A relational approach to bidirectional transformations

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December 3, 2010

Transforming data between different structures is a typical computing problem. Also, in most cases we wish these transformations to be *bidirectional*, with the changes made in either structure reflected in the other. A naive approach to solve this problem involves the creation of two unidirectional transformations and then verify that they are in some way each-other inverses (or *well-behaved*). Besides being an expensive and error-prone task, this verification would need to be performed every-time the transformation is modified. A better approach consists in designing a language where an expression represents both transformations, which are guaranteed to be *correct by construction*. A particularly successful mechanism created under these approach are the *lenses* [3], proposed as a solution to the *view-update problem* of databases (how to propagate updates on a database view to the source).

Recent work has been developed to specify these lenses using functional *point-free* (PF) notation [2], lifting standard PF combinators and recursion patterns to well-behaved lenses. This approach enables easy equational calculation with lenses and optimization of bidirectional transformations. However it has some limitations, namely it is not expressive enough to capture all sorts of bidirectional transformations. In fact, the transformations can be seen as *abstraction* and *representation* relations [4]. By generalizing to a relational setting we obtain a higher degree of freedom in the calculus, becoming easier to calculate inverses of transformations and represent data invariants. Since a PF version of relational calculus has already been widely studied [1], we believe we can improve this previous work under this perspective.

In particular, the objectives of this thesis are:

- To compare and classify the existing approaches to bidirectional transformations using the relational calculus as unifying formalism.
- To propose a methodology for the derivation of inverses by calculation, starting from the specification of the forward transformation and the desired well-behavedness criterion.
- To enlarge the applicability of the previously proposed PF lens notation [2], by proposing new combinators and using data invariants to enlarge the expressiveness of the language.
- To propose an effective technique for bidirectional transformation of non tree-like data structures (graphs and models in general). Some techniques

have already been proposed, but they are either too ad-hoc, giving little or no guarantees to the user, or too complex and limited, making it difficult to express transformations or perform calculations / optimizations.

- To identify and give proper semantics to well-behaved subsets of existing high-level model transformation languages (namely QVT) using the calculus of relations.

References

[1] R. Bird and O. de Moor. *Algebra of Programming*, volume 100 of *International Series in Computer Science*. Prentice-Hall, Inc., 1996.

[2] A. Cunha and H. Pacheco. Generic point-free lenses. In *Proceedings of the 10th International Conference on Mathematics of Program Construction*, number 6120 in LNCS, pages 331–352. Springer-Verlag, 2010.

[3] J. Foster, M. Greenwald, J. Moore, B. Pierce, and A. Schmitt. Combinators for bidirectional tree transformations: A linguistic approach to the view-update problem. *ACM Transactions on Programming Languages and Systems (TOPLAS)*, 29(3):17, 2007.

[4] J. N. Oliveira. Transforming data by calculation. In *Generative and Transformational Techniques in Software Engineering II*, volume 5235 of *LNCS*, pages 134–195. Springer-Verlag, 2008.