between the different levels of linguistic analysis is generally described under the form of very general principles, often dependent from a formalism or a linguistic theory. In these approaches, the prosodic description is expressed according to the syntactic theory (cf. [Hirst93] or [Rossi99]). The Optimality Theory proposes a slightly different conception in which alignment is represented by means of constraints making it possible to establish correspondences between the levels. It is the case for the general alignment constraints described in [Kager99]:

- ALIGN-L : The left edge of a grammatical word coincides with the left edge of the prosodic word.
- ALIGN-R : The right edge of a grammatical word coincides with the left edge of a syllable.

Property grammars make it possible to describe relations between levels using different constraints that can be of different granularity (i.e. general principles or very particular cases). They offer moreover the advantage of being able to be used in a concurrent way with constraints describing other levels of the analysis. They thus form part of grammar and are on the same level as all the other constraints.

5.1. Parsing Dislocated

The case of simple dislocated (containing only one dislocated *NP*) is characterized by a particular intonative mark on the dislocated element. A possible characterization is a rising intonation followed by a break (cf. [Rossi99] or [Mertens01]). It is possible to describe this information in stipulating some characteristics of the different objects of

this construction:

NP _{$\langle i,j \rangle$} Disl _{$\langle i,j \rangle$}
 TOP _{$\langle j,j \rangle$} Break _{$\langle j+1,k \rangle$}

This information plays the role of constraints over categories appearing in the analysis of an utterance. This set of constraints indicates that the dislocated structure has the same coverage $\langle i, j \rangle$ as the NP (i.e. the dislocated consists in one NP) and that this constituent ends on a high tone (noted TOP) and is followed by a break. The description of the constraints of a right simple dislocation bases on the same set of categories, the intonation stipulating a low tone over the dislocated:

Bottom _{$\langle i,j \rangle$}

This set of objects constitute concretely a set of constraints, called *alignment constraints*, that have to be satisfied all together during the parse. It is possible to represent different cases (aligning for example different intonation patterns with the same structure) by means of different subset of covariant constraints.

However, the representation of constraints over the constituents of the syntactic or prosodic structure is not sufficient. It is indeed in some cases necessary to add to the set of *alignment constraints* some specific relations. Let us take the case of complex dislocated containing several NP. Two configurations can appear: either each NP is coreferential with a clitic, or the first NP depends syntactically on the second (in pragmatic terms, the rightmost topic is in the foreground). In the first case, the intonative schema of each NP presents the same pattern (cf. [Rossi99]), while in the second case, the second NP corresponds to a suite of low tones. There is thus in this case interconnection between intonative configurations, categories and dependency relations. These relations can be expressed in the following way:

NP _{$\langle i,j \rangle$} NP _{$\langle k,l \rangle$}
 Disl _{$\langle i,t \rangle$} Clit _{$\langle s,t \rangle$}
 TOP _{$\langle j,j \rangle$} Bottom _{$\langle k,l \rangle$}
 Dep \langle NP _{$\langle i,j \rangle$} , NP _{$\langle k,l \rangle$} \rangle
 Dep \langle NP _{$\langle i,j \rangle$} , Clit _{$\langle s,t \rangle$} \rangle

Generally speaking, alignment constraints are constituted by a set of properties that should be satisfied simultaneously: all the properties specified in this set have to be true. More exactly, if some of these properties are satisfied, one can also infer the others. It is then possible to instantiate new values during analysis. For example, in the second case described above, if the analysis supplies a set of constituents respecting the specified descriptions, it is then possible to instantiate the dependency relations.

But, unlike other approaches, no priority is given to a given subset of constraints which would play the role of pre-condition. An alignment constraint is not an “if- then” inference rule but only a covariant set of properties (in the sense that all values should be true at the same time) .

6. Conclusion

The main advantage of representing the prosody-syntax interface by means of alignment constraints consists in the possibility of representing this relation simultaneously at different granularity levels. Moreover, a constraint-based approach, such as the one proposed by *Property Grammars*, allows to specify all the linguistic information, including alignment constraints, at the same level. This particularity constitutes an efficient solution for an incremental conception of language processing.

7. References

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