Title: Generalized model-checking problems for first-order logic

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Abstract: A fundamental algorithmic problem, playing an important role in different areas of computer science, is the following model-checking problem:

Given a finite relational structure A and a sentence S of some logic L, decide if A satisfies S.

The name model-checking is most commonly used for the appearance of the problem in automated verification. However, the problem of evaluating a query against a finite relational database is of the same type. Constraint satisfaction problems in artificial intelligence can also be seen as model-checking problems. Moreover, many of the best-known algorithmic problems can be directly translated into model-checking problems.

Often, we are not only interested in a model-checking problem itself, but also in certain variants. One example is the evaluation of database queries - model-checking in the strict sense only corresponds to the evaluation of Boolean queries, that is, queries with a yes/no answer, but queries whose output is a set of tuples of database entries also need to be evaluated. Constraint satisfaction problems provide another example - usually, we are not only interested in the question of whether a constraint satisfaction problem has a solution, but we actually want to construct a solution. Sometimes, we want to count the number of solutions, or generate a random solution, or construct a solution that is optimal in some sense. We refer to such problems as generalized model-checking problems.

For many interesting logics, such as first-order logic or monadic second-order logic, generalized model-checking problems are computationally hard in general. However, there is a number of natural tractable restrictions. This paper is a survey of new algorithmic approaches to model-checking for first-order logic.

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