Statement of Interest

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I am currently working with the Knowledge Representation project at USC/ISI to incorporate disjunction and negation into the terminological and assertional components of the LOOM system (MacGregor 1988). These extensions to LOOM are being developed by adapting methods that I previously developed in the context of a unification-based natural language parser (Kasper 1988b). The transferability of these methods is based on the observation that many formal properties are shared by the terminological logics used in the KL-ONE family of knowledge representation systems and feature logics commonly used in recent formalizations of linguistic descriptions (Rounds and Kasper 1986). The similarity between these two types of descriptions has been most clearly documented by (Smolka 1988) in his development of a logic that integrates a significant subset of their expressive capabilities. Smolka has also shown that the subsumption and unification problems for this logic can be reduced to each other in linear time. Thus, systems based on either term subsumption or unification can be expected to solve a similar range of problems, although differing levels of non-asymptotic time/space efficiency can be expected.

Most knowledge representation systems have avoided the use of disjunctive descriptions, because it is well-known that common operations on disjunctive descriptions, such as unification and subsumption, require exponential time in the worst case. However, this argument may have limited prac-
tical significance, because many descriptions do not exhibit the worst case behavior, and because processing time depends on the size of the descriptions that are actually used. A disjunctive description may be significantly more succinct than a non-disjunctive representation of the same facts. Therefore, sub-optimal performance may result from not allowing disjunction, because the system is forced to operate on a larger non-disjunctive description, even in many cases where no exponential expansion of the smaller disjunctive description would be necessary.

The simplest strategy that is often adopted for processing disjunctive descriptions is to expand all descriptions to disjunctive normal form (DNF). DNF has the desirable property that it makes inconsistent combinations of disjuncts easy to detect and eliminate, but it has the undesirable property of intractability for even moderately sized descriptions. The basic strategy that we have adopted (from Kasper 1987) is to use a more compact normal form, and expand portions of a description to DNF only when the subsumption algorithm discovers potential interactions between disjuncts of different concept definitions.

We have completed an initial implementation of disjunction within LOOM, in which concept definitions may contain algebraic expressions composed with n-ary logical operators (:and, :or) in addition to the basic expressions describing features of terms. This implementation includes extensions to LOOM's classification and subsumption algorithms to handle a significant class of inferences involving disjunctive definitions. We are also currently developing an implementation of logical negation within LOOM.

Although we expect the expressive power provided by the addition of disjunction and negation to be of general use, our first planned application of these capabilities is a reimplemention of a natural language parser (described by Kasper 1988b) within the framework of LOOM. We expect that the use of LOOM's classifier will overcome several sources of inefficiency that have been observed with many unification-based parsers.

1. The unification method requires a large amount of structure copying; LOOM's network organization automatically provides substantial structure sharing. Pointers are copied instead of structures.

2. The unification method requires consistency checks between disjuncts and components of a description that often do not share any features in common with those disjuncts; LOOM automatically keeps track of
dependencies between different descriptions, eliminating the need for checking consistency of disjunctive components that have no features in common. In effect, the LOOM data structure incrementally builds up an index from features to descriptions that contain them.

3. The unification method requires repeated computations (e.g. consistency and subsumption checks) over sub-expressions of descriptions; once LOOM’s classifier has placed sub-expressions into the concept network, they remain conveniently indexed for future use.

While some methods to reduce these sources of inefficiency have also been reported in the unification literature, LOOM’s classification-based architecture appears to solve a whole class of related problems by explicitly constructing and maintaining a subsumption-ordered lattice of terms with inheritance.

The discussion of disjunction and negation as logical extensions to KL-ONE can be widened to include a general comparison of how different phenomena are modeled in term subsumption languages and unification-based systems. This comparison naturally includes the treatments of implication, equality predicates (e.g. role-value maps), and defaults. In addition, I would like to participate in discussions of several related topics:

1. using KL-ONE style knowledge representation systems to support knowledge-based parsing and generation of natural language;

2. evaluating the trade-offs between increasing expressive power and achieving inferential completeness in the design of logic-based term description languages.

References:


