The use of MCTAG to Process Elliptic Coordination

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Abstract

In this paper, we introduce a formalization of various elliptical coordination structures within the Multi-Component TAG framework. Numerous authors describe elliptic coordination as parallel constructions where symmetric derivations can be observed from a desired predicate-argument structure analysis. We show that most famous coordinate structures, including zeugma constructions, can be analyzed simply with the addition of a simple synchronous mechanism to the MCTAG framework .

1 Introduction

We assume the reader to be familiar with the TAG framework (Joshi, 1987) and with Multi-Component TAG (MCTAG, (Weir, 1988)). We will focus on the analysis of elliptical coordination and zeugma construction in French. The main goal of this work is to build a syntax-semantic interface based on an acyclic dependency graphs obtained through MCTAG's derivation and a simple synchronous mechanism. Knowing that pure LTAG cannot handle coordination with ellipsis without adding new notions of derivation and new operations (e.g. conjoin operation in (Sarkar and Joshi, 1996b)), we propose to use a enhanced version of MC-TAG for the processing of these structures. To the best of our knowledge, this is the first time that such a proposal is made within this framework. In this paper, we first discuss some of our examples, then we explore divergences of analysis between some elided predicates of a coordination and we finally present, using oriented synchronization links, our MC-TAG proposals going from Non-Local MCTAG (NL-MCTAG) solutions to unlexicalized Tree-Local MCTAG (TL-MCTAG) ones. We conclude by showing that our proposal can deal with a wide range of coordinations using a uniform framework.

2 A Parallel Derivation Structure?

We want our model to be able to deal not only with simple coordinations without any ellipsis, but also with a wide range of non-trivial ones, including gapping (1a), and zeugmas (1d,e). We will focus on gapping coordination and zeugma construction here. For the remainder of this paper, zeugma construction are defined in the sense of the rhetorical construction *syllepsis* when two words are *inappropriately linked together* (Lascarides et al., 1996), where *inappropriately* means that either there is a mismatch between two different subcategorization frames (1d,e) or between two different semantic interpretations with respect to their compositional status (1d). In that interpretation, zeugma constructions are not a rare epiphenomenon. Since Coordination of Unlike Categories (henceforth CUC) actually involves a subcategorization frame mismatch between conjuncts (Sag et al., 1985; Jorgensen and Abeillé, 1992), we treat them jointly with zeugma.

The coordination schema we use is of the form $\boxed{S \rightarrow S\, Conj\, S}$. We will not describe NP coordination here.

2.1 Symmetrical Derivations

In order to process sentences (1a-1g), we consider that any lexeme which is erased in an elliptic coordination can be modeled by an empty lexeme, written ε, which fills the other member of the coordination. This analysis is not new by itself but if we want to obtain dependency graphs such as Fig. 2 or Fig. 3, we must agree that the elided part is more abstract than a lexical coindexation. Actually, to obtain the derivation graph in Fig. 2 we have to anchor the empty element to the tree schemata (N0VN1) anchored by the realized verb.

a) Jean aime$_i$ Marie et Paul ε_i Virginie *John loves Mary and Paul Virginia* Predicate elision
b) Marie fabrique ε_i et Pierre vend des crêpes$_i$ *Mary cooks and Peter sells pancakes* Right node raising
c)Marie$_i$ cuit ε_j et ε_i vend des crêpes$_j$ *Mary cooks and sells pancakes* Left object and right node raising
d) Napoleon prit$_i$ du poids et ε_i beaucoup de pays *Napoleon gained weight and [conquered] a lot of countries* Zeugma construction
e) Jean est un républicain et fier de l'être *John is a republican and proud of it* Coordination of unlike category
f) Paul$_i$ mange une pomme et ε_i achète des cerises *Paul eats an apple and buys cherries* Right subject elision
g) Mary admires ε_i and Sue thinks she likes Peter$_i$ "Unbounded right node raising" (Milward, 1994)

Figure 1: Examples of elliptic constructions

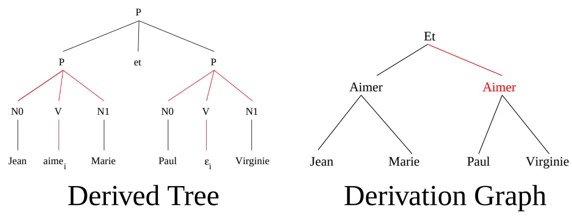

Figure 2: Derived tree and Derivation Graph for sentence 1a

This anchoring of an empty element leads to an unrealized instance of an elementary tree which will be substituted in the rightmost node of the coordination elementary tree (i.e. CET). Cases of Right Node Raising lead to the creation of a dependency link between the realized argument in the rightmost part of the CET and its unrealized counterpart. The idea is to have the same main parallel set of derivations in both parts of the CET (regardless of possible adjunction, see sentence 1g where the tree anchored by "thinks" can be an auxiliary tree of the form N0VS* which will adjoin on the root of the elementary tree N0VN1 anchored by "like").

2.2 Asymmetrical Derivations

It would be possible to handle elliptic coordination with (extended) TAG if both sides of a coordination had parallel derivations (Sarkar and Joshi, 1996a; Seddah and Sagot, 2006). In the case of CUC, the elementary trees which should have been coordinated, following their anchors coindexations, are not of the same type. For example, in sentence (1e) the realized verb anchors a N0VN1 tree whereas its unrealized counterpart anchors a N0VAdj one. Therefore a tree schema copy as suggested by (Seddah and Sagot, 2006) cannot really be applied.[1] In case of pure zeugma construction such as in (1e), the mismatch is even more pronounced because in French "prendre du poids" is a multi word expression meaning "to gain weight". In LTAG this expression would lead to an initial tree with "[prendre]" as a main anchor and "du poids" as co-anchors, so the resulting tree will be similar to an intransitive N0V tree. The rightmost part of the coordination, on the contrary, can be paraphrased as "[Napoleon conquered] a lot of countries" which can be analyzed with a regular N0VN1 tree in a strictly compositional manner. Hence, using a parallelism of derivation is not sufficient to obtain a proper derivation structure. The CCG framework and its elegant handling of gapping (Steedman, 1990) does not handle these mismatches without difficulty, see (Sag et al., 1985) or (Jorgensen and Abeillé, 1992) as well for solutions based on features subsumption and complex category constraints.

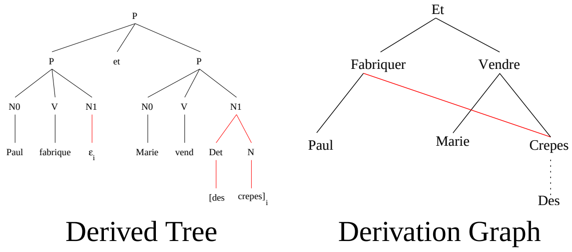

Figure 3: Derived tree and Derivation Graph for sentence 1b

3 MCTAG Analysis

In this section, we briefly present MCTAG as the framework in which we propose several ways to process elliptic coordination. A formal definition of our MCTAG is given section 3.6.

3.1 Introduction to MCTAG

The term "Multi-Component Tree Adjunct Grammar" (MCTAG, (Joshi, 1987; Weir, 1988)) describes a class of descriptive formalisms which extend the derivational generative power (Becker

[1] As suggested by an anonymous reviewer, CUC could be handled by (Sarkar and Joshi, 1996a) using "node contraction" on both argument nodes and anchors.

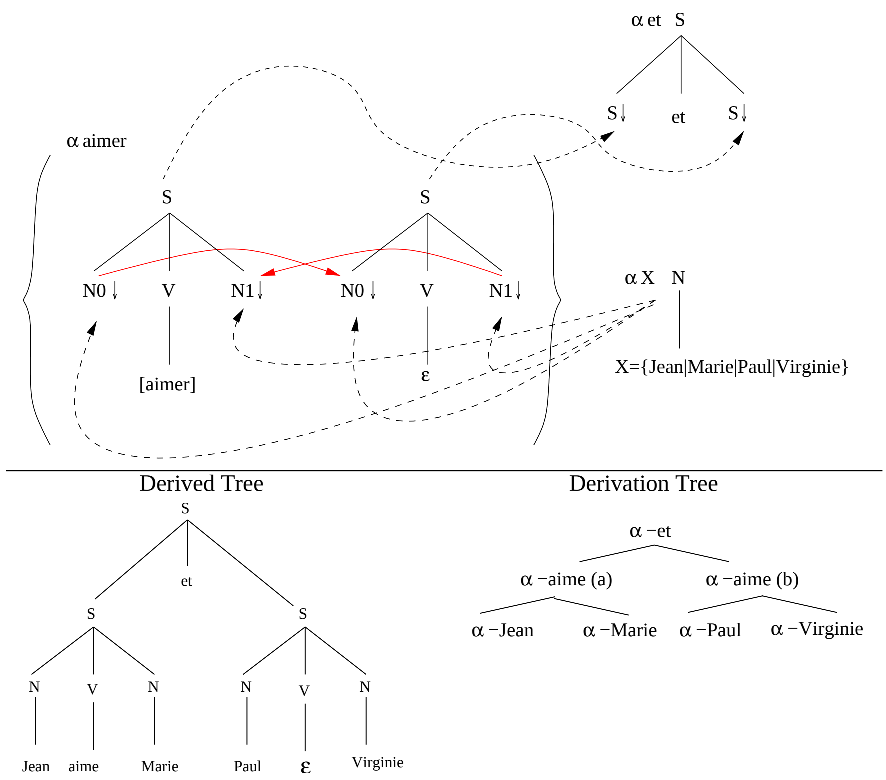

Figure 4: Sketch of analysis : "Jean aime Marie et Paul Virignie"

et al., 1992; Schuler et al., 2000) of Tree Adjunct Grammars by allowing sets of trees, as a whole unit, to be part of a derivation step. Several types of MCTAG can be defined based on how the trees in a set adjoin into various nodes. If all nodes belong to the same elementary tree, MCTAGs are qualified as Tree-Local [TL-MCTAG], if all nodes belong to the same set, MCTAGs are Set-Local [SL-MCTAG] and Non-Local MCTAG [NL-MCTAG] otherwise. All of these MCTAG's subclasses have a stronger generative capacity than TAG and it shall be noted that TL-TAG has the same weak and strong generative power (Weir, 1988). TL and SL-MCTAG can be parsed in a polynomial time (Boullier, 1999; Villemonte de La Clergerie, 2002) whereas NL-MCTAG's parsing is known to be NP-Complete (Rambow and Satta, 1992). Following (Kallmeyer, 2005), we define a MCTAG, M, as a regular TAG, G, with an additional set of tree sets where each tree set is a subset of G's elementary trees.

As opposed to (Weir, 1988), (Kallmeyer, 2005) defines the MCTAG derivations to appear as the ones from the underlying TAG. This means that if a tree set γ, composed of elementary trees γ_i, is derived into a tree set γ', the derivation tree will display every derivation instead of a link between γ' and γ. Thus, in order to allow more precise compositional analysis of coordination with ellipsis via the derivation tree, we adopt this view and for each tree set we add a set, S_L, of oriented links between substitution leaf nodes of its elementary trees. These links provide the means to share arguments between elementary trees inside a tree set.

3.2 Simple case : two Conjuncts

The main idea of our proposal is to include an unrealized tree in a set where the argument nodes are linked from the realized tree to the other one. This constitutes an extension to regular MC-TAG where no constraints of this type are defined. If we restrict the type of MCTAG to be Tree-Local then both trees must be substituted on the same elementary tree. Thus, as the tree schemas are the same, this will ensure that the set of derivations in both sides of the coordination will be parallelized. The dashed arrows in figure 4 exist to force argument position to be linked. An arrow must be oriented to prevent analysis of sentences such as :
"* *[ε_i] aime Marie et Jean$_i$ aime Virginie*". In or-

der to allow regular substitution on linked nodes, a precedence order must be added: Regular substitution on a linked node will always have precedence over linked substitution (w.r.t to feature constraints if any).

Moreover, if some constraints on the application order of the trees are not defined, nothing will prevent the unrealized tree schema to be substituted on the leftmost part of the coordination. The model will thus overgenerate on sentences such as *"* Jean [ε_i] Marie et Paul aime$_i$ Virginie"*[2]. Looking at the analysis provided in figure 4 where all coordinated trees of the tree set are substituted in the same elementary tree (i.e. α-et), it is obvious that the mechanism presented in this paper for gapping coordination with two conjuncts needs only the generative power of Tree Local MCTAG (Weir, 1988). Nevertheless, in the case of multiple gapping coordination such as "Paul aime Marie, Jacques Virginie et Paul Caroline" the question is to know if it is possible to provide an analysis which maintains simple compositional analysis without multiplying the number of elementary tree sets.

3.3 General Case : n Conjuncts with $n > 2$

The method proposed for the particular case of two conjuncts is formally simple and can be implemented relatively easily on top of an existing TAG Parser. However, the case of multiple conjuncts of the type $\boxed{S_1, S_2, S_3, ..\text{and } S_N}$ brings in the necessity of handling as many unrealized trees inside a tree set as conjuncts members of the coordination. We present in section 3.3 our method to handle multiple unrealized trees in a tree set without having an exponential number of elementary tree sets in our grammar. For the presentation of the general case, this technical aspect is not needed. For the moment, let us assume that the grammar provides the correct tree set and the correct number of unrealized trees.

Non-local MCTAG proposal An intuitive method in the *spirit* of the general TAG framework would consist in handling the recursive nature of the conjuncts members using the adjunction of an auxiliary tree anchored by a comma (β–','') which would adjoin on the root of the initial tree (α-et) anchored by the conjunction (see Fig. 5) whereas the n-th member of the coordination would substitute in the left-hand side node of β–','. We restrict the auxiliary trees β–',' to adjoin only on the root of α-et or on the root of another instance of β–','.

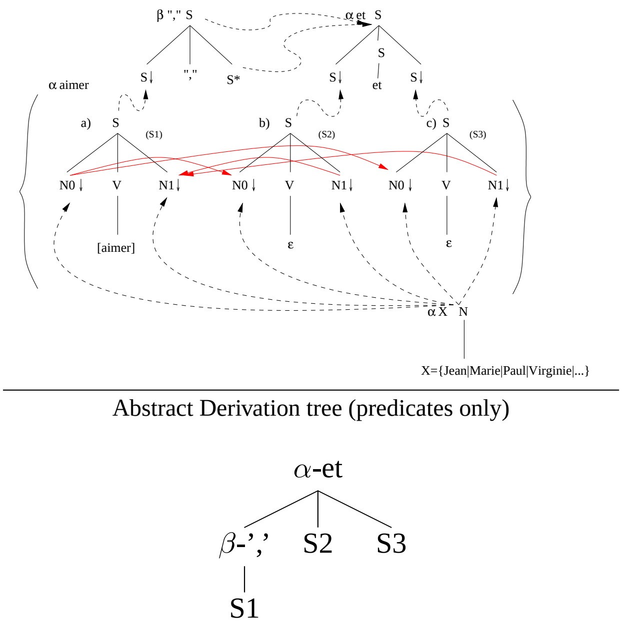

Figure 5: NL-MCTAG Derivations : S_1,S_2 and S_3

The problem with this analysis is that the formalism we use must be Non-local MCTAG (NL-MCTAG, (Weir, 1988)), whose formal power pushes the class of Mildy Context-Sensitive Languages to its upper bound, due to a parsing complexity beyond polynomial complexity (Rambow and Satta, 1992). Moreover, without further constraints on the application order of the derivations, this model overgenerates on sentences of the form $\boxed{* S_1 \text{ and } S_2, S_3}$. One way to restrict this behavior would be to add an internal node labeled S on the spine of the conjunction trees (α-et, β-',') and prevent adjunction of β-',' on its root. Derivations will be correct but the derived trees will be slightly unorthodox.

Set-local MCTAG Solution Let us recall that in SL-TAG every derivation from a tree set must occur in the same tree set and that a tree from a given tree set cannot be adjoined nor substituted in a tree from the same set. In that case, we propose[3], a tree set which contains the initial tree α-et and the correct number of auxiliary trees β-','. Here, the first

[2]Left predicate elision, although rare and somehow questionable in French, can be observed in :"*(?)Paul,ε_i lundi; Jacques,ε_i mardi et Pierre travailleras$_i$ Samedi" - (?) Paul, monday, Jack Tuesday and Peter will work Saturday-*

[3]Following a suggestion from (Danlos L., P.C)

and last trees, named S_1 and S_3 in Fig. 6 are substituted on the leaf nodes of α-et and the intermediate tree (S_2) is substituted on the rightmost node of β-',' which itself is adjoined on the root of S1. Any S_n tree will be handled by recursive adjunction of another instance of β-',' on the root of a tree S_{n-1}.

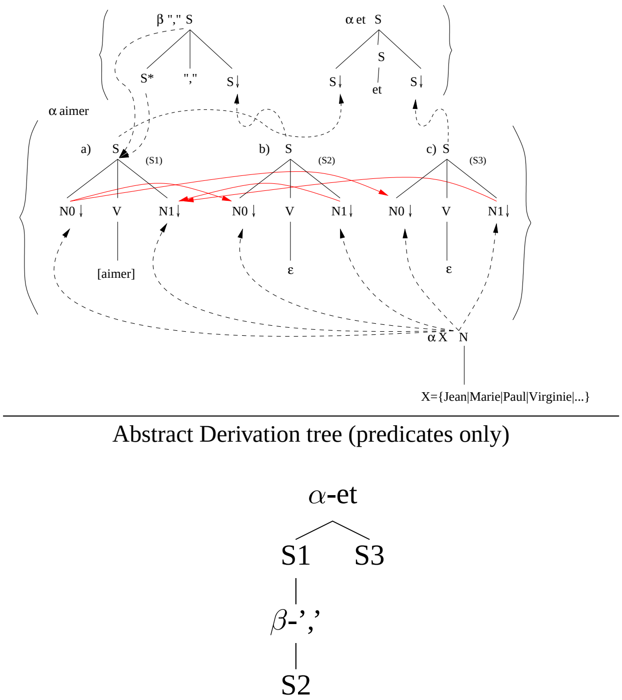

Figure 6: SL-MCTAG Derivations : S_1,S_2 and S_3

For this analysis as well, the same kind of restrictions as for the NL-MCTAG analysis would have to be established.

Dealing with Non Fixed Tree-Set's Cardinality So far, we assumed that the grammar will provide the correct cardinality of a tree set (namely the correct number of unrealized elementary trees). Obviously, such an assumption cannot stand; it would lead to an exponential amount of elementary tree sets inside the grammar. In (Villemonte de La Clergerie, 2005), the author implements a proposal to handle this growing size problem using regular operators (mainly disjunction, Kleene star, interleaving and optionality) on nodes or subpart of a metagrammar tree description (Vijay-Shanker and Schabes, 1992; Candito, 1996). We argue for the use of the Kleene star and the optionality operator to cope with the potential exponential size of our MCTAG. The tree set α-aimer (Fig. 7) would then contain one main anchored tree, an optional unrealized Kleene starred tree of the form N0VN1 and the argument sharing links between substitution leaf nodes.

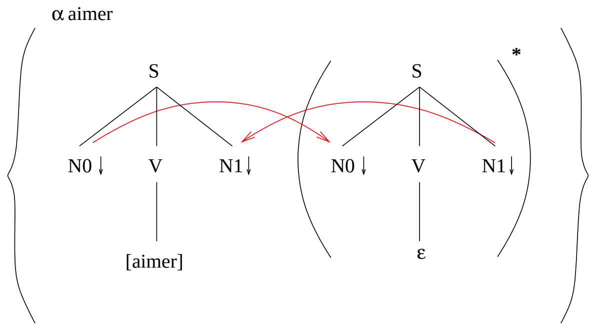

Figure 7: Factorized Tree set for α-aimer

Tree-local MCTAG Proposal Following this path, a straightforward definition of a factorized tree α-et is to insert two optional edges (ended by ',' and S↓) (Fig. 8) between the first two leaves of the tree α-et.

By using the two factorized trees (Fig. 7 & 8), an

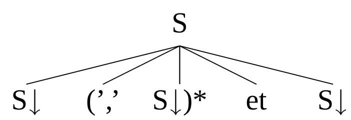

Figure 8: Factorized Tree set for α-et

analysis of gapping coordination with any given number of conjuncts stands in TL-MCTAG ; its logical interpretation is simply a logical *AND* with n arguments.

3.4 Zeugma Construction and CUC

To allow zeugma construction and CUC, we propose a set of trees that includes two different tree schemas, one of them being anchored by the co-indexed lexical element (cf. figure 9) and the other by the empty element. In case of the sentence (1d),

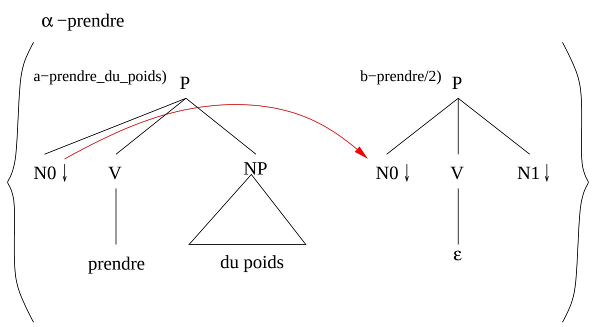

Figure 9: Tree set for α-prendre-du-poids

the tree anchored by "Napoleon" will be substituted on the node N0 of the N0V*prendre-du-poids* and linked to the node N0 of tree schema N0VN1. The rest of the derivations will just be the same as for the regular predicate elision stated before. For CUC, a similar method will operate: the tree set will this time include a NOV[to be]N1 anchored tree and a N0VAdj tree schema.

3.5 Case of Right Node Raising

Right node raising, as in sentence (1b), illustrates perfectly the fact that our model is entirely dependent of the extended domain of locality brought by the use of MCTAG. Being in a same tree set allows two elementary trees to share a "minimal" semantic unit, knowing the main verbal predicate which is elided in one of them. But in a sentence such as *John cooks* ε_i *and Mary sells beans*$_i$, we definitely have two different elementary trees, the first one having its object realized in the second one. However, if we consider only the set of derivations including the anchoring ones (displayed as special substitution nodes in Fig. 10), we must admit that these trees are indeed very similar and that an oriented link from the anchoring node of the first tree to the anchoring node of the second one could exist. This link would be superseded by an effective "anchoring" derivation on the second tree. If we want to keep the benefit of a direct compositional interpretation of the derivation tree, it suffices to establish that the label of an inner tree will be a variable instantiated to the label of its lexical anchor.

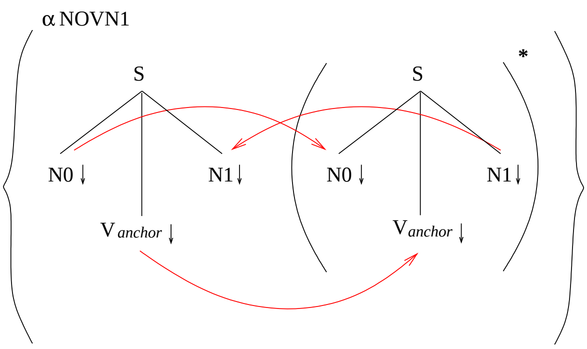

Figure 10: Unlexicalized tree set

To forbid analysis such as "* John cooks$_i$ ε_j and Mary ε_i beans$_j$.", we add a restriction on the set of links (cf. section 3.1) stating that there is a strict alternation between a link from node N1 of a tree γ_i to a node N1 of a tree γ_0 and a link from the main anchoring node (V_{anchor}) of tree γ_0 to the main anchor of the tree γ_i. A side effect of having an oriented link between two anchoring nodes is that it predicts the ungrammaticality of sentences such as "*John Mary and Paul loves Virginia" which were a cause of trouble in the general case. Thus, the main cause of overgeneration is avoided and we can provide a reasonable analysis of many elliptic coordinations without having to choose between the different types of MCTAG. Using this method and tree factorization, sentences with argument order alternation between conjuncts can be processed simply by defining an alternation between two sets of edges in a tree of a tree set, as long as the oriented links continue to point to the correct nodes.[4]

3.6 Definition of MCTAG with Local Synchronous Derivation

Following (Kallmeyer, 2005), we define the formalism used in this paper as MCTAG with Local Synchronous Derivations (MCTAG-Local SD). A MCTAG-Local SD is a tuple $G = \langle I, A, N, T, S, L, R \rangle$ with I being the set of initials trees, A the set of auxiliary trees, N (resp. T) the set of nonterminal (resp. terminal) labels, S the set of elementary tree sets, L the set of oriented links between two leaf nodes of two different elementary trees of a tree set of S and R the set of application constraints of L. $G_{TAG} = \langle I, A, N, T \rangle$ is the underlying TAG whose derivations constitute the backbone of MCTAG-Local SD derivation tree. We define the local synchronous derivation.
Let Γ be the tree set with γ_i and γ_0 as its trees. γ_0 is called the main anchor tree. Let L_Γ be the set of tuples $\langle N_L, N_R \rangle$ with a tuple characterizing an oriented link from N_L to N_R with N_L the site node of a derivation and N_R a site node of a derivation in another tree of the same tree set. Let R_Γ be the set of restrictions of L_Γ.
1) if an instance of an elementary tree γ' is derived (by substitution or mandatory adjunction) on a node N_L of a tree γ_i
2) if there exists a node N_R of γ_j such that $\langle N_L, N_R \rangle$ is a valid oriented link of L_Γ
3) if no derivation succeeds on the node N_R of γ_j
4) if no derivation exists from a node N_j of a tree

[4]Therefore Gorn's address should not be used for node's id as the order of nodes will not be fixed.

γ_j to a node N_i of γ_i such that $\langle N_j, N_i \rangle$ is a valid oriented link of L_Γ (this is a restriction of R)
5) then a derivation of the same instance as the one of the tree γ' (cf. (1)), which substituted to γ_i in N_L, is created in the node N_R of γ_j.
To define the local-SD of anchoring, let us assume that unrealized trees are tree schemas with a special leaf node labeled "V$_{anchor}$ $\downarrow$" and that each anchor is realized by substituting a special initial tree of root "V$_{anchor}$" dominating the "real" lexical anchor. Thus, anchoring is realized through substitution and the relevant oriented link is of the form $\langle N_{\gamma_0}, N_{\gamma_j} \rangle$ with N_{γ_0} the leaf node where this special substitution takes place and N_{γ_j} the relevant leaf nodes of the unrealized anchors where the special substitution should have taken place. Therefore, the same process that was valid for the regular local synchronous derivation can be applied. If we need any restriction on which tree should be selected by any anchor, it would suffice to establish a checking function (unification check, subcat. frame checking, type checking...) for each anchoring derivation. We made sure that no linked derivation could occur on already realized substitution node, therefore we can conjecture than the weak generative power of MCTAG is preserved.

4 Related Work

The principal work done on Coordination in the LTAG framework has been done by (Sarkar and Joshi, 1996a). The authors extend the formalism itself by a new operation, the conjoin operation, to provide derivation structures which cannot be obtained by pure (Lexicalized)TAG. Although powerful by allowing node merging and rich derivational structures, this operation leads to a difficult interpretation of the derivation tree in terms of generated languages even though the final derivation tree is actually a derivation graph. The derived tree becomes also a bit difficult to interpret for any classical phrase based linguistic theory. However, this model has been implemented among others by (Banik, 2004) for an interface syntax-semantic framework. Closer to our approach, to process elliptic coordination (Sarkar, 1997) introduces Link-Sharing TAG, a more constrained formalism than Synchronous TAG (Shieber and Schabes, 1990) while belonging to the same family. The main idea is to dissociate dependency from constituency by the use of pairs of trees, one being a regular elementary trees, the other being a dependency tree. Derivations are shared thanks to a synchronization mechanism over different pairs of the same type (dependency and constituency). On the contrary, our approach builds parallel derivations by simply having trees inside a same tree set and links are built explicitly for the sharing of arguments. Our methods seems to operate on two different axes (vertical vs horizontal) but further analysis will be needed to exploit potential points of convergence.

5 Discussion

The main argument in favor of the use of MCTAG to process gapping coordination is that using tree sets with unrealized trees allows pure compositional analysis of the resulting derivation tree without the need to capture the missing lexical anchors through different elementary trees. In short, associating realized and unrealized trees in a same tree set allows the handling of parallel derivation structures simply by means of the MCTAG's extended domain of locality and by a few links between argument position. By allowing trees to be described as unlexicalized, we go deeper in the abstraction, resulting in the capacity to handle multiple kinds of elliptic coordinations using a unified framework. Of course losing the advantage of lexicalization may be a huge drawback so one possibility is to keep the main tree of a set (γ_0) lexicalized and during the tree selection we add to a shared derivation forest the "pseudo" derivation proof of an anchoring substitution, thus we maintain illusion of unlexicalization while benefiting from its counterpart. Some questions remain open, in particular, knowing exactly what kind of parsing complexity can we expect from a MCTAG with tree sets of dynamic cardinality? Even if we stick to the TL-MCTAG with Local SD, the parsing complexity is directly related to the number of nodes of a tree set and to its cardinality. Adding a synchronous mechanism even of a limited range, and with restrictions, but over k inner local trees, increases again the parsing complexity.

6 Conclusion

In this paper, we have proposed a simple model of coordination within an extended MCTAG framework. We showed that the extended power of MCTAG permits strict and relaxed parallelism analysis for coordination while allowing the analysis of problematic constructions even within the TL-MCTAG framework. Future work will be oriented toward formal characterization of this promising formalism.

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