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To whom it may concern,

Review of Mateusz Pyzik's doctoral dissertation

Mateusz Pyzik's dissertation is entitled "Reflection of continuation-passing style in calculi for delimited control". It studies operational correspondence results, between lambda calculi with delimited control operators and pure lambda calculus, by way of Galois reflections.

It comprises an introduction chapter along with three other chapters each of which consists of a peer-reviewed article published respectively in the proceedings of the conferences FSCD 2020, PPDP 2021, and MSFP 2022.

Chapter 1 introduces the technical background and outlines the contributions of the rest of the dissertation. It begins by briefly describing the history of control effects including abortive control operators such as call/cc and various composable delimited control operators along with their relationship to continuation-passing style (CPS). It presents a formal account of the primary theoretical framework used in the rest of the dissertation, namely Galois reflections, as pioneered for operational correspondences by Sabry and Wadler. It places the Galois reflection approach in the context of prior work on inverting CPS transformations and on equational correspondences. Finally, it outlines the contributions of the rest of the dissertation and speculates about how a similar methodology might also apply to effect handler calculi.

Each subsequent chapter follows the pattern of Sabry and Wadler's work. A Galois reflection is exhibited between a source calculus and a target calculus via a CPS translation and its inverse. By composing the CPS translation with its inverse a kernel of the source calculus is obtained which enjoys an order-isomorphism with the target calculus. Careful syntactic analysis, requiring a non-trivial degree of technical prowess, is used to precisely characterise the image of each translation. This syntactic analysis relies on using a form of context-sensitive grammar in which productions are constrained by various parameters.

Chapter 2 exhibits a Galois reflection between λ_{cS} , a variant of Moggi's computational lambda-calculus extended with the shift and reset control operators, and a pure lambda calculus. It does so via a CPS translation and its inverse. It further shows that λ_S , a more standard course-grained call-by-value lambda-calculus, embeds into λ_{cS} .

Chapter 3 exhibits a Galois reflection between $\lambda_{c\$}$, a variant of Moggi's computational lambda-calculus

extended with the `shift0` and dollar control operators and a pure lambda calculus. It does so via a CPS translation and its inverse. The source calculus $\lambda_{c\$}$ is also compared with $\lambda_{\$}$, a coarse-grained call-by-value calculus extended with `shift0` and dollar, previously introduced by Materzok and Biernacki. Many of the axioms of $\lambda_{\$}$ are undirected, ruling out a Galois reflection with pure lambda calculus. It is shown that $\lambda_{c\$}$ is sound and complete with respect to all but one of the rules of $\lambda_{\$}$.

Chapter 4 reprises Chapter 3 by also exhibiting a Galois reflection between $\Lambda_{\$}$, a different, somewhat ad hoc, call-by-value calculus extended with the `shift0` and dollar control operators, and a pure lambda calculus. By carefully tuning the syntax and reduction rules of the source calculus such that the reduction relation defines a complete axiomatisation of `shift0` and dollar, the image of the CPS translation becomes the entire call-by-name lambda calculus. This induces a tight correspondence between $\Lambda_{\$}$ and call-by-name lambda calculus via a CPS translation and its inverse. A remarkable corollary of this result is that *every* call-by-name lambda calculus term can be viewed as the CPS translation of some call-by-value $\Lambda_{\$}$ term. It is further shown that there is an equational correspondence between $\lambda_{\$}$ and $\Lambda_{\$}$.

The approach of the dissertation is unashamedly syntactic and there are some minor wrinkles. One of the strengths of the method of Sabry and Wadler is that it is robust in the face of arbitrary ad hoc choices of syntax and reduction rules. Despite the minor wrinkles, the results are significant and compelling. Nonetheless, I cannot help wondering whether there may be opportunities to design a somewhat more elegant variant of $\Lambda_{\$}$, perhaps motivated by additional semantic considerations — such questions are for future work.

The material in the dissertation is focused on a relatively narrow area, but this focus is accompanied by a thoroughness which pays off. The method of Sabry and Wadler is skilfully extended and applied to three separate problems. The results are interesting and novel, and have all already been endorsed through the peer-review process. I am happy to recommend that the dissertation be accepted, and that Mateusz Pyzik be awarded a PhD.

Yours sincerely,



Dr Sam Lindley
Reader