

Preface

In memory of my teacher, friend and mentor, Max Dresden

The book that you-kind reader-are holding in your hand represents a labor of love, in the purest sense, for most of the five-and-a-half years that it took to write; and the additional five years that, because of various setbacks and self-imposed periods of inactivity, it took me to struggle through in order to have it finally see the light of day. In the time that the book has matured from a vague but interesting idea—first brought up by the author’s thesis advisor while waiting for dessert to arrive during a casual luncheon—to its final unintentionally massive form, I have myself evolved dramatically from an idealistic, 28-year-old, sadly underpaid graduate physics student to a husband, father and senior defense analyst working for a naval think-tank,[†] currently developing one of the first cellular-automata-based *artificial-life* simulations of combat. I would like to briefly share a few personal notes about how this book came to be.

I received my Ph.D. in theoretical physics from the *Institute of Theoretical Physics (ITP)* at the State University of Stony Brook in 1988. My thesis research, entitled “Computer Explorations of Discrete Complex Systems,” was conducted under Professor Max Dresden, who was at the time nearing the end of his professional career; a career that began when Max was studying for his own Ph.D. under Uhlenbeck (of spin fame). I was, in fact, Max’s last Ph.D. student, and it was Max who one day suggested to me during one of our frequent lunches that he and I ought to write a book on cellular automata together.

At the time, Max had just had his well-received biography of the Dutch physicist

[†]The *Center for Naval Analyses (CNA)* is a not-for-profit federally funded research & development center.

Kramers[†] published, and was, I suspect, anxious to start a new writing project. The year was 1987: four years after Wolfram's groundbreaking review article on cellular automata that appeared in *Reviews of Modern Physics* [wolf83a], and three years after the founding of the *Santa Fe Institute*, now arguably one of the world's leading centers for complex systems research.

My own interest in cellular automata manifested itself during my first year as a physics graduate student, while I was exploring the conceptual foundations of physics by looking into novel approaches to unifying quantum field theory and relativity. What was then, and remains today, an essentially open problem (string theory notwithstanding), is the unification of quantum mechanics—whose laws operate on the microscopic level—with general relativity—which describes phenomena on the very macroscopic level.

An idea that I had been tinkering with, in early 1983, involved re-writing some microscopic equations of motion on a discrete dynamic lattice representation of space-time. I wanted to see if one could construct a toy universe in which the fundamental distinction between *figure* (i.e. particles) and *ground* (i.e. space-time) is blurred (or disappears completely). Though I did not know it at the time (this was many months prior to Wolfram's review article, and whatever else I may have read on cellular automata certainly was not memorable enough in my own mind to start its own cognitive meme), the formalism I was struggling with to create and understand was precisely that of cellular automata!

The day that Wolfram's article appeared at ITP's library is forever etched in my mind as one of those proverbial milestone events in one's life. I knew instantly that cellular automata embodied a profound new approach to looking at physics and the world; and that cellular automata were a subject about which I had to do a lot of thinking. I will forever be indebted to Max for allowing me to pursue musings that seemed—certainly to those making up the intellectual inner-circle of ITP at the time—comical, at best and childishly unphysics-like, at worst. So...

It was with great pleasure that—three years later, and at the tail-end of completing my dissertation—I accepted Max's kind offer to jointly write a book on CA. "One or two years," I thought, "is all it will take." I was wrong.

Following my successful thesis defense in early 1988, I moved down to Washington, D.C. to start what has become a more than decade-long professional occupation as research analyst for the US Navy. My new job was, (and still is!) profoundly time consuming. My official duties soon took me to several (many-week-long) naval exercises at sea, included an intensive several-month-long reconstruction effort of *Operation Desert Storm* (which itself included virtually around-the-clock work days), and culminated in a multi-year stint as CNA's field representative at the naval air station located on Whidbey Island in Washington state (during which time many of my duties introduced me to the unhappy sport of prolonged sleep deprivation).

[†]Max Dresden, *Kramers: Between Tradition and Revolution*, Springer-Verlag, 1987.

Needless to say, the time (and energy) that remained for making any progress on this book after the long work days that characterized this period of my life, kept taking increasingly bigger hits.

Adding to these difficulties of writing a book, Max's own schedule had also undergone significant changes, and he was soon to back off from making a deeper commitment. Soon after I received my Ph.D., Max retired to Professor Emeritus status at Stanford University in California. He became engrossed in editing journals, working on several new physics projects with a fresh set of post Docs, and lecturing throughout the country on extended trips.[§] His schedule thus, unfortunately, left precious little time for writing. Though we had contract offers from two distinguished and reputable publishing houses (we accepted the one from Springer-Verlag), the co-authored project that began in earnest in 1989, was first converted to single authorship (namely, mine), and not long afterward, began languishing from a terminal case of *much, much too much to do in too short a time!*

The premature end of the project seemed to finally come when I learned in 1995 that Max had been diagnosed with an inoperable form of cancer. At the time, I had completed roughly 80% of the book, and the reality of actually completing the Herculean task no longer seemed so farfetched. However, without Max—without his encouragement and always happy outlook—I found that, for psychological reasons, it was difficult for me to continue. The book thus remained in its semi-complete form for several years following Max's sad announcement. Max died a few years later in 1997. As all of us who were graced by this gentle soul know well, Max was a profoundly gifted and inspiring teacher. He will be intensely missed.

What finally saw the book through to its conclusion? I confess to not having a solid answer. However, I am fairly certain that, had it not been for a serendipitous intervention of Jungian synchronicity, the book would never have been completed. In my professional capacity as a research analyst for the US Navy (working for a think tank that also does work for the Marine Corps), I had the distinct privilege and honor of getting to know a truly visionary military thinker: *Lt.Gen (Ret) Paul van Riper*.

General van Riper, during the time when he was Commanding General at the Marine Corps Concept Development Command at Quantico, VA. (1994-1996), approached CNA with an idea for a study that asked, *What do all of these new ideas I've been hearing about – nonlinearity, complexity, complex adaptive systems – have to do with combat?* Since many at CNA knew of my deep interest in the subject, I was soon asked to direct a project addressing this question; a project that has since spawned a follow-on multi-year effort sponsored by the *Office of Naval Research* to develop an artificial-life model of combat.[¶] To say that Lt.Gen van Riper's appear-

[§]Max was particularly fond of giving (always well received) talks at frequently held Chautauqua conferences for schoolteachers.

[¶]Those parts of this research that involve cellular automata are described in chapter 11 of this book. For additional details, including all approved-for-public-release documentation, see

ance on the scene was “welcome” would be a gross understatement. His vision has led me down many interesting new intellectual paths I would likely otherwise have never encountered.

Thus, slowly, at first, then more strongly, my CNA complexity project eventually re-ignited the passion I had inexplicably lost for my *other* complexity project: this book! Thus, to both Max and Gen van Riper, I owe an absolutely enormous, sincerely heartfelt, thanks. To Max for originally igniting and encouraging what was to become a life-long passion; to Paul van Riper for reminding me, more recently, and just as forcefully, of the passion that life’s circumstances had somehow, inadvertently and – as it turns out – only temporarily, dislodged. Thank you both!

I conclude this preface with an observation. Despite the very long gestation period for this book (nearly ten years, from original concept to publication), no other graduate-level book on cellular automata, comparable to the length and scope of this one, has appeared in the interim. Most likely, this is a direct reflection of the very broad scope, along with the relative immaturity, of the field. In any case, I am humble enough to know that my own effort will likely prove to be neither definitive nor complete. This book is intended solely to provide the interested reader with a self-contained reference summarizing some of the groundbreaking work that has been done by a great many researchers.

My greatest pleasure will come from learning that, for those of you who are not immediately put off by the daunting sight of a behemoth of a book sitting on your favorite bookseller’s shelf, this book has inspired a few of you to muse about cellular automata on your own. I am convinced that CA, in one form or another, will eventually be found lurking at the very heart of how our universe really works.

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