Fixpoint Semantics for Active Integrity Constraints: Extended Abstract *

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One of the key components of modern-day databases is the inclusion of integrity constraints: logical formulas that specify semantic relationships between the data being modeled. When the database is changed (typically due to updating), it is necessary to check if its integrity constraints still hold; if not, the database must be repaired.

The problem of database repair has been an important topic of research for more than thirty years [1]. There are two major problems when deciding how to repair an inconsistent database: *finding* possible repairs and *choosing* which one to apply. Indeed, there are typically several ways to fix an inconsistent database, and several criteria to choose the "best" one have been proposed over the years. One such approach is the formalism of *active integrity constraints (AICs)* [9], which grew out of the idea of giving the user more control over how inconsistencies are fixed. AICs express database dependencies through logic programming-style rules that include update actions in their heads. They have been equipped with various declarative semantics.

It is striking that many intuitions about what "good" repairs are, such as the principle of minimality of change (change as little as possible), are similar to intuitions that surfaced in various domains of non-monotonic reasoning. Still, it has been hard to find satisfying semantics for AICs. As shown by Cruz-Filipe et al. [6], the semantics of so-called *founded repairs* [3] unexpectedly fails to respect the common-sense law of inertia (all changes must have an underlying reason), while the more restricted semantics of justified repairs [4] forbids natural repairs in some cases. On the other hand, well-founded repairs are not modular [5] and therefore severely restricted in their practical applicability.

In the full version of this paper [2], we use techniques that were developed for non-monotonic reasoning to solve the semantic problems of the field of active integrity constraints. More specifically, we develop several novel semantics for AICs that are natural counterparts of existing logic programming semantics using *approximation fixpoint theory*, a general algebraic framework for studying logics with a fixpoint semantics [8]. In a nutshell, given a complete lattice L and an operator $O : L \to L$, Denecker, Marek, and Truszczynski [8] defined the notion of an *approximating operator* $A : L^2 \to L^2$ on the square bilattice

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L^2. From such an operator and approximator, using purely algebraic techniques, various types of fixpoints are defined (supported, (partial) stable, Kripke-Kleene, well-founded, (partial) grounded). For logic programming, Denecker, Marek, and Truszczynski showed that Fittings four-valued immediate consequence operator $\Phi_{\mathcal{P}}$ is an approximator of van Emden-Kowalski's two-valued immediate consequence operator $T_{\mathcal{P}}$ and that various types of fixpoints capture the equally named semantics of logic programming. AFT has been applied to various other fields, such as non-monotonic reasoning, abstract argumentation and causality.

In order to bring this rich family of semantics to the field of AICs, we define a semantic operator and an approximator associated with a set of AICs. Two of the resulting semantics stand out. We argue that *grounded repairs* match our intuitions regarding AICs on a broad set of examples. We argue that, from a practical point of view, the *AFT-style well-founded repair* is very valuable. Indeed, we show that the AFT-well-founded repair can be computed in polynomial time, and that, on a broad set of practical examples, it provides natural upper and lower bounds on the set of acceptable repairs (formally: the AFT-style well-founded model approximates all justified, stable and grounded repairs).

The contribution of this work goes beyond the definition of new semantics for AICs. By integrating active integrity constraints in AFT, we provide solid foundations for applying a rich algebraic theory to AICs. For instance, we can now directly apply existing results from AFT, such as modularity results to AICs. It remains to be researched how these related for instance to existing modularity results for AICs. Furthermore, our work paves the way to applying AFT to revision programming [4], and to AICs outside the database world [7].

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