Partial Proof Trees and Structural Modalities*

Aravind K. Joshi and **Seth Kulick** and **Natasha Kurtonina**
Institute for Research in Cognitive Science
University of Pennsylvania
Suite 400A, 3401 Walnut Street, Philadelphia, PA 19104-6228
{joshi,skulick,natashak}@linc.cis.upenn.edu

An important theme in current categorial research is the shift of emphasis from individual category logics to communicating families of such systems. The reason for this shift is that the individual logics are not expressive enough for realistic grammar development; the grammar writer needs access to the combined inferential capacities of family of logics. Categorial systems with structural modalities (see Moortgat 1997, Kurtonina and Moortgat 1997, Morrill 1994 for details) can incorporate not only limited relaxation of the rigid structure to provide more generative capacity, but also impose additional constraints to block undesired derivations[1]. Although they provide a powerful extension of capacities of categorial inference, their use can be linked to overgeneration in some cases. In this paper we will show how this problem can be handled if categorial systems based on partial proof trees are used as building blocks of the system. The key idea is that the use of PPTs allow us to 'localize' the management of resources, thereby freeing us from this management as the PPTs are combined.

Here we provide a very brief overview of the PPT system. See Joshi and Kulick (1997) for details. The basic idea is to associate with each lexical item one or more PPTs, obtained by unfolding the arguments of the type that would be associated with that lexical item in a simple categorial grammar, such as the Ajdukiewicz and Bar-Hillel grammar. The basic PPTs then serve as the building blocks of the grammar, and complex proof trees are obtained by 'combining' these PPTs by various inference rules, that basically allow the linking of conclusion nodes to assumption nodes, and the stretching of a node in a proof. The main motivation of this approach is to incorporate into the categorial framework the key insights from LTAG, namely the notion of an extended domain of locality and the consequent factoring of recursion from the domain of dependencies.

In CG the engine of grammatical inference is, of course, a multiplicative fragment of intuitionistic linear logic (Lambek Calculus) and logical derivability of some distinguished types from a sequence of types is crucial for determination of grammaticality of linguistic expressions. On a deductive level the logical architecture of categorial inference is reflected in the rules of a calculus (for instance, sequent calculus). In contrast to CG, the PPTs system is a tree rewriting system. However, we can make explicit the underlining logic of the system to provide a logical explanation of the resource management. In fact, two kinds of logics are involved in PPTs system. Construction of basic trees is guided by the logic of a CG, while operations of combining trees are monitored by a single rule – Cut.

We now consider the use of two kinds of structural modalities, following Moortgat (1997), Kurtonina and Moortgat (1997), Morrill (1994).

Structural Relaxation: Consider the relative clauses in (1a) and (2a):

(1) a. (the book) that John read
b. $r/(s/np), np, (np\backslash s)/np \Rightarrow r$

(2) a. (the book) that John read yesterday
b. $r/(s/np), np, (np\backslash s)/np, s\backslash s \Rightarrow r$

The two sentences correspond to the sequent derivations in (1b) and (2b). The former is a valid derivation, but the latter is not derivable. The problem is that the hypothetical np assumption is not in the required position adjacent to the verb. Here the so-called Permutation modality comes into the picture. We refine the assignment to the relative pronoun to the type $r/(s/np^{\sharp})$, where the decoration with $^{\sharp}$ indicates an access to *restricted* Permutation.

Structural Constraints: Interaction of the relative clause formation with coordination leads to

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[1]In this paper we focus on categorial systems that use structural modalities. Another branch of categorial grammar is that represented by Combinatory Categorial Grammar (CCG) (Steedman 1996). Work is currently in progress to investigate the relationship between CCG and the partial proof tree system described here.

(3) a. (the book) that John wrote and Bob read

b. $r/(s/np), np, (np\backslash s)/np, (X\backslash X)/X, np, (np\backslash s)/np \Rightarrow r$

(4) a. (the book) that John wrote Moby Dick and Bob read

b. $r/(s/np), np, (np\backslash s)/np, np, (X\backslash X)/X, np, (np\backslash s)/np \Rightarrow r$

(5) $r/(s/np), (np, (np\backslash s)/np, (X\backslash \Box^{\downarrow} X)/X, np, (np\backslash s)/np)^{\diamond} \Rightarrow r$

(6) $np, (np\backslash s)/np, (X\backslash \Box^{\downarrow} X)/X, np, (np\backslash s)/np \Rightarrow \Box^{\downarrow}(s/np)$

(7) a. (the book) that John wrote yesterday and Bob read today

b. $r/(s/np^{\natural}), np, (np\backslash s)/np, s\backslash s, (X\backslash X)/X, np, (np\backslash s)/np, s\backslash s \Rightarrow r$

overgeneration. Sentence (3a), with the corresponding sequent (3b), is derivable with X instantiated to s/np. However, the ungrammatical (4a), corresponding to the sequent (4b), can be derived with X instantiated to s.

This problem can be fixed by refining the type assignment to 'and' to be $(X\backslash \Box^{\downarrow} X)/X$ and by closing off the coordinate structure with the dual structural modality $\diamond$. The resulting sequent corresponding to (3) is now (5), with its validity proved by (6):

The island violation (4) fails, because the hypothetical np assumption finds itself in the scope of modal operator. Thus, the idea of the approach is to *freeze* complete coordination into an island configuration. The introduction of this other type of structural modality imposes structural *constraints* rather than structural *relaxation*, as with the permutation modality.

Conflict: However, if the two types of modalities appear in the same sentence, then they require a simultaneous relaxation and constraining of the interaction between the types. Consider the derivation of (7a), with the corresponding sequent (7b).

To derive this sequent, X must be instantiated as $(s/np^{\natural})$, due to the presence of *yesterday* and *today*. And, as we just saw, the type for *and* should have the type assignment $(X\backslash \Box^{\downarrow} X)/X$, and so the type for *and* in this example becomes $((s/np^{\natural})\backslash \Box^{\downarrow}(s/np^{\natural}))/(s/np^{\natural})$. It is unfortunate that such a complex type for *and* is required simply because of the way that adverbs interact with extraction in the inference system. Using PPTs offers an interesting way to resolve the conflict, because of the way that it employs two different logics.

We cannot show the relevant PPTs here for space reasons. However, the basic idea is that, as discussed in Joshi and Kulick (1997), permutation is not needed for an adverb with a relative clause as in (2a) since the adverb is simple inserted via "stretching" a node in the object relative clause tree. Refinement of the system to account for coordination allows the derivation of (3a), while (4a) is ruled because, of course, the two conjuncts need to be of the same type, and they cannot coordinate if one is s while the other is s/np. Crucially, allowing (7a) is not a problem, since the adverbs simply come in via "stretching", and have no effect whatsoever on the type constraints for coordination. Therefore, there is no need for any modification of the basic type for coordination.

We conclude that by using PPTs, the linguistic phenomena motivating the introduction of structural modalities in categorial grammar can be handled by either eliminating them (such as for an adverb in a relative clause) or by retaining them but *localizing* them within basic PPTs (e.g., topicalization by permutation, as described in Joshi and Kulick 1997), thus avoiding the problem of overgeneration which requires constraints on modalities. This is due to the existence of of two types of logic in the PPTs, a consequence of combining trees rather than just strings, and is a very desirable consequence of localizing the management of resources in the PPT system.

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