Familial monads and structural operational semantics

Research area: programming language semantics

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CONTEXT

Structural operational semantics [5] is a method for specifying the dynamics of programming languages by induction on their syntax. It produces a labelled graph whose vertices are programs and whose edges model evaluation steps, including interactions with the environment. An important issue in this area is to ensure that the obtained language behaves well, notably by proving that program equivalence is a congruence. This often turns out to be difficult, which motivated the design of various *formats* [4] and accompanying well-behavedness results. However, formats have grown to be very diverse, which further motivated *functorial operational semantics* [2, 9], an abstract, unifying framework based on category theory [3]. Though quite well developed, functorial operational semantics does not scale well to languages with variable binding. E.g., even the most promising solution [8] has not really been adopted by the community.

GOAL

In recent work [1], we propose to distinguish two goals:

- on the one hand, finding a high-level, abstract language for reasoning on structural observational semantics,
- on the other hand, designing formats for generating well-behaved semantics.

We define a new categorical framework contributing to the former goal, based on *familial monads* [10]. In this setting, under suitable hypotheses, we smoothly prove two important, standard properties of the obtained semantics: *congruence of bisimilarity* [7] and soundness of *bisimulation up to context* [6].

The goal of the internship/thesis is to contribute to the development of the new framework. E.g., this could take one of the following forms:

(1) We could try to prove that existing formats are covered by the new framework. This would probably be a good place to start.
(2) In a similar vein, it could be useful to adapt the framework to other, related techniques, e.g., Howe's method, weak bisimulation, environmental bisimulation, or finding solutions to process equations.
(3) In the longer run, we could investigate new formats based on familial monad theory.

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