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Genetic and Evolutionary Computation – GECCO 2003

Genetic and Evolutionary Computation Conference
Chicago, IL, USA, July 12-16, 2003
Proceedings, Part I



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Preface

These proceedings contain the papers presented at the 5th Annual Genetic and Evolutionary Computation Conference (GECCO 2003). The conference was held in Chicago, USA, July 12–16, 2003.

A total of 417 papers were submitted to GECCO 2003. After a rigorous doubleblind reviewing process, 194 papers were accepted for full publication and oral presentation at the conference, resulting in an acceptance rate of 46.5%. An additional 92 submissions were accepted as posters with two-page extended abstracts included in these proceedings.

This edition of GECCO was the union of the 8th Annual Genetic Programming Conference (which has met annually since 1996) and the 12th International Conference on Genetic Algorithms (which, with its first meeting in 1985, is the longest running conference in the field). Since 1999, these conferences have merged to produce a single large meeting that welcomes an increasingly wide array of topics related to genetic and evolutionary computation.

Possibly the most visible innovation in GECCO 2003 was the publication of the proceedings with Springer-Verlag as part of their Lecture Notes in Computer Science series. This will make the proceedings available in many libraries as well as online, widening the dissemination of the research presented at the conference.

Other innovations included a new track on Coevolution and Artificial Immune Systems and the expansion of the DNA and Molecular Computing track to include quantum computation.

In addition to the presentation of the papers contained in these proceedings, the conference included 13 workshops, 32 tutorials by leading specialists, and presentation of late-breaking papers.

GECCO is sponsored by the International Society for Genetic and Evolutionary Computation (ISGEC). The ISGEC by-laws contain explicit guidance on the organization of the conference, including the following principles:

(i) GECCO should be a broad-based conference encompassing the whole field of genetic and evolutionary computation.

(ii) Papers will be published and presented as part of the main conference proceedings only after being peer-reviewed. No invited papers shall be published (except for those of up to three invited plenary speakers).

(iii) The peer-review process shall be conducted consistently with the principle of division of powers performed by a multiplicity of independent program committees, each with expertise in the area of the paper being reviewed.

(iv) The determination of the policy for the peer-review process for each of the conference's independent program committees and the reviewing of papers for each program committee shall be performed by persons who occupy their positions by virtue of meeting objective and explicitly stated qualifications based on their previous research activity.

(v) Emerging areas within the field of genetic and evolutionary computation shall be actively encouraged and incorporated in the activities of the conference by providing a semiautomatic method for their inclusion (with some procedural flexibility extended to such emerging new areas).

(vi) The percentage of submitted papers that are accepted as regular full-length papers (i.e., not posters) shall not exceed 50%.

These principles help ensure that GECCO maintains high quality across the diverse range of topics it includes.

Besides sponsoring the conference, ISGEC supports the field in other ways. ISGEC sponsors the biennial Foundations of Genetic Algorithms workshop on theoretical aspects of all evolutionary algorithms. The journals *Evolutionary Computation* and *Genetic Programming and Evolvable Machines* are also supported by ISGEC. All ISGEC members (including students) receive subscriptions to these journals as part of their membership. ISGEC membership also includes discounts on GECCO and FOGA registration rates as well as discounts on other journals. More details on ISGEC can be found online at <http://www.isgec.org>.

Many people volunteered their time and energy to make this conference a success. The following people in particular deserve the gratitude of the entire community for their outstanding contributions to GECCO:

James A. Foster, the General Chair of GECCO for his tireless efforts in organizing every aspect of the conference.

David E. Goldberg and John Koza, members of the Business Committee, for their guidance and financial oversight.

Alwyn Barry, for coordinating the workshops.

Bart Rylander, for editing the late-breaking papers.

Past conference organizers, William B. Langdon, Erik Goodman, and Darrell Whitley, for their advice.

Elizabeth Ericson, Carol Hamilton, Ann Stolberg, and the rest of the AAAI staff for their outstanding efforts administering the conference.

Gerardo Valencia and Gabriela Coronado, for Web programming and design.

Jennifer Ballentine, Lee Ballentine and the staff of Professional Book Center, for assisting in the production of the proceedings.

Alfred Hofmann and Ursula Barth of Springer-Verlag for helping to ease the transition to a new publisher.

Sponsors who made generous contributions to support student travel grants:

Air Force Office of Scientific Research

DaimlerChrysler

National Science Foundation

Naval Research Laboratory

New Light Industries

Philips Research

Sun Microsystems

The track chairs deserve special thanks. Their efforts in recruiting program committees, assigning papers to reviewers, and making difficult acceptance decisions in relatively short times, were critical to the success of the conference:

A-Life, Adaptive Behavior, Agents, and Ant Colony Optimization,
 Russell Standish
 Artificial Immune Systems, Dipankar Dasgupta
 Coevolution, Graham Kendall
 DNA, Molecular, and Quantum Computing, Natasha Jonoska
 Evolution Strategies, Evolutionary Programming, Hans-Georg Beyer
 Evolutionary Robotics, Alan Schultz, Mitch Potter
 Evolutionary Scheduling and Routing, Kathryn A. Dowsland
 Evolvable Hardware, Julian Miller
 Genetic Algorithms, Kalyanmoy Deb
 Genetic Programming, Una-May O'Reilly
 Learning Classifier Systems, Stewart Wilson
 Real-World Applications, David Davis, Rajkumar Roy
 Search-Based Software Engineering, Mark Harman, Joachim Wegener

The conference was held in cooperation and/or affiliation with:

American Association for Artificial Intelligence (AAAI)
 Evonet: the Network of Excellence in Evolutionary Computation
 5th NASA/DoD Workshop on Evolvable Hardware
Evolutionary Computation
Genetic Programming and Evolvable Machines
Journal of Scheduling
Journal of Hydroinformatics
Applied Soft Computing

Of course, special thanks are due to the numerous researchers who submitted their best work to GECCO, reviewed the work of others, presented a tutorial, organized a workshop, or volunteered their time in any other way. I am sure you will be proud of the results of your efforts.

May 2003

Erick Cantú-Paz
 Editor-in-Chief GECCO 2003
 Center for Applied Scientific Computing
 Lawrence Livermore National Laboratory

GECCO 2003 Conference Organization

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Proceedings Editor-in-Chief: Erick Cantú-Paz

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Russell Standish

Artificial Immune Systems, Dipankar Dasgupta

Coevolution, Graham Kendall

DNA, Molecular, and Quantum Computing, Natasha Jonoska

Evolution Strategies, Evolutionary Programming, Hans-Georg Beyer

Evolutionary Robotics, Mitchell A. Potter and Alan C. Schultz

Evolutionary Scheduling and Routing, Kathryn A. Dowsland

Evolvable Hardware, Julian Miller

Genetic Algorithms, Kalyanmoy Deb

Genetic Programming, Una-May O'Reilly

Learning Classifier Systems, Stewart Wilson

Real-World Applications, David Davis, Rajkumar Roy

Search-Based Software Engineering, Mark Harman and Joachim Wegener

Workshops Chair: Alwyn Barry

Late-Breaking Papers Chair: Bart Rylander

Workshop Organizers

Biological Applications for Genetic and Evolutionary Computation (Bio GEC 2003), Wolfgang Banzhaf, James A. Foster

Application of Hybrid Evolutionary Algorithms to NP-Complete Problems, Francisco Baptista Pereira, Ernesto Costa, Günther Raidl

Evolutionary Algorithms for Dynamic Optimization Problems, Jürgen Branke

Hardware Evolutionary Algorithms and Evolvable Hardware (HEAEH 2003), John C. Gallagher

Graduate Student Workshop, Maarten Keijzer, Sean Luke, Terry Riopka

Workshop on Memetic Algorithms 2003 (WOMA-IV), Peter Merz, William E. Hart, Natalio Krasnogor, Jim E. Smith

Undergraduate Student Workshop, Mark M. Meysenburg

Learning, Adaptation, and Approximation in Evolutionary Computation, Sibylle Mueller, Petros Koumoutsakos, Marc Schoenauer, Yaochu Jin, Sushil Louis, Khaled Rasheed

Grammatical Evolution Workshop (GEWS 2003), Michael O'Neill, Conor Ryan

Interactive Evolutionary Search and Exploration Systems, Ian Parmee

Analysis and Design of Representations and Operators (ADoRo 2003), Franz Rothlauf, Dirk Thierens
Challenges in Real-World Optimisation Using Evolutionary Computing, Rajkumar Roy, Ashutosh Tiwari
International Workshop on Learning Classifier Systems, Wolfgang Stolzmann, Pier-Luca Lanzi, Stewart Wilson

Tutorial Speakers

Parallel Genetic Algorithms, Erick Cantú-Paz
Using Appropriate Statistics, Steffan Christensen
Multiobjective Optimization with EC, Carlos Coello
Making a Living with EC, Yuval Davidor
A Unified Approach to EC, Ken DeJong
Evolutionary Robotics, Dario Floreano
Immune System Computing, Stephanie Forrest
The Design of Innovation & Competent GAs, David E. Goldberg
Genetic Algorithms, Robert Heckendorn
Evolvable Hardware Applications, Tetsuya Higuchi
Bioinformatics with EC, Daniel Howard
Visualization in Evolutionary Computation, Christian Jacob
Data Mining and Machine Learning, Hillol Kargupta
Evolvable Hardware, Didier Keymeulen
Genetic Programming, John Koza
Genetic Programming Theory I & II, William B. Langdon, Riccardo Poli
Ant Colony Optimization, Martin Middendorf
Bionics: Building on Biological Evolution, Ingo Rechenberg
Grammatical Evolution, C. Ryan, M. O'Neill
Evolution Strategies, Hans-Paul Schwefel
Quantum Computing, Lee Spector
Anticipatory Classifier Systems, Wolfgang Stolzmann
Mathematical Theory of EC, Michael Vose
Computational Complexity and EC, Ingo Wegener
Software Testing via EC, J. Wegener, M. Harman
Testing & Evaluating EC Algorithms, Darrell Whitley
Learning Classifier Systems, Stewart Wilson
Evolving Neural Network Ensembles, Xin Yao
Neutral Evolution in EC, Tina Yu
Genetics, Annie S. Wu

Keynote Speakers

John Holland, "The Future of Genetic Algorithms"
Richard Lenski, "How the Digital Leopard Got His Spots: Thinking About Evolution Inside the Box"

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A Word from the Chair of ISGEC

You may have just picked up your proceedings, in hard copy and CD-ROM, at GECCO 2003, or purchased it after the conference. You've doubtless already noticed the new format – publishing our proceedings as part of Springer's Lecture Notes in Computer Science (LNCS) series will make them available in many more libraries, broadening the impact of the GECCO conference dramatically!

If you attended GECCO 2003, we, the organizers, hope your experience was memorable and productive, and you have found these proceedings to be of continuing value. The opportunity for first-hand interaction among authors and other participants in GECCO is a big part of what makes it exciting, and we all hope you came away with many new insights and ideas.

If you were unable to come to GECCO 2003 in person, I hope you'll find many stimulating ideas from the world's leading researchers in evolutionary computation reported in these proceedings, and that you'll be able to participate in a future GECCO – for example, next year, in Seattle!

The International Society for Genetic and Evolutionary Computation, the sponsoring organization of the annual GECCO conferences, is a young organization, formed through the merger of the International Society for Genetic Algorithms (sponsor of the ICGA conferences) and the organization responsible for the annual Genetic Programming conferences. It depends strongly on the voluntary efforts of many of its members. It is designed to promote not only the exchange of ideas among innovators and practitioners of well-known methods such as genetic algorithms, genetic programming, evolution strategies, evolutionary programming, learning classifier systems, etc., but also the growth of newer areas such as artificial immune systems, evolvable hardware, agentbased search, and others. One of the founding principles is that ISGEC operates as a confederation of groups with related but distinct approaches and interests, and their mutual prosperity is assured by their representation in the program committees, editorial boards, etc., of the conferences and journals with which ISGEC is associated. This also insures that ISGEC and its functions continue to improve and evolve with the diversity of innovation that has characterized our field.

ISGEC has seen many changes this year, in addition to its growth in membership. We have completed the formalities for recognition as a tax-exempt charitable organization. We have created the new designations of Fellow and Senior Fellow of ISGEC to recognize the achievements of leaders in the field, and by the time you read this, we expect to have elected the first cohort. Additional Fellows and Senior Fellows will be added annually. GECCO continues to be subject to dynamic development – the many new tutorials, workshop topics, and tracks will evolve again next year, seeking to follow and encourage the developments of the many fields represented at GECCO. The best paper awards were presented for the second time at GECCO 2003, and we hope many of you participated in the balloting. This year, for the first time, most presentations at GECCO

were electronic, displayed with the LCD projectors that ISGEC has recently purchased. Our journals, *Evolutionary Computation* and *Genetic Programming and Evolvable Machines*, continue to prosper, and we are exploring ways to make them even more widely available. The inclusion of the proceedings in Springer's Lecture Notes in Computer Science series, making them available in many more libraries worldwide, should have a strong positive impact on our field.

ISGEC is your society, and we urge you to become involved or continue your involvement in its activities, to the mutual benefit of the whole evolutionary computation community. Three members were elected to new five-year terms on the Executive Board at GECCO 2002 – Wolfgang Banzhaf, Marco Dorigo, and Annie Wu.

Since that time, ISGEC has been active on many issues, through actions of the Board and the three Councils – the Council of Authors, Council of Editors, and Council of Conferences.

The organizers of GECCO 2003 are listed in this frontmatter, but special thanks are due to James Foster, General Chair, and Erick Cantú-Paz, Editor-in-Chief of the Proceedings, as well as to John Koza and Dave Goldberg, the Business Committee. All of the changes this year, particularly in the publication of the proceedings, have meant a lot of additional work for this excellent team, and we owe them our thanks for a job well done.

Of course, we all owe a great debt to those who chaired or served on the various core and special program committees that reviewed all of the papers for GECCO 2003. Without their effort it would not have been possible to put on a meeting of this quality.

Another group also deserves the thanks of GECCO participants and ISGEC members – the members of the ISGEC Executive Board and Councils, who are listed below. I am particularly indebted to them for their thoughtful contributions to the organization and their continuing demonstrations of concern for the welfare of ISGEC.

I invite you to communicate with me (goodman@egr.msu.edu) if you have questions or suggestions for ways ISGEC can be of greater service to its members, or if you would like to get more involved in ISGEC and its functions.

Don't forget about the 8th Foundations of Genetic Algorithms (FOGA) workshop, also sponsored by ISGEC, the biennial event that brings together the world's leading theorists on evolutionary computation, which will be held in 2004.

Finally, I hope you will join us at GECCO 2004 in Seattle. Get your ideas to Ricardo Poli, the General Chair of GECCO 2004, when you see him at GECCO 2003, and please check the ISGEC Website, www.isgtec.org, regularly for details as the planning for GECCO 2004 continues.

Erik D. Goodman

ISGEC Executive Board

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Council of Conferences, Riccardo Poli (Chair)

The purpose of the Council of Conferences is to provide information about the numerous conferences that are available to researchers in the field of Genetic and Evolutionary Computation, and to encourage them to coordinate their meetings to maximize our collective impact on science.

- ACDM, Adaptive Computing in Design and Manufacture, 2004, Ian Parmee
(Ian.Parmee@uwe.ac.uk)
- EuroGP, European Conference on Genetic Programming, Portugal, April 2004,
Ernesto Costa (ernesto@dei.uc.pt)
- EvoWorkshops, European Evolutionary Computing Workshops, Portugal, April
2004, Stefano Cagnoni (cagnoni@ce.unipr.it)
- FOGA, Foundations of Genetic Algorithms Workshop, 2004
- GECCO 2004, Genetic and Evolutionary Computation Conference, Seattle,
June 2004, Riccardo Poli (rpoli@essex.ac.uk)
- INTROS, INtroductory TutoRials in Optimization, Search and Decision Support
Methodologies, August 12, 2003, Nottingham, UK, Edmund Burke
(ekb@cs.nott.ac.uk)
- MISTA, 1st Multidisciplinary International Conference on Scheduling: Theory
and Applications August 8-12, 2003, Nottingham, UK, Graham Kendall
(gxxk@cs.nott.ac.uk)
- PATAT 2004, 5th International Conference on the Practice and Theory of Au-
tomated Timetabling, Pittsburgh, USA, August 18-20, 2004, Edmund Burke
(ekb@cs.nott.ac.uk)
- WSC8, 8th Online World Conference on Soft Computing in Industrial Applica-
tions, September 29th - October 10th, 2003, Internet (hosted by University
of Dortmund), Frank Hoffmann (hoffmann@esr.e-technik.uni-dortmund.de)
- An up-to-date roster of the Council of Conferences is available online at
<http://www.isgec.org/conferences.html>.

Please contact the COC chair Riccardo Poli (rpoli@essex.ac.uk) for additions
to this list.

Papers Nominated for Best Paper Awards

In 2002, ISGEC created a best paper award for GECCO. As part of the double
blind peer review, the reviewers were asked to nominate papers for best paper
awards. The chairs of core and special program committees selected the papers
that received the most nominations for consideration by the conference. One win-
ner for each program track was chosen by secret ballot of the GECCO attendees
after the papers were presented in Chicago. The titles and authors of the winning
papers are available at the GECCO 2003 website (www.isgec.org/GECCO-2003).

- Finite Population Models of Co-evolution and Their Application to Haploidy
versus Diploidy, Anthony M.L. Liekens, Huub M.M. ten Eikelder, and Peter
A.J. Hilbers
- A Game-Theoretic Memory Mechanism for Coevolution, Sevan G. Ficici and
Jordan B. Pollack
- A Non-dominated Sorting Particle Swarm Optimizer for Multiobjective Opti-
mization, Xiaodong Li
- Emergence of Collective Behavior in Evolving Populations of Flying Agents, Lee
Spector, Jon Klein, Chris Perry, and Mark Feinstein

- Immune Inspired Somatic Contiguous Hypermutation for Function Optimisation, Johnny Kelsey and Jon Timmis
- Efficiency and Reliability of DNA-Based Memories, Max H. Garzon, Andrew Neel, and Hui Chen
- Hardware Evolution of Analog Speed Controllers for a DC Motor, D.A. Gwaltney and M.I. Ferguson
- Integration of Genetic Programming and Reinforcement Learning for Real Robots, Shotaro Kamio, Hideyuki Mitsuhashi, and Hitoshi Iba
- Co-evolving Task-Dependent Visual Morphologies in Predator-Prey Experiments, Gunnar Buason and Tom Ziemke
- The Steady State Behavior of $(\mu/\mu_I, \lambda)$ -ES on Ellipsoidal Fitness Models Disturbed by Noise, Hans-Georg Beyer and Dirk V. Arnold
- On the Optimization of Monotone Polynomials by the (1+1) EA and Randomized Local Search, Ingo Wegener and Carsten Witt
- Ruin and Recreate Principle Based Approach for the Quadratic Assignment Problem, Alfonsas Misevicius
- Evolutionary Computing as a tool for Grammar Development, Guy De Pauw
- Adaptive Elitist-Population Based Genetic Algorithm for Multimodal Function Optimization, Kwong-Sak Leung and Yong Liang
- Scalability of Selectorecombinative Genetic Algorithms for Problems with Tight Linkage, Kumara Sastry and David E. Goldberg
- Effective Use of Directional Information in Multi-objective Evolutionary Computation, Martin Brown and R.E. Smith
- Are Multiple Runs of Genetic Algorithms Better Than One? Erick Cantú-Paz and David E. Goldberg
- Selection in the Presence of Noise, Jürgen Branke and Christian Schmidt
- Difficulty of Unimodal and Multimodal Landscapes in Genetic Programming, Leonardo Vanneschi, Marco Tomassini, Manuel Clergue, and Philippe Collard
- Dynamic Maximum Tree Depth: a Simple Technique for Avoiding Bloat in Tree-Based GP, Sara Silva and Jonas Almeida
- Generative Representations for Evolving Families of Designs, Gregory S. Hornby
- Identifying Structural Mechanisms in Standard Genetic Programming, Jason M. Daida and Adam M. Hilss
- Visualizing Tree Structures in Genetic Programming, Jason M. Daida, Adam M. Hilss, David J. Ward, and Stephen L. Long
- Methods for Evolving Robust Programs, Liviu Panait and Sean Luke
- Population Implosion in Genetic Programming, Sean Luke, Gabriel Catalin Balan, and Liviu Panait
- Designing Efficient Exploration with MACS: Modules and Function Approximation, Pierre Gérard and Olivier Sigaud
- Tournament Selection: Stable Fitness Pressure in XCS, Martin V. Butz, Kumara Sastry, and David E. Goldberg
- Towards Building Block Propagation in XCS: a Negative Result and Its Implications, Kurian K. Tharakunnel, Martin V. Butz, and David E. Goldberg

- Quantum-Inspired Evolutionary Algorithm-Based Face Verification, Jun-Su Jang, Kuk-Hyun Han, and Jong-Hwan Kim
- Mining Comprehensive Clustering Rules with an Evolutionary Algorithm, Ioannis Sarafis, Phil Trinder and Ali Zalzal
- System-Level Synthesis of MEMS via Genetic Programming and Bond Graphs, Zhun Fan, Kisung Seo, Jianjun Hu, Ronald C. Rosenberg, and Erik D. Goodman
- Active Guidance for a Finless Rocket Using Neuroevolution, Faustino J. Gomez and Risto Miikkulainen
- Extracting Test Sequences from a Markov Software Usage Model by ACO, Karl Doerner and Walter J. Gutjahr
- Modeling the Search Landscape of Metaheuristic Software Clustering Algorithms, Brian S. Mitchell and Spiros Mancoridis

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