GECCO-2002

Proceedings of the Genetic and Evolutionary Computation Conference

A Joint Meeting of the Seventh Annual Genetic Programming Conference (GP-2002) and the Eleventh International Conference on Genetic Algorithms (ICGA-2002)

July 9–13, 2002
New York City, New York

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PREFACE

These proceedings contain the papers presented at the fourth annual Genetic and Evolutionary Computation conference (GECCO-2002). The conference was held in New York City, July 9–13, 2002.

The GECCO series of international conferences are a unique series of events, drawing together in one time and place (and proceedings) the increasing diversity of evolutionary computational techniques. The conference is a truly global event, which this year attracted submissions from more than 27 countries across all continents. Although GECCO-2002 was the union of the Seventh Annual Genetic Programming Conference and the Eleventh International Conference on Genetic Algorithms, it included leading edge scientific work on many strands of research (from artificial life to software engineering from ant systems to scheduling, from evolutionary programming to philosophy), as well as real world applications and industrial computing. It is sponsored by the International Society for Genetic and Evolutionary Computation (ISGEC), and presented in cooperation with the American Association for Artificial Intelligence (AAAI).

In addition to the presentation of papers (these proceedings) the conference included 13 workshops, 29 tutorials by leading specialists in each field and presentation of "late breaking papers."

The first GECCO conference, in 1999, combined the International Conference on Genetic Algorithms (which had met biennially since 1985) and the Genetic Programming Conference (then in its fourth year of annual meetings) to produce a single larger meeting, bringing together researchers from the many diverse research areas that together comprise the field of genetic and evolutionary computation. The conference was a success and the following year brought not only GECCO-2000 but also a new organization, the International Society for Genetic and Evolutionary Computation (ISGEC), with a mission to run the GECCO conference and to support the field in several other ways. These include support for the *Evolutionary Computation* and *Genetic Programming and Evolvable Machines* journals as well as the intimate biennial "Foundations of Genetic Algorithms" workshop on theoretical aspects of all evolutionary computation algorithms. This year has brought the link to *Journal of Hydroinformatics*. Details about ISGEC can be found on-line at http://www.isgec.org/.

There are several innovations this year. First, these proceedings are available electronically in CD-ROM format. Second, the new Evolutionary Computing in Industry track (which has its own proceedings). ECI was specifically designed to deal with both learning and disseminating widely within commerce and manufacturing the numerous benefits of using all manner of evolutionary approaches to solve practical problems. Third, the introduction of best at GECCO prizes.

In spite of world events the number of submissions to this the fourth GECCO conference is only marginally down (within 10%) on last year. This is strong support for the combined conference, and I am sure there will be many more GECCOs to come. Planning for GECCO-2003, to be held in Chicago, 12–16 July, is already underway (details will be available from http://www.isgec.org/).

The ISGEC by-laws contain explicit guidance on the organization of the conference, including the following principles:

(i) The GECCO conference shall 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 consistent 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 scientific 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 semi-automatic method for their inclusive into the activities of the conference (with some procedural flexibility being extended to such emerging new areas).

(vi) The percentage of submitted papers that are accepted as regular papers (i.e., papers other than one-page poster papers) shall not exceed 50%.

These principles, along with the time and energy contributed by many people to ensure that they were upheld, are largely

responsible for the success of the conference and for the diversity and high quality of the papers in these proceedings.

A total of 322 papers were submitted for double blind scientific peer review. Of these, 160 were accepted for full publication and presentation at the conference, resulting in an acceptance rate of 50%. An additional 70 papers were accepted for poster presentation at the conference (with single-page abstracts in these proceedings).

Many people worked hard to make this conference a reality. In particular the following people deserve the gratitude of the entire genetic and evolutionary computation community for their outstanding contributions to the GECCO conference:

- General Chair, Erick Cantú-Paz, and Business committee members, David Goldberg and John Koza for tireless guidance on every aspect of the organization and administration of the conference.
- Past conference organizers Lee Spector, Erik Goodman, and Darrell Whitley.
- Melinda Allred, Elizabeth Ericson, Carol Hamilton, and Erin Hogan (who stepped in at a critical juncture) of the AAAI for outstanding efforts staffing and administering the conference.
- Gerardo Valencia for web programming and design.
- Kumara Sastry as the electronic publicity chair.
- The staff of Professional Book Center.
- The staff of Morgan Kaufmann Publishers.
- Sponsors who made generous contributions to support student travel grants:
  Naval Research Laboratory
  American Association for Artificial Intelligence
  Philips Research
  Air Force Office of Scientific Research
  DaimlerChrysler

In the distributed organization of GECCO, the track chairs are critical and deserve special thanks:

- Artificial life, Adaptive behavior, Agents & Ant Colony Optimization: Karthik Balakrishnan and Vasant Honavar
- DNA and Molecular Computing: Natasha Jonoska
- Evolutionary Robotics: Mitchell A. Potter and Alan C. Schultz
- Evolvable Hardware: Julian Miller
- Evolutionary Scheduling & Routing: Edmund Burke
- Evolution Strategies & Evolutionary Programming: Guenter Rudolph
- Genetic Algorithms: Keith Mathias
- Genetic Programming: Riccardo Poli
- Learning Classifier Systems: Larry Bull
- Methodology, Pedagogy, and Philosophy: Erick Cantú-Paz
- Real World Applications: Rajkumar Roy and David Davis
- Search-based Software Engineering: Joachim Wegener

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

- The American Association for Artificial Intelligence (AAAI).
- Evonet: The Network of Excellence in Evolutionary Computation
- The Fourth NASA/DoD Workshop on Evolvable Hardware (EH-2002)
- The Parallel Problem-Solving From Nature conferences (PPSN)
- *Evolutionary Computing*
- *Genetic Programming and Evolvable Machines*
- *Journal of Scheduling*
- *International Journal of Hydroinformatics*

The most important contributions to this conference, however, were made by the researchers who submitted their work, reviewed the work of others, presented tutorials, organized workshops, made suggestions to the organizers, and participated in countless other ways in the preparations for the conference. GECCO is the fruit of the collective efforts of a large and diverse community of researchers, all of whom should be proud of the exciting conference they helped to create.

W. B. Langdon, Proceedings Editor-in-Chief
GECCO-2002
Computer Science
University College, London

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Workshops Chair: Alwyn Barry, *Bath University*

WORKSHOP ORGANIZERS

Alwyn Barry (workshop coordinator)

Wolfgang Banzhaf and James A. Foster, *Biological Applications of Evolutionary Computation*

Peter J. Bentley, *ISGEC Workshop on Standards*

Claudio Bonacina, Cefn Hoile, Paul Marrow, and Robert E. Smith, *Evolutionary Computation and Multi-Agent Systems (ECOMAS 2002)*

Peter Cowling and Graham Kendall, *Scheduling: Bringing Together Theory and Practice*

Yaochu Jin, Sushil J. Louis, and Khaled M. Rasheed, *Approximation and Learning in Evolutionary Computation*

Sibylle Mueller, Nicol Schraudolph, and Petros Koumoutsakos, *Learning and Adaptation in Evolutionary Computation*

Michael O'Neill and Conor Ryan, *Grammatical Evolution Workshop (GEWS 2002)*

Ian Parmee, *Towards Interactive Evolutionary Search and Exploration Systems*

Franz Rothlauf, *Representations for Genetic and Evolutionary Algorithms*

Rajkumar Roy and Ashutosh Tiwari, *Evolutionary Computing for Optimisation in Industry*

Oswaldo Velez-Langs, Angelica de Antonio, and Ricardo Imbert Paredes, *Intelligent Interface and Interactive Agents Through Evolutionary Computation (IIIATEC)*

R. Paul Wiegand and Kenneth A. De Jong, *Understanding Coevolution: Theory and Analysis of Coevolutionary Algorithms*

Sean Luke, Conor Ryan, and Maarten Keijzer, *Graduate Student Workshop*

TUTORIAL SPEAKERS

Peter J. Bentley, *Creative Evolutionary Systems*

Erick Cantú-Paz, *Parallel Genetic Algorithms*

Carlos Coello, *Multiobjective Genetic Algorithms*

Dipankar Dasgupta, *Immune System Computing*

Kenneth De Jong, *Evolutionary Computation: A Unified Overview*

David E. Goldberg, *Design of competent Genetic Algorithms*

David Grierson and P. Hajela, *Evolution of Engineered Structures*

Robert Heckendorn, *Introduction to Genetic Algorithms*

Tetsuya Higuchi, *Evolvable Hardware*

Christian Jacob, *Visualization in Evolutionary Computation*

Charles Karr, *Introduction to Adaptive Geno-Fuzzy Systems*

John Koza, *Introduction to Genetic Programming*

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Barbara Minsker and Patrick Reed, *Making Genetic Algorithms work in the real world: Guidelines from competent Genetic Algorithms theory*

Martin Middendorf, *Ant Colony Optimization*

Martin Pelikan, *Probabilistic Model Building Genetic Algorithms*

Daniel Polani and Thomas Uthmann, *Evolution of Sensors*

Ingo Rechenberg, *Bionics: Building on Bio-Evolution*

Ingo Rechenberg, *Introduction to Evolution Strategies*

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Jonathan Rowe, *Genetic Algorithms Theory*

Conor Ryan and Michael O'Neill, *Grammatical Evolution*

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

Lee Spector, *Quantum Computing for Genetic Programming*

Wolfgang Stolzmann and Pier Luca Lanzi, *Introduction to Classifier Systems*

Joachim Wegener and Mark Harman, *Software Testing via Evolutionary Computing*

Darrell Whitley, *Beyond No Free Lunch theorem*

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A WORD FROM THE CHAIR OF ISGEC

To those of you just picking up your proceedings at GECCO-2002, welcome to what we believe will be a very exciting chance to exchange ideas about evolutionary computation in its many forms! To those of you who were unable to participate in person in GECCO-2002, I hope you will find these proceedings useful in conveying the exciting advances going on in genetic and evolutionary computation today.

The International Society for Genetic and Evolutionary Computation, sponsoring organization of the annual GECCO conferences, is a young organization, formed through 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 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, agent-based 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.

The year since GECCO-2001 has seen many changes in our society and in the world. The tragic events of September 11, 2001, certainly caused the leaders of GECCO-2002 to reconsider the siting of the meeting in New York City, as was initially decided before June, 2001. The organizers have chosen to assert their belief that our members and participants would not want to abandon New York in the face of terrorist acts, but rather to demonstrate support for New York as part of the global resolve that terrorism shall not dominate our lives.

The ISGEC has also seen many changes this year, in addition to its growth in membership. David Goldberg's term as the first chair of ISGEC ended in November, 2001, when I was elected to succeed him by the ISGEC's Executive Board. I hope all of you who have been ISGEC members during these first few years understand and appreciate the skill and effort Dave has devoted to nurturing of this new organization—it has not been an easy task. Three members were elected to new five-year terms on the Executive Board at GECCO-2001—Prof. John Holland and Prof. Darrell Whitley were re-elected to the Board, and Prof. Dr.-Ing. Ingo Rechenberg was newly elected. Since that time, the 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 ISGEC:

- has decided that it will continue its sponsorship of the biennial FOGA (Foundations of Genetic Algorithms) workshop, with a strong effort to encourage broad participation by theorists from all areas of evolutionary computation
- has created Best Papers Awards for GECCO, with nominations by reviewers and selection by attendees at GECCO
- is creating ISGEC Fellows and Senior Fellows (for those over the age of 45 years) of the ISGEC, in order to recognize major and long-term contributors to our field, beginning a process that will continue with annual election of two new Fellows and two new Senior Fellows
- has continued to support the two journals, Evolutionary Computation and Genetic Programming and Evolvable Machines, to which all ISGEC members receive an annual subscription
- continues to seek additional benefits for its members, such as the discounted subscription rates already available from the Journal of Scheduling and the Journal of Hydroinformatics
- continues to seek better ways to coordinate with organizers of other conferences in this and related fields, so that potential participants can benefit from co-located or nearby conferences in adjacent time periods, to maximize the utility of their travel budgets

The organizers of GECCO-2002 are shown in this front matter, but special thanks are due to Erick Cantú-Paz, General Chair, and Bill Langdon, Editor-in-Chief of the Proceedings, as well as to John Koza and Dave Goldberg, the Business Committee. This year, they have worked to create a new feature for the proceedings—a CD-ROM will now accompany the printed volume. We hope this availability of GECCO proceedings in digital form will prove to be useful for GECCO participants and those who later purchase the proceedings. The Real-World Applications track has also been expanded with the creation of a new track for Evolutionary Computing in

Industry, in an effort to make GECCO participation more attractive to our colleagues in industry. Dave Davis and Rajkumar Roy deserve special thanks for spearheading this effort. This type of continual re-invention is an important component in assuring the future success of GECCO and ISGEC.

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-2002. Without their effort, it would not be 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 on the next page. I am particularly indebted to them for their thoughtful contributions to the organization and their continuing demonstrations of concern for the welfare of the 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.

Finally, I hope you will join us at GECCO-2003 in Chicago, July 12–16 (Saturday–Wednesday), 2003. Please check the ISGEC web site, www.isgec.org, for the details as the planning continues.

Sincerely,

Erik D. Goodman
ISGEC Chair

EH Conference on Evolvable Hardware, 15–18 July 2002 Washington, D.C., Adrian Stoica (adrian.stoica@jpl.nasa.gov)

EuroGP European Conference on Genetic Programming, 14–16 April 2003, Essex, UK, Terence Soule (tsoule@cs.uidaho.edu)

EvoWorkshops Evolutionary Computation Workshops, 14–16 April 2003, Essex, UK, Stefano Cagnoni (cagnoni@ce.unipr.it) and Gunther Raidl (raidl@ads.tuwien.ac.at)

FOGA Foundations of Genetic Algorithms, 4–6 September 2002, Torremolinos, Spain, Ken De Jong (kdejong@gmu.edu)

GECCO Genetic and Evolutionary Computation Conference, 12–16 July 2003, Chicago, James A. Foster (foster@cs.uidaho.edu)

ICES Evolvable Systems: From Biology To Hardware, 18–20 March 2003, Trondheim, Norway, Andrew M Tyrrell (amt@ohm.york.ac.uk)

PPSN Parallel Problem Solving from Nature, 7–11 September 2002, Granada, Spain, J. J. Merelo (jmerelo@geneura.ugr.es)

IWLCS International Workshop on Learning Classifier Systems, 7–8 September 2002, Granada, Spain, Wolfgang Stolzmann (Wolfgang.Stolzmann@DaimlerChrysler.com)

Please notify the COC chair (James A. Foster at foster@cs.uidaho.edu) of additions.

PAPERS NOMINATED FOR BEST AT GECCO PRIZE

As part of the "double blind" scientific peer review, the following papers were nominated for consideration by the conference for a "Best at GECCO" prize. The final winners were chosen after these papers had been presented in New York by secret ballot of the GECCO registrants.

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