

## **Relational Programming in miniKanren**



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Typeset by the author in X<sub>Y</sub>L<sup>A</sup>T<sub>E</sub>X, using Tufte-Style Book from <http://www.LaTeXTemplates.com>.  
June 14, 2013 version.



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*For my H211 students: Indiana University, Fall 2010 & 2011.*

*Learning with always trumps learning from.*

—Woodie Flowers



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# Preface

## Audience

This book is written for intermediate-to-advanced programmers, computer science students, and researchers. For this book, *intermediate* means that you are comfortable writing simple recursive procedures in a functional programming language, such as Scheme, Racket, Clojure, Lisp, ML, or Haskell. I also assume you have a reading knowledge of Scheme. No knowledge of relational programming, logic programming, or programming language theory is required.

If you want to learn about relational programming, but are new to programming, Dan Friedman, Oleg Kiselyov, and I have written a book just for you, called *The Reasoned Schemer*<sup>1</sup>. In that book we assume you are familiar with the material in *The Little Schemer*<sup>2</sup>, which is a very gentle introduction to recursion and functional programming.

If you are an experienced programmer, but weak on recursion, you, too, might benefit from *The Little Schemer*. If you are comfortable with recursion, but not functional programming, good introductions include *Scheme and the Art of Programming*<sup>3</sup> and the classic *Structure and Interpretation of Computer Programs*<sup>4</sup>.

If you are an experienced functional programmer, but do not know Scheme, the beginning of *Structure and Interpretation of Computer Programs* should get you up to speed, while *The Scheme Programming Language, 4th Edition*<sup>5</sup> describes the language in detail.

## Goals

The high-level goals for this book are to make relational programming accessible to a broader audience, and to explain the state-of-the-art in the design, implementation, and use of the miniKanren language.

Specifically, the book aims to:

1. describe the current state of the miniKanren language, and its Constraint Logic Programming (CLP) extensions;

I have attempted to deliver [these lectures] in a spirit that should be recommended to all students embarking on the writing of their PhD theses: imagine that you are explaining your ideas to your former smart, but ignorant, self, at the beginning of your studies!

—Richard P. Feynman  
*The Feynman Lectures on Computation*

<sup>1</sup> D. P. Friedman, W. E. Byrd, and O. Kiselyov. *The Reasoned Schemer*. MIT Press, Cambridge, MA, 2005

<sup>2</sup> D. P. Friedman and M. Felleisen. *The Little Schemer (4th ed.)*. MIT Press, Cambridge, MA, 1996

<sup>3</sup> G. Springer and D. P. Friedman. *Scheme and the Art of Programming*. MIT Press, Cambridge, MA, 1989

<sup>4</sup> H. Abelson and G. J. Sussman. *Structure and Interpretation of Computer Programs*. MIT Press, Cambridge, MA, 2nd edition, 1996

(full text at <http://mitpress.mit.edu/sicp/full-text/book/book.html>)

<sup>5</sup> R. K. Dybvig. *The Scheme Programming Language, 4th Edition*. The MIT Press, 4th edition, 2009

(full text at <http://www.scheme.com/tspl4/>)

2. present a variety of relational programs that exemplify the relational style and introducing important relational idioms;
3. explain how to derive miniKanren relations from pure Scheme functions, in a systematic manner;
4. give a detailed explanation of the latest implementation of core miniKanren, and to show how to hack the implementation to change the behavior of miniKanren, or add new operators;
5. explain how constraint solving works in the cKanren Constraint Logic Programming framework, and show how to design and implement new constraint domains;
6. demonstrate how to debug miniKanren relations;
7. explain how miniKanren differs from related languages, including Prolog, Curry, Mercury, and Oz;
8. describe important open problems in relational programming, and limitations of miniKanren;
9. explain the rationale behind key design decisions for miniKanren;
10. use relational programming to explain important and interesting concepts from programming languages, such as interpreters, type inferencers, and Continuation-Passing Style.

Describing these programming languages concepts has the important side effect of making accessible the academic papers presented on miniKanren.

## Margin Notes

This book is typeset in the style of Edward Tufte’s magnificent and beautiful *The Visual Display of Quantitative Information*<sup>6</sup>. I share Tufte’s love of margin notes, and use them in this book to help solve the problem of addressing readers with widely varying knowledge of computer science and programming. To make the book accessible as possible, in the main text I assume the reader is the hypothetical *intermediate-level* programmer or student described in the *Audience* section above. In the margin notes, however, anything goes.

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Salt Lake City, Utah  
June 2013

This book is set using the “Tufte-Style Book” L<sup>A</sup>T<sub>E</sub>X style, freely available from <http://www.LaTeXTemplates.com>

<sup>6</sup> E. R. Tufte. *The visual display of quantitative information*. Graphics Press, Cheshire, CT, 1986

Another great lover of marginalia was David Foster Wallace (1962–2008). The *Harry Ransom Center’s* DFW collection includes heavily annotated books from Wallace’s personal library: <http://www.hrc.utexas.edu/press/releases/2010/dfw/books/>. Wallace’s love of margin notes is best demonstrated by his essay “Host”, in:

D. F. Wallace. *Consider the Lobster and Other Essays*. Little, Brown and Co., 2005

# *Introduction*

*gl hf!*

(Traditional greeting in the Koprulu Sector)



## *Conclusion*

G.G.

—Sean “Day[9]” Plott



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