Hypothetical Datalog: Complexity and Expressibility*

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Abstract

We present an extension of Horn-clause logic which can hypothetically add and delete tuples from a database. Such logics have been discussed in the literature, but their complexities and expressibilities have remained an open question. This paper examines two such logics in the function-free, predicate case. It is shown, in particular, that augmenting Horn-clause logic with hypothetical addition increases its data-complexity from PTIME to PSPACE. When deletions are added as well, complexity increases again, to EXPTIME. To establish expressibility, we augment the logic with *negation-by-failure* and view it as a query language for relational databases. The logic of hypothetical additions then expresses all database queries which are computable in PSPACE. When deletions are included, the logic expresses all database queries computable in EXPTIME.

1 Introduction

Several researchers in the logic programming community have pointed out the utility of augmenting Horn-clause logic with the ability to hypothetically add facts to a database [13, 12, 22, 26, 19, 4]. Others have done as much by investigating the intuitionistic semantics of embedded implications [20, 21]. However, the complexity and expressibility of these logics has remained an open question. This paper addresses these issues from a database point of view. In particular, results on data-complexity and expressibility are established for the function-free predicate case.

This paper also examines hypothetical deletion. In contrast to additions, hypothetical deletions have received little attention in the logic-programming literature, one exception being the work of Manchanda and Warren [19]. As in their work, this paper focuses on deletions from the database, and not from the least fixpoint. Although relatively simple, such deletions nevertheless increase the complexity and expressibility of the logic from PSPACE to EXPTIME.[1,2]

Results are established for two distinct extensions of Horn-clause logic: (i) Horn logic augmented with hypothetical additions (called the *restricted* logic), and (ii) Horn logic augmented with both hypothetical additions and deletions (called the *full* logic).

Hypothetical queries are particularly useful in the context of rule-based systems and deductive databases. For example, one might ask, "If I were to take *eng*423,

*This paper appears in the *Proceedings of the Second International Conference on Database Theory (ICDT)*, pages 144–160. Volume 326 of Lecture Notes in Computer Science. Springer Verlag. Conference held August 1988 at Bruges, Belgium.

[1] In this paper, the terms EXPTIME and "exponential time" denote DTIME($2^{n^{O(1)}}$).

[2] The increase is strict iff $PSPACE \neq EXPTIME$, which although considered likely, is an open question.