New Ideas on Term Indexing

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Indexing data structures are well-known to be crucial for the efficiency of the current state-of-the-art theorem provers. In this talk we first recall discrimination trees, which are like tries where terms are seen as strings and common prefixes are shared, and substitution trees, where terms keep their tree structure and all common contexts can be shared.

Second, we describe a new indexing data structure, called context trees, where, by means of a limited kind of context variables, also common subterms can be shared, even if they occur below different function symbols.

Third, we discuss our new methodology for objectively evaluating indexing data structures. Experiments using this methodology for matching show that our preliminary implementation is already competitive with tightly coded current state-of-the-art implementations of the other main techniques. In particular space consumption of context trees is substantially less than for other index structures.

Finally, we describe current work on intelligent backtracking for retrievals on context trees, and the possibility of using flatterm queries in compiled context trees.

Polynomial-time Cost-based Hypothetical Reasoning: Propositional and Predicate Logic Cases

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Hypothetical reasoning (or abduction) is an important framework for knowledge-based systems because it is theoretically founded and useful for many practical problems. Since the inference time of hypothetical reasoning grows exponentially with respect to problem size, its efficiency becomes the most crucial problem when applied to practical problems.

As the first topic, we present an efficient method called SL (slide-down and lift-up) method, which uses a linear programming technique, namely the simplex method, for determining an initial search point, and a non-linear programming technique for efficiently finding a near-optimal 0-1 solution. To escape from trapping into local optima, a local handler is incorporated which systematically fixes a set of variables to locally consistent values when a locally optimal point is detected. The SL method, whose behavior is very comprehensive for humans, can find a near-optimal solution for propositional cost-based hypothetical reasoning problems in polynomial time with respect to problem size.

During the above research, we have noticed that there are two major ways of transforming propositional clauses into numerical constraints. One transforms the clauses into linear inequalities, while the other transforms them into non-linear equalities; these two transformations reveal different characteristics. As the second topic, we show a method of integrating these two transformations by using the augmented Lagrangian method to effectively find better near-optimal solutions in propositional cost-based hypothetical reasoning.

As described above, these exist some efficient reasoning mechanisms in propositional-level hypothetical reasoning. However, these methods are not directly applicable to predicate-logic-version hypothetical reasoning. As the third topic, we present our approach to this problem. Specially, we first perform a knowledge-level transformation followed by instantiation of the first-order clauses into propositional ones, and then apply an efficient propositional-level reasoning mechanism to find a near-optimal solution. The knowledge-level transformation here is based on equivalency-preserving unfold/definition/fold transformations, and allows to obtain a compact propositional representation with significantly less clauses than a simple-minded instantiation of the original first-order theory.

One important message of this research is the effectiveness of using search mechanisms in continuous-value space rather than those in binary space to compute near-optimal solutions efficiently. In the continuous-value space, we can obtain the guiding information of search everywhere in the space as a gradient value of the defined objective function, whereas this is not true in binary space.

The Calculus of Structures

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Our main goal is the development of appropriate logics and calculi for distributed computing such that we can solve existential problems like planning problems as well as universal ones like verifying deadlock freeness. Distributed computing is characterized by parallel and interacting processes as well as by sequential processes. It is well known that parallel and interacting processes can be modelled using two binary operators, which are associative, commutative and admit a unit element, but which are not idempotent. But how can sequential processes be modelled? Clearly, we need an associative, but non-commutative operator. It seems to be quite difficult if not impossible to develop a calculus with two commutative and a single non-commutative operator using a standard methodology like natural deduction