On Graph Queries and Modal Constraints

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Abstract

Some fundamental problems in database theory and knowledge representation can be viewed as instances of the *query entailment problem*. While query *evaluation* asks whether a given query holds in a specific structure, query *entailment* consists in determining whether the query holds in every model of a given theory that extends that structure. The input structure represents the raw data stored in a database; the theory captures contextual information such as a set of database constraints or an ontology; and the query is used to extract specific information of interest.

The recent proliferation of graph databases has brought the database and knowledge representation communities closer together, as many key problems in both fields involve the same structures – labelled graphs – and similar combinations of formalisms for theories and queries. A notable example is the combination of description logics and conjunctive regular path queries. Description logics are a family of formalisms based on fragments of first order logic, akin to modal logics. They are among the most prominent ontology languages and they are capable of expressing most kinds of constraints relevant in graph databases. Conjunctive regular path queries extend conjunctive queries (primitive positive first-order formulas) by allowing regular expressions over binary predicates to be used as atoms. They form the core of practical query languages employed in graph database systems and the Semantic Web.

What distinguishes the two fields is the approach to infinity: knowledge representation embraces infinite models, whereas database theory focuses on finite models. Although many cases of the entailment problem have long been solved over unrestricted (finite or infinite) models, their finite-model counterparts have only recently seen progress, and many questions remain open.

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