Equality-friendly well-founded semantics and applications to description logics

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Introduction and results

• Datalog+ is a recent family of languages that allow for efficient ontological reasoning, and cover several important description logics (DLs). It is based on an extension of Datalog.
• We give a well-founded semantics (WFS) for Datalog+ extended by (non-stratified) non-monotonic negation in rule bodies. Our WFS: – does not make the unique name assumption to bring it close to OWL and its profiles, and to typical DLs, – allows for query answering with roughly the same complexity as in the negation-free case, for guarded Datalog+ with negation.
• Our results lead to precise definitions of standard WFS extension of LC and members of the DL-Lite family, and corresponding complexity results.

1 Datalog

The Datalog+ family of ontology languages [1] • extends plain Datalog by existential quantification in rule heads (and certain additional features).
• restricts the rule syntax to achieve tractability (members of Datalog+ are defined by this restriction). It bridges an apparent gap in expressive power between query languages and description logics (DLs), and allows for transferring important concepts and proof techniques from database theory to DLs.

2 Adding negation

Normal Datalog+ generalizes Datalog+ by non-monotonic negation in rule bodies:

\[ \text{Normal Datalog+ rules} \]

Normal tuple-generating dependencies (NTGDs):

\[ R(X_1, \ldots, X_n) \rightarrow \bigtriangledown Y \]

Negative constraints:

\[ \lnot R(X_1, \ldots, X_n) \rightarrow \perp \]

3 Semantics

We define a semantics for normal Datalog+ that is:

• based on the well-founded semantics (WFS) for logic programs with negated atoms in rule bodies [3],
• equality-friendly in that it does not make the unique name assumption (UNA).

Why basing the semantics on the WFS?

It is one of the most widely used semantics for logic programs with negated atoms in rule bodies [3], and the standard semantics for such programs in the database context.

Why do not make the UNA?

OWL and its profiles as well as typical DLs don’t do it. Not making the UNA is often more appropriate:

Why do not make the UNA?

The UNA leads to the undesired answer “yes”.

Steps for defining the semantics

Step 1: For each possible way \( W \) of equating individuals and assigning individuals to existential variables in rule heads, devise a logic program \( F^+ \) that simulates the original normal Datalog+ program \( P \) with individuals equated and assigned according to \( W \).

Step 2: The semantics of \( F^+ \) is the set of the well-founded semantics of the programs \( F^+ \) (that satisfy all negative constraints).

4 Query answering

An NTGD is guarded if all the positive body literals \( R(X_1, \ldots, X_n) \) contains all variables in the body.

Complexity of query answering over normal Datalog+, where all NTGDs are guarded

• 2-EXPTIME complete in general
• EXPTIME complete if bounded arities + acyclic queries

5 WFS for OWL 2 QL

• Important DLs such as LC and all members of the DL-Lite family can be embedded into Datalog+ [2].
• Our results lead to extensions of such DLs with non-monotonic negation under the equality-friendly WFS.

Outlook

• What is the data complexity of query answering under the equality-friendly WFS?
• An equality-friendly answer set semantics

Literature


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