

Preface

Outrageous Dreams Realized: A Fascinating Country in the World of Computing

Here you will visit a fascinating country in the world of computing, the country known as automated reasoning. This book will be your guide, to its language, to its customs, to its delights. This book also features a dream once thought (almost four decades ago) to be just that—a wild and outrageous dream presenting obstacles that were almost certainly insurmountable.

But such dreams, rather than simply remaining forever dormant, often herald great events, as was true of earlier dreams, dreams that grew bigger as the likelihood of their realization grew smaller: running a mile in less than four minutes; building a skyscraper more than 1000 feet high; walking on the moon. Each of these dreams was outrageous. Nevertheless, each was realized.

Then the most outrageous dream was born: access to a single computer program that would solve puzzles, design circuits, verify the accuracy of computer code, and—most absurd of all—answer questions that had for years baffled the minds of mathematicians and logicians. But, how could a researcher tell a computer—that had no experience, no intuition, no schooling—about weighing billiard balls to find the odd one among twelve? Which *language* would permit you to discuss with your computer AND gates, OR gates, and the like? What means could exist for conveying the notion of nested DO loops? And—even difficult for many people—could a means be found to ask a computer to study group theory?

Then, if some language could be found or invented, what means (*inference rules*) could exist to enable your computer to draw logical conclusions, to reason flawlessly? After all, to solve puzzles, design circuits, verify computer code, and prove theorems, required is the ability to reason deeply and without error. Even with such an ability, if an inordinate time were needed to complete assignments, you would be in possession of an aesthetically pleasing and versatile computer program, but a program that is, from a practical viewpoint, essentially useless.

Therefore, even if the obstacles of a versatile language and a flawless means for conclusion drawing proved not to be insurmountable, access to the desired program would still be little more than a dream—unless perhaps the severest obstacle of all could be overcome. You may indeed know what that obstacle was, if you have played chess, poker, the stock market, basketball, or even monopoly. The flawless reasoning must be controlled, and controlled well. The use of *strategy* of various types would be required.

The four-minute mile has been run, often; the skyscraper of more than 1000 feet has been built; the moon has been walked; and, most satisfying to me, the sought-after program now exists, McCune's OTTER. Yes, the language has been found, the flawless inference rules formulated, and the powerful strategies created (all, and more, covered in this volume). The dream has been realized—and to a far greater extent than I would have predicted but twenty years ago. Indeed, despite the fact that the vast majority of my research time since 1963 has been devoted to the automation of logical reasoning, I was convinced as late as 1978 that the field would not make substantial contributions to mathematics and to logic in my lifetime. My estimate of what would occur fell far, far short of the mark—the field of automated reasoning has contributed significantly to diverse areas of both mathematics and logic.

This book and its included CD-ROM provide you with many choices for your journey through the country known as automated reasoning, some leisurely and full of detail, some rather brisk but offering varied food, some extremely brief. The map given in Chapter 1 discusses some of the choices. You need not have visited other countries in the world of computing to enjoy your journey. Nor need you be especially interested in automated reasoning to experience intrigue; for example, mathematicians and logicians will be presented with open questions to answer and hard problems to solve.

Although your possession of this book and its companion (two volumes of my published papers, entitled *The Collected Works of Larry Vos*) may not satisfy all of your life's desires and ambitions, the two books with their respective CD-ROMs offer you a rather complete environment for spending hours of time and thought. At one end of the spectrum, you are offered a gentle introduction to the basic components of logic, a chapter that familiarizes you with the elements of automated reasoning, a chapter that thoroughly discusses the underlying formalism, exercises to test your understanding, and answers to enable you to grade yourself. At perhaps the midpoint of the spectrum, you are offered chapters that focus on various applications of automated reasoning: mathematics, logic, circuit design, and circuit validation. At the other end of the spectrum, you find open questions, hard problems, research topics, and fine challenges. To aid you with your browsing in the two-volume set of my papers, this book contains vignettes that touch on key aspects of most of them. Finally, among the offerings of this book, you will find your own copy of OTTER (for workstations, for personal computers, for the

Macintosh), a manual, a chapter to guide you in your use of OTTER, numerous input files, fragments of output files, proofs—and more.

This book will serve you well as a text (for professor or student), as an introduction to the field and some of its uses, and as a source for research topics whose resolution could easily lead to publications. Whichever your interest and whatever your motivation, with this book and its companion I welcome you to a trip that you will long remember.

Acknowledgments

I thank William McCune for his many contributions to automated reasoning, not the least of which is his program OTTER. Without access to OTTER, this book, my research, and the field as a whole would be unrecognizable. I also thank him for his invaluable assistance with the preparation of the included figures.

I thank Robert Veroff for staying as young as when we first met in 1975. Also I thank him for his contributions to elements of Chapter 10 and to aspects of the Appendix. The zeal and delight we share for experimentation has brought me immense satisfaction.

I thank Ross Overbeek for his continued encouragement, his honesty, and his insights. I continue to present material in the manner that I do in part because he considers it unusually appropriate.

I thank Branden Fitelson for his expertise and effort in the preparation of the included CD-ROM. Even more, I thank him for proving to me that some students are still alive, exhibiting more than excitement at the prospect of conquering areas of logic and mathematics with the aid of an automated reasoning program. Since I met McCune, none has shown the promise that Branden shows.

Finally, although the presence of her name on this book (supposedly) demands no acknowledgment, I thank Gail Pieper. Because of her devotion to truth, clarity, and consistency, this book is a far, far better volume than it would have otherwise been. Most of all, I thank her for being the finest of colleagues.

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