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# Illustrating Evolutionary Computation with Mathematica

Christian Jacob  
University of Calgary

*Translated from German by Christian Jacob*



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# Illustrating Evolutionary Computation With Mathematica

**Marco Dorigo, Mauro Birattari, Christian  
Blum, Maurice Clerc, Thomas  
Stützle, Alan Winfield**

## **Illustrating Evolutionary Computation With Mathematica:**

*Illustrating Evolutionary Computation with Mathematica* Christian Jacob, 2001 Part 1 Fascinating Evolution Part 2 Evolutionary Computation Part 3 If Darwin was a Programmer Part 4 Evolution of Developmental Programs **Illustrating Evolutionary Computation with Mathematica** Christian Jacob, 2001-02-23 An essential capacity of intelligence is the ability to learn An artificially intelligent system that could learn would not have to be programmed for every eventuality it could adapt to its changing environment and conditions just as biological systems do *Illustrating Evolutionary Computation with Mathematica* introduces evolutionary computation to the technically savvy reader who wishes to explore this fascinating and increasingly important field Unique among books on evolutionary computation the book also explores the application of evolution to developmental processes in nature such as the growth processes in cells and plants If you are a newcomer to the evolutionary computation field an engineer a programmer or even a biologist wanting to learn how to model the evolution and coevolution of plants this book will provide you with a visually rich and engaging account of this complex subject Introduces the major mechanisms of biological evolution Demonstrates many fascinating aspects of evolution in nature with simple yet illustrative examples Explains each of the major branches of evolutionary computation genetic algorithms genetic programming evolutionary programming and evolution strategies Demonstrates the programming of computers by evolutionary principles using Evolvica a genetic programming system designed by the author Shows in detail how to evolve developmental programs modeled by cellular automata and Lindenmayer systems Provides Mathematica notebooks on the Web that include all the programs in the book and supporting animations movies and graphics [The Art of Artificial Evolution](#) Juan J. Romero, 2008 Art is the Queen of all sciences communicating knowledge to all the generations of the world Leonardo da Vinci Artistic behavior is one of the most valued qualities of the human mind Although artistic manifestations vary from culture to culture dedication to artistic tasks is common to all In other words artistic behavior is a universal trait of the human species The current Western definition of art is relatively new However a dedication to artistic endeavors such as the embellishment of tools body ornamentation or gathering of unusual arguably aesthetic objects can be traced back to the origins of humanity That is art is ever present in human history and prehistory Art and science share a long and enduring relationship The best known example of the exploration of this relationship is probably the work of Leonardo da Vinci Somewhere in the 19th century art and science grew apart but the cross transfer of concepts between the two domains continued to exist Currently albeit the need for specialization there is a growing interest in the exploration of the connections between art and science Focusing on computer science it is interesting to notice that early pioneers of this discipline such as Ada Byron and Alan Turing showed an interest in using computational devices for art making purposes Oddly in spite of this early interest and the ubiquity of art it has received relatively little attention from the computer science community in general and more surprisingly from the artificial intelligence community **Genetic and**

**Evolutionary Computation — GECCO 2003** Erick Cantú-Paz, James A. Foster, Kalyanmoy Deb, Lawrence David Davis, Rajkumar Roy, Una-May O'Reilly, Hans-Georg Beyer, Russel Standish, Graham Kendall, Stewart Wilson, Joachim Wegener, Dipankar Dasgupta, Mitchell A. Potter, Alan C. Schultz, 2003-06-30 The set LNCS 2723 and LNCS 2724 constitutes the refereed proceedings of the Genetic and Evolutionary Computation Conference GECCO 2003 held in Chicago IL USA in July 2003 The 193 revised full papers and 93 poster papers presented were carefully reviewed and selected from a total of 417 submissions The papers are organized in topical sections on a life adaptive behavior agents and ant colony optimization artificial immune systems coevolution DNA molecular and quantum computing evolvable hardware evolutionary robotics evolution strategies and evolutionary programming evolutionary scheduling routing genetic algorithms genetic programming learning classifier systems real world applications and search based software engineering Agent-Based Evolutionary Search Ruhul A. Sarker, Tapabrata Ray, 2010-07-12 Agent based evolutionary search is an emerging paradigm in computational intelligence offering the potential to conceptualize and solve a variety of complex problems such as currency trading production planning disaster response management business process management etc There has been a significant growth in the number of publications related to the development and applications of agent based systems in recent years which has prompted special issues of journals and dedicated sessions in premier conferences The notion of an agent with its ability to sense learn and act autonomously lowers the development of a plethora of efficient algorithms to deal with complex problems This notion of an agent differs significantly from a restrictive definition of a solution in an evolutionary algorithm and opens up the possibility to model and capture emergent behavior of complex systems through a natural age oriented decomposition of the problem space While this flexibility of representation offered by agent based systems is widely acknowledged they need to be signed for specific purposes capturing the right level of details and description This edited volume is aimed to provide the readers with a brief background of agent based evolutionary search recent developments and studies dealing with various levels of information abstraction and applications of agent based evolutionary systems There are 12 peer reviewed chapters in this book authored by distinguished researchers who have shared their experience and findings spanning across a wide range of applications **Design by Evolution** Philip F. Hingston, Luigi C. Barone, Zbigniew Michalewicz, 2008-09-30 Evolution is Nature's design process The natural world is full of wonderful examples of its successes from engineering design feats such as powered flight to the design of complex optical systems such as the mammalian eye to the merely stunningly beautiful designs of orchids or birds of paradise With increasing computational power we are now able to simulate this process with greater fidelity combining complex simulations with high performance evolutionary algorithms to tackle problems that used to be impractical This book showcases the state of the art in evolutionary algorithms for design The chapters are organized by experts in the following fields evolutionary design and intelligent design in biology art computational embryogeny and engineering The book will be of interest to researchers practitioners and graduate students

in natural computing engineering design biology and the creative arts      **A Field Guide to Genetic Programming**, 2008

Genetic programming GP is a systematic domain independent method for getting computers to solve problems automatically starting from a high level statement of what needs to be done Using ideas from natural evolution GP starts from an ooze of random computer programs and progressively refines them through processes of mutation and sexual recombination until high fitness solutions emerge All this without the user having to know or specify the form or structure of solutions in advance GP has generated a plethora of human competitive results and applications including novel scientific discoveries and patentable inventions This unique overview of this exciting technique is written by three of the most active scientists in GP See [www.gp-field-guide.org.uk](http://www.gp-field-guide.org.uk) for more information on the book      **Evolutionary and Biologically Inspired Music, Sound, Art and Design** Penousal Machado, Juan J. Romero, Adrian Carbballal, 2012-03-23 This book constitutes the refereed proceedings of the First International Conference on Biologically Inspired Music Sound Art and Design EvoMUSART 2012 held in M laga Spain in April 2012 colocated with the Evo 2012 events EuroGP EvoCOP EvoBIO and EvoApplications Due to its significant growth in the last 10 years this 10th EvoMUSART event has become an Evo conference in 2012 The 15 revised full papers and 5 poster papers presented were carefully reviewed and selected from 43 submissions They cover a wide range of topics reflecting the current state of research in the field including theory generation computer aided creativity computational creativity and automation      **MICAI 2009: Advances in Artificial Intelligence** Arturo Hernández Aguirre, Raúl Monroy Borja, Carlos Albetro Reyes García, 2009-10-26 This book constitutes the refereed proceedings of the 8th Mexican International Conference on Artificial Intelligence MICAI 2009 held in Guanajuato Mexico in November 2009 The 63 revised full papers presented together with one invited talk were carefully reviewed and selected from 215 submissions The papers are organized in topical sections on logic and reasoning ontologies knowledge management and knowledge based systems uncertainty and probabilistic reasoning natural language processing data mining machine learning pattern recognition computer vision and image processing robotics planning and scheduling fuzzy logic neural networks intelligent tutoring systems bioinformatics and medical applications hybrid intelligent systems and evolutionary algorithms

*Advances in Artificial Life* Wolfgang Banzhaf, Thomas Christaller, Peter Dittrich, Jan, T. Kim, Jens Ziegler, 2011-03-31 This book constitutes the refereed proceedings of the 7th European Conference on Artificial Life ECAL 2003 held in Dortmund Germany in September 2003 The 96 revised full papers presented were carefully reviewed and selected from more than 140 submissions The papers are organized in topical sections on artificial chemistries self organization and self replication artificial societies cellular and neural systems evolution and development evolutionary and adaptive dynamics languages and communication methodologies and applications and robotics and autonomous agents      *Ant Colony Optimization and Swarm Intelligence* Marco Dorigo, Mauro Birattari, Christian Blum, Maurice Clerc, Thomas Stützle, Alan Winfield, 2008-09-10 The series of biannual international conferences ANTS International Conference on Ant Colony Optimization and Swarm Intelligence now

in its sixth edition was started ten years ago with the organization of ANTS 98. As some readers might recall the first edition of ANTS was titled ANTS 98 From Ant Colonies to Artificial Ants First International Workshop on Ant Colony Optimization. In fact at that time the focus was mainly on ant colony optimization (ACO) the first swarm intelligence algorithm to go beyond a pure scientific interest and to enter the realm of real world applications. Interestingly in the ten years after the first edition there has been a growing interest not only for ACO but for a number of other studies that belong more generally to the area of swarm intelligence. The rapid growth of the swarm intelligence field is attested by a number of indicators. First the number of submissions and participants to the ANTS conferences has steadily increased over the years. Second a number of international conferences in computational intelligence and related disciplines organize workshops on subjects such as swarm intelligence ant algorithms ant colony optimization and particle swarm optimization. Third IEEE started organizing in 2003 the IEEE Swarm Intelligence Symposium in order to maintain unity in this growing field we are currently establishing a cooperation agreement between IEEE SIS and ANTS so as to have 1 IEEE SIS in odd years and ANTS in even years. Last the Swarm Intelligence journal was born.

**Genetic Programming Theory and Practice** Rick Riolo, Bill Worzel, 2012-12-06. Genetic Programming Theory and Practice explores the emerging interaction between theory and practice in the cutting edge machine learning method of Genetic Programming (GP). The material contained in this contributed volume was developed from a workshop at the University of Michigan's Center for the Study of Complex Systems where an international group of genetic programming theorists and practitioners met to examine how GP theory informs practice and how GP practice impacts GP theory. The contributions cover the full spectrum of this relationship and are written by leading GP theorists from major universities as well as active practitioners from leading industries and businesses. Chapters include such topics as John Koza's development of human competitive electronic circuit designs, David Goldberg's application of competent GA methodology to GP, Jason Daida's discovery of a new set of factors underlying the dynamics of GP starting from applied research and Stephen Freeland's essay on the lessons of biology for GP and the potential impact of GP on evolutionary theory.

*Genetic Programming IV* John R. Koza, Martin A. Keane, Matthew J. Streeter, William Mydlowec, Jessen Yu, Guido Lanza, 2005-03-21. Genetic Programming IV: Routine Human Competitive Machine Intelligence presents the application of GP to a wide variety of problems involving automated synthesis of controllers, circuits, antennas, genetic networks and metabolic pathways. The book describes fifteen instances where GP has created an entity that either infringes or duplicates the functionality of a previously patented 20th century invention, six instances where it has done the same with respect to post 2000 patented inventions, two instances where GP has created a patentable new invention and thirteen other human competitive results. The book additionally establishes that GP now delivers routine human competitive machine intelligence. GP is an automated invention machine. GP can create general solutions to problems in the form of parameterized topologies. GP has delivered qualitatively more substantial results in synchrony with the relentless iteration of Moore's Law.

**Challenging the Boundaries of Symbolic Computation** Peter Mitic, Philip Ramsden, Janet Carne, 2003 This volume consists of papers delivered at the International Mathematica Symposium 2003 an interdisciplinary meeting bringing together users of Mathematica in research and education It gathers research papers reports on classroom practice reports on the use of Mathematica in industry and commerce and descriptions of fresh applications List of contributors J Nash S Wolfram R Maeder B Buchberger and C McTague

**Challenging The Boundaries Of Symbolic Computation (With Cd-rom), Proceedings Of The Fifth International Mathematica Symposium** Philip Ramsden, Peter Mitic, Janet Carne, 2003-06-02 This volume consists of papers delivered at the International Mathematica Symposium 2003 an interdisciplinary meeting bringing together users of Mathematica in research and education It gathers research papers reports on classroom practice reports on the use of Mathematica in industry and commerce and descriptions of fresh applications List of contributors J Nash S Wolfram R Maeder B Buchberger and C McTague

*The Next Wave in Computing, Optimization, and Decision Technologies* Bruce L. Golden, S. Raghavan, Edward A. Wasil, 2006-10-13 Computer Science and Operations Research continue to have a synergistic relationship and this book represents the results of the cross fertilization between OR MS and CS AI It is this interface of OR CS that makes possible advances that could not have been achieved in isolation Taken collectively these articles are indicative of the state of the art in the interface between OR MS and CS AI and of the high caliber research being conducted by members of the INFORMS Computing Society

**Handbook of Genetic Programming Applications** Amir H. Gandomi, Amir H. Alavi, Conor Ryan, 2015-11-06 This contributed volume written by leading international researchers reviews the latest developments of genetic programming GP and its key applications in solving current real world problems such as energy conversion and management financial analysis engineering modeling and design and software engineering to name a few Inspired by natural evolution the use of GP has expanded significantly in the last decade in almost every area of science and engineering Exploring applications in a variety of fields the information in this volume can help optimize computer programs throughout the sciences Taking a hands on approach this book provides an invaluable reference to practitioners providing the necessary details required for a successful application of GP and its branches to challenging problems ranging from drought prediction to trading volatility It also demonstrates the evolution of GP through major developments in GP studies and applications It is suitable for advanced students who wish to use relevant book chapters as a basis to pursue further research in these areas as well as experienced practitioners looking to apply GP to new areas The book also offers valuable supplementary material for design courses and computation in engineering

Differential Evolution: A Handbook for Global Permutation-Based Combinatorial Optimization Godfrey C. Onwubolu, Donald Davendra, 2009-01-13 This is the first book devoted entirely to Differential Evolution DE for global permutative based combinatorial optimization Since its original development DE has mainly been applied to solving problems characterized by continuous parameters This means that only a subset of real world problems could be solved by

the original classical DE algorithm This book presents in detail the various permutative based combinatorial DE formulations by their initiators in an easy to follow manner through extensive illustrations and computer code It is a valuable resource for professionals and students interested in DE in order to have full potentials of DE at their disposal as a proven optimizer All source programs in C and Mathematica programming languages are downloadable from the website of Springer

*Foundations of Genetic Algorithms 2001 (FOGA 6)* Worth Martin, 2001-07-18 Foundations of Genetic Algorithms Volume 6 is the latest in a series of books that records the prestigious Foundations of Genetic Algorithms Workshops sponsored and organised by the International Society of Genetic Algorithms specifically to address theoretical publications on genetic algorithms and classifier systems Genetic algorithms are one of the more successful machine learning methods Based on the metaphor of natural evolution a genetic algorithm searches the available information in any given task and seeks the optimum solution by replacing weaker populations with stronger ones Includes research from academia government laboratories and industry Contains high calibre papers which have been extensively reviewed Continues the tradition of presenting not only current theoretical work but also issues that could shape future research in the field Ideal for researchers in machine learning specifically those involved with evolutionary computation

**Swarm Intelligence** Russell C. Eberhart, Yuhui Shi, James Kennedy, 2001-04-11 Traditional methods for creating intelligent computational systems have privileged private internal cognitive and computational processes In contrast Swarm Intelligence argues that human intelligence derives from the interactions of individuals in a social world and further that this model of intelligence can be effectively applied to artificially intelligent systems The authors first present the foundations of this new approach through an extensive review of the critical literature in social psychology cognitive science and evolutionary computation They then show in detail how these theories and models apply to a new computational intelligence methodology particle swarms which focuses on adaptation as the key behavior of intelligent systems Drilling down still further the authors describe the practical benefits of applying particle swarm optimization to a range of engineering problems Developed by the authors this algorithm is an extension of cellular automata and provides a powerful optimization learning and problem solving method This important book presents valuable new insights by exploring the boundaries shared by cognitive science social psychology artificial life artificial intelligence and evolutionary computation and by applying these insights to the solving of difficult engineering problems Researchers and graduate students in any of these disciplines will find the material intriguing provocative and revealing as will the curious and savvy computing professional Places particle swarms within the larger context of intelligent adaptive behavior and evolutionary computation Describes recent results of experiments with the particle swarm optimization PSO algorithm Includes a basic overview of statistics to ensure readers can properly analyze the results of their own experiments using the algorithm Support software which can be downloaded from the publisher's website includes a Java PSO applet C and Visual Basic sourcecode



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