

## **Working with Constrained Systems:**

A Review of A. K. Joshi's IJCAI-97 Research Excellence Award Acceptance Lecture<sup>1</sup>

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The search for artificial intelligence in machines might be thought of as the search for the most general and powerful computational mechanisms, perhaps Turing's O-machines or predicate logic with relations, predicate variables, branching quantifiers, and even, perhaps, quantifier variables, and the like. Yet much of Joshi's successful work in AI—he cites five areas and details three of them—has not used general computational mechanisms. On the contrary, he has found that constrained formal-computational systems are often most helpful. These constrained systems are helpful because the constraints on the system may mirror the constraints of the problem.

Joshi considers natural language processing. Ideally, we would want not a universal mechanism whose constraints are all stipulated and include both the constraints of (all) language as well as the constraints of a (particular) language, but a restricted mechanism which builds in the constraints general to language so that all that requires stipulation are the language-specific constraints. Such a restricted mechanism will be a language template, a generator of the family of languages, and its excellence will be in the fact that its structure already does much of the processing required. Now there is not now available and Joshi says that there may never be available such a general restricted mechanism for language. But he reviews areas of his research which have solved *part* of the natural language processing complex of problems using constrained systems.

The first area he reviews concerns some work he did in the late '50's using cascaded finite state transducers for parsing. Suffice it to say that by now the use of finite state machines for all kinds of parsing is standard—and much to be preferred over much more complicated and general mechanisms. The second area he reviews concerns work on lexicalized tree adjoining grammars, the recognition of syntactic *and* semantic structure using a particular type of tree, grown with two operators, substitution and adjoining. Again, the use of trees in syntactic and semantic analysis of natural language is ubiquitous. The third area of his research that he reviews is centering in discourse analysis. The basic idea is that every utterance in a discourse

focuses primarily on one of the objects that are arguments of the main predicate. The way Joshi applied this idea is by replacing, in part, relational predicate logic with monadic predicate logic. In each case, a restriction (from the O-machine to the finite state machine, from the directed graph with loops, multiple edges, and cycles to the acyclic, directed graph (tree), from the polyadic logic to the monadic logic) makes the natural language processing problem easier because it *builds in* the constraints of the problem.

It is interesting to wonder whether we process language with truly general mechanisms or with constrained systems localized in various areas of the brain customized for the task they undertake. I suspect that Joshi and I would agree that the latter is more likely.

1. Aravind K. Joshi, "Relationship between Natural Language Processing and AI: Role of Constrained Formal-Computational Systems," *AI Magazine* 19(Fall 1998): (3)95-107.