Genetic and Evolutionary Computation Conference 2008

Conference Program

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GECCO is sponsored by the Association for Computing Machinery Special Interest Group on Genetic and Evolutionary Computation (SIGEVO). SIG Services: 2 Penn Plaza, Suite 701, New York, NY, 10121, USA, 1-800-342-6626 (USA and Canada) or +212-626-0500 (Global).


GECCO
2008
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SIGEVO
GRAMMATICAL EVOLUTION
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Michael Korns
Genetic and Evolutionary Computation Conference
July 12 –16, 2008
Saturday – Wednesday
Atlanta, Georgia, USA

GECCO is evolving!

Welcome to GECCO 2008! I would like to take this opportunity to welcome you, thank all those who have participated to create the current GECCO, and tell you what's new this year.

After last year's highly successful conference in London, GECCO has returned to the United States, but remains a highly international event, with, at the time of writing, attendees from 42 different countries registered.

Part of GECCO's success is, of course, its own continued adaptation. This includes two new tracks, Evolutionary Combinatorial Optimization and Bioinformatics and Computational Biology, as well as expanded events such as the Graduate Student Workshop and the Job Shop.

Similarly, the breadth of tutorials and workshops – which often serve as the primordial ooze from which new tracks spring – continues to be impressive, with many field leaders and founders presenting in an exciting line up.

We have two wonderful keynote speakers this year: Prof. PZ Myers, who's work in Evolutionary Developmental Biology makes him an ideal speaker for GECCO and Dr. Martin Meltzer, who works here in Atlanta at the Centre for Disease Control, and will be giving us a unique view into the use of agent based modeling at the CDC.

Another part of GECCO's continued success is its personnel. Between organizers, track chairs and tutorial speakers, there are almost seventy people involved in making GECCO the high quality conference that it is. Organizing this number of academics is a daunting task, and we have this year's Editor-in-Chief, Dr. Maarten Keijzer to thank for ensuring that everyone stuck with their deadlines.

The third, and most important part of GECCO's success is its attendees. A conference can only be as good as those attending it, and GECCO has been fortunate enough to attract a wonderful mix of innovation, curiosity and geekiness. We have done our best to facilitate this, with free wireless in hotel rooms and in all public areas, as well as two meeting rooms on our floor reserved for mini-meetings. This year GECCO attendees even get a free mini-white board. We're confident that these facilities will be used to their full extent.

Finally, I need to thank GECCO administrator Pat Cattolico whose perfect balance of organization and passion meant that all of us involved always knew exactly what was going on and what was expected. Without Pat, this conference simply would not function.

Remember that GECCO is continuously evolving: New tracks, workshops and tutorials, new presentation formats and new organizational styles. Some of these changes work better than others, and your input is critical in maintaining progress. Please let us know your opinions, what worked and what didn't, and how can things be improved next year.

Enjoy the Conference!

Conor Ryan
Conference Chair

Program Outline

All activities will take place on the Second Floor.

Saturday, July 12 and Sunday, July 13
Workshop and Tutorial Sessions

8:30 – 10:20	Session 1
10:20 – 10:40	Coffee Break
10:40 – 12:30	Session 2
12:30- –14:00	Lunch on your own
14:00 – 15:50	Session 3
15:50 – 16:10	Coffee Break
16:10 – 18:00	Session 4

Monday, July 14 – Wednesday, July 15
Accepted Papers, Evolutionary Computation in Practice track, Late Breaking Papers

10:10 – 10:40	Coffee Break
10:40 – 12:20	Paper Presentations
12:20- –14:00	Lunch on your own
14:00 – 15:40	Paper Presentations
15:40 – 16:10	Coffee Break
16:10 – 17:50	Paper Presentations

Registration Desk Open Hours

Saturday and Sunday:	7:00 – 17:00
Monday	7:00 – 17:00
Tuesday	7:30 –16:30
Wednesday	8:00 – 12:30

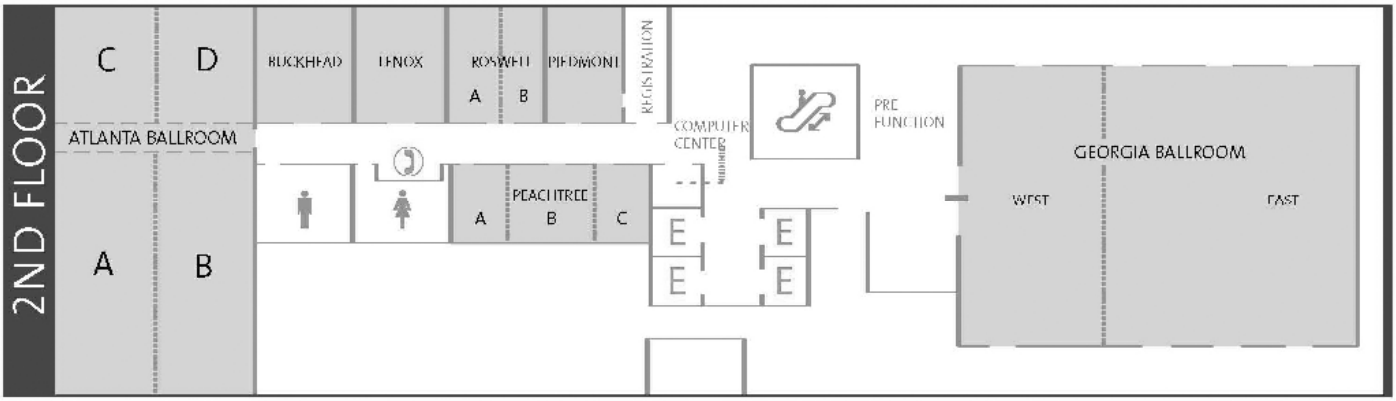
Special Events

Sunday, July 13
18:30 – 20:30 **Opening Reception**: free to all registered GECCO attendees. Hot and cold hors d'ouevre, wine, beer, and soft drinks will be served. **Bring your Badge and Beverage Tickets.**

Monday, July 14
8:30 – 10:10 Keynote: **Martin I. Meltzer, Ph. D**: Modeling for public health policy: Complexity and simplicity
10:40 – 12:20 Competitions Presentations
14:00 – 15:40 HUMIE Finalists Presentations

Tuesday, July 15
8:30 – 10:10 Keynote: **PZ Myers**: Developmental Perspective for Understanding Evolution
18:30 – 21:00 **Poster Session and Reception**, Posters on display with authors available for discussion. Hot and cold hors d'ouevre, wine, beer, and soft drinks will be served. **Bring your Badge and Beverage Tickets**.

Wednesday, July 16
8:30 – 10:10 **Awards Presentations and SIGEVO meeting**
16:10 – 17:50 **Job Shop**: have a job to offer? looking for a job? Sign up sheet at the Registration Desk.



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Sara Silva, *CISUC*
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Martin Skutella, *TU Berlin*
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Stephen Leslie Smith, *University of York*
Jim Smith, *University of the West of England*
Guido Smits, *Dow Chemical*

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Tony White, *Carleton University*
Darrell Whitley, *Colorado State University*
Joerg Wichard, *Institute of Molecular Pharmacology, Berlin*
R. Paul Wiegand, *Institute for Simulation and Training / UCF*
Stewart W Wilson, *Prediction Dynamics*
Carsten Witt, *FB Informatik, LS 2, Univ. Dortmund*
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Shengxiang Yang, *University of Leicester*
Tian-Li Yu, *Illinois Genetic Algorithms Laboratory*
Tina Yu, *Memorial University*
Bo Yuan, *Graduate School at Shenzhen, Tsinghua University*
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Qingfu Zhang, *University of Essex*
Shude Zhou, *Tsinghua University*
Wensheng Zhou, *HRL Labs*
Eckart Zitzler, *ETH Zurich*
Victor Zykov, *Cornell University*

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. We continue this tradition at GECCO-2008. The Track Chairs, Editor in Chief, and the Conference Chair nominated the papers that received the most nominations and/or the highest evaluation scores for consideration by the conference. The winners are chosen by secret ballot of the GECCO attendees after the papers have been orally presented at the conference. Best Paper winners are posted on the conference website. The titles and authors of all papers nominated are given below:

Ant Colony Optimization, Swarm Intelligence, and Artificial Immune Systems

Collective Intelligence and Bush Fire Spotting
David Howden *(Swinburne University of Technology)*,
Tim Hendtlass *(Swinburne University of Technology)*

Convergence Behavior of the Fully Informed Particle Swarm Optimization Algorithm
Marco A. Montes de Oca *(Université Libre de Bruxelles)*,
Thomas Stützle *(Université Libre de Bruxelles)*

Evolutionary Swarm Design of Architectural Idea Models
Sebastian von Mammen *(University of Calgary)*,
Christian Jacob *(University of Calgary)*

Theoretical and Empirical Study of Particle Swarms with Additive Stochasticity and Different Recombination Operators
Jorge Peña *(Université de Lausanne)*

Artificial Life, Evolutionary Robotics, Adaptive Behavior, Evolvable Hardware

The Influence of Scaling and Assortativity on Takeover Times in Scale-Free Topologies
Joshua L Payne *(University of Vermont)*,
Margaret J Eppstein *(University of Vermont)*

Designing Multi-Rover Emergent Specialization
Geoff Nitschke *(Vrije Universiteit)*,
Martijn Schut *(Vrije Universiteit)*

A Multi-scaled Approach to Artificial Life Simulation With P Systems and Dissipative Particle Dynamics
James Smaldon *(University of Nottingham)*,
Jonathan Blakes *(University of Nottingham)*,
Natalio Krasnogor *(University of Nottingham)*,
Doron Lancet *(Weizmann Institute of Science)*

Modular Neuroevolution for Multilegged Locomotion
Vinod K Valsalam *(The University of Texas at Austin)*,
Risto Miikkulainen *(The University of Texas at Austin)*

Bioinformatics and Computational Biology

An Efficient Probabilistic Population-Based Descent for the Median Genome Problem
Adrien Goeffon *(INRIA)*,
Macha Nikolski *(CNRS / LaBRI)*,
David J. Sherman *(INRIA)*

Structure and Parameter Estimation for Cell Systems Biology Models
Francisco J. Romero-Campero *(Univeristy of Nottingham)*,
Hongqing Cao *(University of Nottingham)*,
Miguel Camara *(University of Nottingham)*,
Natalio Krasnogor *(University of Nottingham)*

Mask Functions for the Symbolic Modeling of Epistasis Using Genetic Programming
Ryan J Urbanowicz *(Dartmouth College)*,
Nate Barney *(Dartmouth College)*,
Bill C White *(Dartmouth College)*,
Jason H Moore *(Dartmouth College)*

Coevolution

An Empirical Comparison of Evolution and Coevolution for Designing Artificial Neural Network Game Players
Min Shi (Norwegian University of Science and Technology)

Estimation of Distribution Algorithms

Using Previous Models to Bias Structural Learning in the Hierarchical BOA
Mark W Hauschild *(University of Missouri - St. Louis)*,
Martin Pelikan *(University of Missouri - St. Louis)*,
Kumara Sastry *(University of Illinois at urbana-Champaign)*,
David E. Goldberg *(University of Illinois at Urbana-Champaign)*

On the Effectiveness of Distributions Estimated by Probabilistic Model Building
Chung-Yao Chuang *(National Chiao Tung University)*,
Ying-ping Chen *(National Chiao Tung University)*

From Mating Pool Distributions to Model Overfitting
Claudio F Lima *(University of Algarve)*,
Fernando G Lobo *(University of Algarve)*,
Martin Pelikan *(University of Missouri at St. Louis)*

Evolution Strategies, Evolutionary Programming

Why Noise May be Good
Silja Meyer-Nieberg *(Universitaet der Bundeswehr Muenchen)*,
Hans-Georg Beyer *(Vorarlberg University of Applied Sciences)*

Functionally Specialized CMA-ES: A Modification of CMA-ES based on the Specialization of the Functions of Covariance Matrix Adaptation and Step Size Adaptation
Youhei Akimoto *(Tokyo Institute of Technology)*,
Jun Sakuma *(Tokyo Institute of Technology)*,
Shigenobu Kobayashi *(Tokyo Institute of Technology)*,
Isao Ono *(Tokyo Institute of Technology)*

Aiming for a theoretically tractable CSA variant by means of empirical investigations
Jens Jägersküpper *(TU Dortmund)*,
Mike Preuss *(TU Dortmund)*

Evolutionary Combinatorial Optimization

A Study of NK Landscapes' Basins and Local Optima Networks
Gabriela Ochoa *(University of Nottingham)*,
Marco Tomassini *(University of Lausanne)*,
Sebastien Verel *(CNRS-University of Nice)*,
Christian Darabos *(University of Lausanne)*

Crossover Can Provably be Useful in Evolutionary Computation
Benjamin Doerr *(Max-Planck-Institut für Informatik)*,
Edda Happ *(Max-Planck-Institut für Informatik)*,
Christian Klein *(Max-Planck-Institut für Informatik)*

Evolutionary Multiobjective Optimization

A New Memetic Strategy for the Numerical Treatment of Multi-Objective Optimization Problems
Oliver Schuetze *(CINVESTAV-IPN)*,
Gustavo Sanchez *(Simon Bolivar University)*,
Carlos A. Coello Coello *(CINVESTAV-IPN)*

Introducing MONEDA: Scalable Multiobjective Optimization with a Neural Estimation of Distribution Algorithm
Luis Martí *(Universidad Carlos III de Madrid)*,
Jesús García *(Universidad Carlos III de Madrid)*,
Antonio Berlanga *(Universidad Carlos III de Madrid)*,
José Manuel Molina *(Universidad Carlos III de Madrid)*

Pattern Identification in Pareto-Set Approximations
Tamara Ulrich *(ETH Zurich)*,
Dimo Brockhoff *(ETH Zurich)*,
Eckart Zitzler *(ETH Zurich)*

Benefits and Drawbacks for the Use of epsilon-Dominance in Evolutionary Multi-Objective Optimization
Christian Horoba *(Technische Universität Dortmund)*,
Frank Neumann *(Max-Planck-Institut für Informatik)*

Formal Theory

Computing Minimum Cuts by Randomized Search Heuristics
Frank Neumann *(Max-Planck-Institut für Informatik)*,
Joachim Reichel *(TU Berlin)*,
Martin Skutella *(TU Berlin)*

Memetic Algorithms with Variable-Depth Search to Overcome Local Optima
Dirk Sudholt *(TU Dortmund)*

Precision, Local Search and Unimodal Functions
Martin Dietzfelbinger *(Technische Universitat Ilmenau)*,
Jonathan E Rowe *(University of Birmingham)*,
Ingo Wegener *(Technische Universitat Dortmund)*,
Philipp Woelfel *(University of Calgary)*

Generative and Developmental Systems

Generative Encoding for Multiagent Systems
David B. D'Ambrosio *(University of Central Florida)*,
Kenneth O. Stanley *(University of Central Florida)*

A Cellular Model for the Evolutionary Development of Lightweight Material with an Inner Structure
Till Steiner *(Honda Research Institute Europe GmbH)*,
Yaochu Jin *(Honda Research Institute Europe GmbH)*,
Bernhard Sendhoff *(Honda Research Institute Europe GmbH)*

Genetic Algorithms

Optimal Sampling of Genetic Algorithms on Polynomial Regression
Tian-Li Yu *(National Taiwan University)*,
Wei-Kai Lin *(National Taiwan University)*

Rank Based Variation Operators for Genetic Algorithms
Jorge Cervantes *(Universidad Autónoma Metropolitana)*,
Christopher Rhodes Stephens *(Instituto de Ciencias Nucleares UNAM)*

Theoretical Analysis of Diversity Mechanisms for Global Exploration
Tobias Friedrich *(Max-Planck-Institut fuer Informatik)*,
Pietro S. Oliveto *(University of Birmingham)*,
Dirk Sudholt *(TU Dortmund)*,
Carsten Witt *(TU Dortmund)*

Rigorous Analyses of Fitness-Proportional Selection for Optimizing Linear Functions
Edda Happ *(Max-Planck-Institut Informatik)*,
Daniel Johannsen *(Max-Planck-Institut Informatik)*,
Christian Klein *(Max-Planck-Institut Informatik)*,
Frank Neumann *(Max-Planck-Institut Informatik)*

Genetic Programming

Parsimony Pressure Made Easyød:
Riccardo Poli *(University of Essex)*,
Nicholas Freitag McPhee *(University of Minnesota, Morris)*

The Impact of Population Size on Code Growth in GP:Analysis and Empirical Validation
Riccardo Poli *(University of Essex)*,
Nicholas Freitag McPhee *(University of Minnesota, Morris)*,
Leonardo Vanneschi *(University of Milano-Bicocca)*

Rapid Prediction of Optimum Population Size in Genetic Programming Using a Novel Genotype - Fitness Correlation
David C Wedge *(University of Manchester)*,
Douglas B Kell *(University of Manchester)*

Learning to Recognise Mental Activities: Genetic Programming of Stateful Classifiers for Brain-Computer Interfacing
Alexandros Agapitos *(University of Essex)*,
Matthew Dyson *(University of Essex)*,
Simon M Lucas *(University of Essex)*,
Francisco Sepulveda *(University of Essex)*

Genetics-Based Machine Learning and Learning Classifier Systems

Context-Dependent Predictions and Cognitive Arm Control with XCSF
Martin V Butz *(University of Würzburg)*,
Oliver Herbort *(University of Würzburg)*

Real World Applications

Speeding Online Synthesis via Enforced Selecto-Recombination
Shunsuke Saruwatari *(University of Illinois at Urbana-Champaign)*,
Xavier Llora *(University of Illinois at Urbana-Champaign)*,
Noriko Imafuji Yasui *(University of Illinois at Urbana-Champaign)*,
Hiroshi Tamura *(Hakuhodo Inc)*,
Kumara Sastry *(University of Illinois at Urbana-Champaign)*,
David E. Goldberg *(University of Illinois at Urbana-Champaign)*

Evolved Bayesian Networks as a Versatile Alternative to Partin Tables for Prostate Cancer Management
Ratiba Kabli *(The Robert Gordon University)*,
John McCall *(The Robert Gordon University)*,
Frank Herrmann *(The Robert Gordon University)*,
Eng Ong *(Aberdeen Royal Infirmary)*

Genetic Algorithms for Mentor-Assisted Evaluation Function Optimization
Omid David-Tabibi *(Bar-Ilan University)*,
Moshe Koppel *(Bar-Ilan University)*,
Nathan S. Netanyahu *(Bar-Ilan University)*

Multiobjective Robustness for Portfolio Optimization in Volatile Environments
Ghada Hassan *(UCL)*,
Christopher D. Clack *(UCL)*

Search-Based Software Engineering

Empirical Analysis of a Genetic Algorithm-based Stress Test Technique
Vahid Garousi *(University of Calgary)*

Fitness Calculation Approach for the Switch-Case Construct in Evolutionary Testing
Yan Wang *(Software Engineering Institute, Xidian University)*,
Zhiwen Bai *(Software Engineering Institute, Xidian University)*,
Miao Zhang *(Software Engineering Institute, Xidian University)*,
Wen Du *(Software Engineering Institute, Xidian University)*,
Ying Qin *(Software Engineering Institute, Xidian University)*,
Xiyang Liu *(Software Engineering Institute, Xidian University)*

Searching for Liveness Property Violations in Concurrent Systems with ACO
Francisco Chicano *(University of Málaga)*,
Enrique Alba *(University of Málaga)*

Tutorials and Workshops Schedule — Saturday 12 July

Room	8:30 – 10:20	10:40 – 12:30	14:00 – 15:50	16:10 – 18:00
Georgia Ballroom West	Intro **Financial Evolutionary Computation** Christopher D. Clack	Advanced **Computational Complexity and EC** Frank Neumann	Intro **Learning Classifier Systems** Martin V. Butz	Advanced **GA Theory** Jonathan Rowe
Georgia Ballroom East			Advanced **Evolutionary Multiobjective Optimization** Eckart Zitzler, Kalyanmoy Deb Intro	
Atlanta Ballroom A	Intro **Coevolution** Anthony Bucci, Paul Wiegand, Sevan Ficici	Special **Cartesian Genetic Programming** Julian F. Miller Simon Harding	**Open-Source Software for Applied Genetic and Evolutionary Computation (SoftGEC)** Jason H. Moore	Special **Evolution Strategies and Related Estimation of Distribution Algorithms** Nikolaus Hansen
Atlanta Ballroom B	Advanced **No Free Lunch** Darrell Whitley			Advanced **Coevolution** Anthony Bucci, Paul Wiegand, Sevan Ficici
Atlanta Ballroom D	Special **Evolving Neural Networks** Risto Miikkulainen, Kenneth O. Stanley		**ARC-FEC: Advanced Research Challenges in Financial Evolutionary Computation** Christopher D. Clack	
Buckhead	Advanced **Constraint Handling Techniques** Carlos Coello Coello Special		Special **Symbolic Regression in Genetic Programming** Maarten Keijzer	Special **Evolutionary Design** Ian Parmee
Lenox	**Undergraduate Student Workshop** Laurence D. Merkle, Frank W. Moore, Clare Bates Congdon		**Intro to Genetic Algorithms** Erik Goodman	Intro **Grammatical Evolution** Conor Ryan Atif Azad
Roswell	**Graduate Student Workshop** Steven M. Gustafson		**Graduate Student Workshop (continued)**	
Peachtree			**Medical Applications of Genetic and Evolutionary Computation** Stephen L. Smith, Stefano Cagnoni	
Piedmont	**Open Meeting Room**			
Atlanta Ballroom C	**Open Meeting Room**			

Key

▩ Workshop

□ Tutorial

Intro: Introductory level

Advanced: Advanced level

Special: Specialized Techniques and Applications

Coffee Breaks

Coffee breaks are served in the Registration area at:

- 10:20 – 10:40
- 15:50 – 16:10

Lunch

Lunch is on your own from 12:30 – 14:00

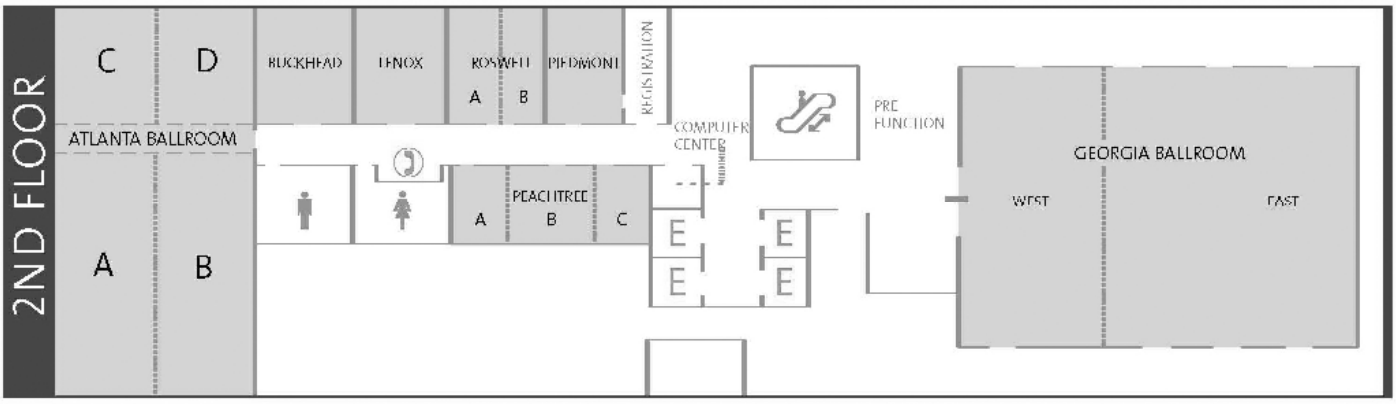
Conference Opening Reception

Sunday, 18:30 until 20:30

The conference opens with a reception on Sunday evening in the Georgia Ballroom. The receiption is free to all registred GECCO attendees. An assortment of hot and cold hors d'ouevre, wine, beer, and soft drinks will be served. Remember to **bring your Badge and beverage tickets**.

Tutorials and Workshops Schedule — Sunday 13 July

Room	8:30 – 10:20	10:40 – 12:30	14:00 – 15:50	16:10 – 18:00
Georgia Ballroom West		Advanced **Representations** Franz Rothlauf		Special **Genetic and Evolutionary Computer Vision** Stephano Cagnoni
Georgia Ballroom East	Intro **Particle Swarm Optimization** Riccardo Poli			
Atlanta Ballroom A	Special **Evolutionary Computation and Games** Moshe Sipper	Special **Evolutionary Multiobjective Combinatorial Optimization (EMCO)** Rajeev Kumar	Advanced **Bioinformatics** Jason H. Moore	Advanced **Evolutionary Practical Optimization** Kalyanmoy Deb
Atlanta Ballroom B	**Evolutionary Computation and Multi-Agent Systems and Simulation (ECoMASS)** William M. Rand, Sevan G. Ficici, Rick L. Riolo		**Optimization by Building and Using Probabilistic Models (OBUPM-2008)** Mark Hauschild, Martin Pelikan, Kumara Sastry	
Atlanta Ballroom D	**2nd Defense Applications of Computational Intelligence** Laurence D. Merkle, Frank W. Moore		**Defense Applications of Computational Intelligence (continued)**	
Buckhead	Special **Experimental Research in EC** Thomas Bartz-Beielstein Mike Preuss	Special **Generative and Developmental Systems** Kenneth O. Stanley	Intro **Evolution Strategies** Thomas Bäck	Intro **Intro to Genetic Programming** John Koza
Lenox	Special **EA-based Test and Verification of Microprocessors** Giovanni Squillero	Intro **A Unified Approach to EC** Kenneth De Jong	Special **An Information Perspective on Evolutionary Computation** Yossi Borenstein	Special **Quantum Computing** Lee Spector
Roswell	**Learning Classifier Systems** Jaume Bacardit, Ester Bernadó-Mansilla, Martin V. Butz		**Learning Classifier Systems (continued)**	
Peachtree	Intro **Probabilistic Model-Building GAs** Martin Pelikan	Advanced **Statistics for EC** Mark Wineberg	Special **Theory of Randomized Search Heuristics in Combinatorial Optimization** Carsten Witt	Advanced **GP Theory** Riccardo Poli
Piedmont	**Open Meeting Room**			
Atlanta Ballroom C	**Open Meeting Room**			



Workshop Presentations

Graduate Student Workshop

SSNNS - A Suite of Tools to Explore Spiking Neural Networks
Heike Sichtig, J. David Schaffer, Craig B. Laramee

Spiking Neural Networks, Genetic Algorithms, Complexity, Learning, Temporal Pattern Recognition, Machine Learning

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Towards High Speed Multiobjective Evolutionary Optimizers
A.K.M. Khaled Ahsan Talukder

Evolutionary Multiobjective Optimization, Variation Operator, Dynamic System Identification, Function Evaluation

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Multiple Sequence Alignment using a GLOCSA Guided Genetic Algorithm
Edgar David Arenas-Díaz, Helga Ochoterena-Booth, Katya Rodríguez-Vázquez

biological applications, genetic algorithms, sequence alignment, autoadaptation, GLOCSA

Accelerating Convergence using Rough Sets Theory for Multi-Objective Optimization Problems
Luis V. Santana-Quintero, Carlos A. Coello Coello

Multi-objective optimization, Rough Sets Theory, Local Search

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How Social Structure and Institutional Order Co-evolve Beyond Instrumental Rationality
Jae-Woo Kim

Prisoner's Dilemma Game, Instrumental Rationale, Homophily, Coordination, Emergent Order, Emergent Structure, NetLogo

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Specialization with NeuroEvolution in a Collective Behaviour Task
D. W. F. van Krevelen

NeuroEvolution, Collective Behavior, Specialization

Local Dominance and Controlling Dominance Area of Solutions in Multi and Many Objectives EAs
Hiroyuki Sato, Hernan E Aguirre, Kiyoshi Tanaka

Evolutionary multi and many objectives optimization, selection, local dominance, control of dominance area of solutions

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Using Holey Fitness Landscapes to Counteract Premature Convergence in Evolutionary Algorithms
Gregory Paperin

evolutionary algorithm, genetic algorithm, holey fitness landscape, gene flow, premature convergence, reproductive isolation.

Workshop Presentations

Search-Based Test Case Generation for Object-Oriented Java Software Using Strongly-Typed Genetic Programming

José Carlos Bregieiro Ribeiro

Search-Based Test Case Generation, Evolutionary Testing, Strongly-Typed Genetic Programming, Object-Orientation

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Bacterial Foraging Oriented by Particle Swarm Optimization Strategy for PID Tuning

Wael Mansour Korani

Bacterial Foraging, Particle Swarm Optimization, Tuning of PID controller

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Search for Human Competitive Results in Open Ended Automated Synthesis of a Primordial Mechatronic System

Saheeb Ahmed Kayani

Bond-Graphs, Genetic Programming, Unified/Automated Design, Topology Synthesis, Multi Domain Dynamic or Mechatronic Systems, Physical Design Realization, Dynamic Analysis

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Undergraduate Student Workshop

Topology Optimization Of Compliant Mechanism Using Multi-Objective Particle Swarm Optimization

Nikhil Padhye

Topology Optimization

Interplanetary trajectory Optimization with Swing-bys Using Evolutionary Multi-Objective Optimization

Nikhil Padhye

Optimization

Agent Smith: a Real-Time Game-Playing Agent for Interactive Dynamic Games

Ryan K Small

Learning Classifier System (LCS), Games, Agents, Evolutionary Computation, Rule-Based System

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A Study for Multi-Objective Fitness Function for Time Series Forecasting with Intelligent Techniques

Aranildo Rodrigues Lima Junior

Evolutionary Strategies, Neural Network, Time Series, Forecasting, Fitness Function

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Workshop Presentations

Advanced Research Challenges in Financial Evolutionary Computing (ARC-FEC)

Ultra High Frequency Financial Data
Martin Victor Sewell, Wei Yan

high frequency, data, finance, evolutionary algorithms

Technical Market Indicators Optimization using Evolutionary Algorithms
Pablo Fernández-Blanco, Diego J. Bodas-Sagi, Francisco J. Soltero, J. Ignacio Hidalgo

Finance, Optimization, Evolutionary Algorithms, Stock Market Data Mining, Decision Making, Technical Trading Rules

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Non-Linear Factor Model for Asset Selection using Multi Objective Genetic Programming
Ghada Hassan

GP, Multiobjective Optimization, Factor Models, Portfolio Optimization, Finance

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ADANN: Automatic Design of Artificial Neural Networks
Juan Peralta, German Gutierrez, Araceli Sanchis

Evolutionary Computation, Genetic Algorithms, Artificial Neural Networks, Time Series, Forecasting

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Design of Stock Trading System for Historical Market Data Using Multiobjective Particle Swarm Optimization of Technical Indicators
Antonio C. Briza, Prospero C. Naval Jr.

Multiobjective optimization, particle swarm optimization, stock trading systems, technical indicators

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Defense Applications of Computational Intelligence (DACI)

Applications of Multi-objective Evolutionary Algorithms to Air Operations Mission Planning
Brad Rosenberg, Marc Richards, John T. Langton, Sofya Tenenbaum, Daniel W. Stouch

evolutionary algorithms, multi-objective evolutionary algorithms, air operations, mission planning

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Evolving Combat Algorithms to Control Space Ships in a 2D Space Simulation Game with Co-evolution using Genetic Programming and Decision Trees
Tiago Francisco, Gustavo Reis

Genetic Programming

Workshop Presentations

Evolving Predator and Prey Behaviours with Co-evolution using Genetic Programming and Decision Trees

Tiago Francisco, Gustavo Reis

Genetic Programming

Evolving Better Satellite Image Compression and Reconstruction Transforms

Brendan Babb, Frank Moore, Michael Peterson, Gary Lamont

Evolved Transforms, Wavelets, Genetic Algorithms, Quantization Error, Satellite Images, Image Compression, Image Reconstruction

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A Differential Evolution Algorithm for Optimizing Signal Compression and Reconstruction Transforms

Frank W Moore, Brendan Babb

Evolved Transforms, Wavelets, Genetic Algorithms, Quantization Error, Satellite Images, Image Compression, Image Reconstruction

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Emergent Architecture in Self Organized Swarm Systems for Military Applications

Dustin J Nowak, Gary B Lamont, Gilbert L Peterson

Agents, Self-Organization, Autonomous, Swarm Intelligence

Metaoptimization of the In-lining Priority Function for a Compiler Targeting a Polymorphous Computing Architecture

Laurence D. Merkle

Evolutionary computation, Polymorphous computing architectures, Compiler optimization

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Automated Network Forensics

Laurence D. Merkle

Network Forensics, Computational Intelligence

Evolutionary Computation and Multi-Agent Systems and Simulation (ECoMASS)

Comparing Different Modes of Horizontal Information Transmission in Stabilizing Cooperation in Different Complex Networks

Ivette C. Martínez, Klaus Jaffe

Cooperation, Selfish Herd, Complex Networks, Spatial Effects, Horizontal Information Transmission

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Workshop Presentations

Towards Incremental Social Learning in Optimization and Multiagent Systems
Marco A. Montes de Oca, Thomas Stützle

Social Learning, Particle Swarm Optimization, Multiagent systems

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Infection-Based Self-Configuration in Agent Societies
Norman Salazar, Juan A Rodriguez-Aguilar, Josep Lluis Arcos

Distributed evolutionary algorithm, norms evolution, infection-based algorithm

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Exploring Population Geometry and Multi-Agent Systems:
A New Approach to Developing Evolutionary Techniques
Camelia Chira, Anca Gog, D. Dumitrescu

Evolutionary algorithms, Multi-agent systems, Population topology

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Autonomous Agent Behavior Generation Using Multiobjective Evolutionary Optimization
Dustin J Nowak, Gary B Lamont

Self-Organization, Agents, Autonomous, Swarm Intelligence

An Agent-Based Collaborative Evolutionary Model for Multimodal Optimization
Rodica I Lung, Camelia Chira, D. Dumitrescu

evolutionary multimodal optimization, multi-agent systems, collaborative search

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Learning Classifier Systems

On the Effects of Node Duplication and Connection-Oriented Constructivism in Neural XCSF
Gerard David Howard, Larry Bull

Constructivism, Learning Classifier Systems, Neural Networks, Reinforcement Learning, Self-adaptation

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Recursive Least Squares and Quadratic Prediction in Continuous Multistep Problems
Daniele Loiacono, Pier Luca Lanzi

learning classifier systems, recursive least squares, multistep problems

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Supply Chain Management Sales Using XCSR
Maria A. Franco, Ivette C. Martinez, Celso Gorrin

TAC SCM, Supply Chain Management, Classifier Systems, XCSR

Workshop Presentations

Adapted Pittsburgh Classifier System : Building accuratestrategies in non markovian environments

Gilles Enée, Mathias Peroumalnaïk

APCS, XCS, classifier system, non markovian multistep environment, strategy

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Evolving Prediction Weights Using Evolution Strategy

Trung Hau Tran, Cédric Sanza, Yves Duthen

XCSF, function approximation, evolution strategy

A New Approach for Multi-label Classification Based on Default Hierarchies and Organizational Learning

Rosane M. M. Vallim, David E. Goldberg, Xavier Llorà, Thyago S. P. C. Duque, André C. P. L. F. Carvalho

LCS, default hierarchies, organizational sizing

Towards Increasing Learning Speed and Robustness of XCSF: Experimenting with Larger Offspring Set Sizes

Patrick Stalph, Martin V Butz

Learning Classifier Systems, XCSF, Reproduction, Selection Pressure

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First Approach toward On-line Evolution of Association Rules with Learning Classifier Systems

Albert Orriols-Puig, Jorge Casillas, Ester Bernadó-Mansilla

Genetic Algorithms, Learning Classifier Systems, Unsupervised Learning, Association Rules

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Learning Classifier Systems for Optimisation Problems: a Case Study on Fractal Travelling Salesman Problem

Maximiliano Tabacman, Natalio Krasnogor, Jaume Bacardit, Irene Loiseau

traveling-salesman-problem, optimization, learning-classifier-systems, machine learning

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MedGEC - Medical Applications of Genetic and Evolutionary Computation

Informative Sampling for Large Unbalanced Data Sets

Zhenyu Lu, Anand I Rughani, Bruce I Tranmer, Josh Bongard

sampling, active learning, coevolution, EEA

Multiobjective Optimization of a Stent in aFluid-Structure Context

Adel Blouza, Laurent Dumas, Ibrahima M'Baye

optimization, stent, fluid-structure interaction

Workshop Presentations

Analysis of Mammography Reports Using Maximum Variation Sampling
Robert M Patton, Barbara Beckerman, Thomas E Potok

Unstructured radiology reports, text analysis, genetic algorithms, maximum variation sampling

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Interactive Search of Rules in Medical Data Using Multiobjective Evolutionary Algorithms
Daniela Zaharie, Diana Lungeanu, Flavia Zamfirache

rules mining, multiobjective optimization, evolutionary algorithms, interestingness measures, interactive search

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Towards an Objective Assessment of Alzheimer's Disease
Alex Hazell, Stephen L Smith

Evolutionary algorithm, Cartesian genetic programming, medical applications, Alzheimer s disease, image analysis

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Optimization by Building and Using Probabilistic Models (OBUPM)

An Information Geometry Perspective on Estimation of Distribution Algorithms: Boundary Analysis
Luigi Malagò, Matteo Matteucci, Bernardo Dal Seno

Estimation of Distribution Algorithms, Information Geometry, Boundary of a Manifold

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A Bivariate Probabilistic Model-building Genetic Algorithm for Graph Bipartitioning
Dirk Thierens

Probabilistic model-building EAs

Monday – Wednesday Sessions at a Glance

Monday 14 July

Room	8:30 – 10:10	10:10 – 10:40 Break	10:40 – 12:20	12:20 – 14:00 Lunch	14:00 – 15:40	15:40 – 16:10 Break	16:10 – 17:50
Georgia Ballroom West	Keynote: Martin I. Meltzer, Ph. D		GP-2		GP-3		GP-1★
Georgia Ballroom East			GA-1★		GA-2		GA-3
Atlanta Ballroom A			BIO-2		HUMIE		BIO-3
Atlanta Ballroom B			RWA-2		RWA-3		RWA-4
Atlanta Ballroom D			ECP-1		ECP-2		COEVO★
Buckhead			COMP		ALIFE-2		ALIFE-3
Lenox			ALIFE-1★		EDA-1★		EDA-3
Roswell			ESEP-1★		ACO-2		LBP-1
Peachtree			EMO-2		GDS-1★		GDS-2
Atlanta Ballroom C	Open Meeting Room						
Piedmont	Open Meeting Room						

Key

★	Best Paper Nominations	**FT**	Formal Theory
ALIFE	A-Life, Evolutionary Robotics, Adaptive Behavior, Evolvable Hardware	**GA**	Genetic Algorithms
ACO	Ant Colony Optimization, Swarm Intelligence, and Artificial Immune Systems	**GBML**	Genetics-Based Machine Learning and Learning Classifier Systems
BIO	Bioinformatics and Computational Biology	**GDS**	Generative and Developmental Systems
COEVO	Coevolution	**GP**	Genetic Programming
COMP	Competitions	**HUMIE**	Human-Competitive Results Awards
ECP	Evolutionary Computation in Practice	**LBP**	Late-Breaking Papers
EDA	Estimation of Distribution Algorithms	**RWA**	Real-World Applications
EMO	Evolutionary Multiobjective Optimization	**SBSE**	Search-Based Software Engineering
ESEP	Evolutionary Strategies, Evolutionary Programming		

Instructions for Paper Presentations

GECCO provides an LCD projector in each meeting room. Presenters must bring their own laptop, or arrange to use a laptop for your presentation. Speakers presenting papers are allotted the following presentations time. **If a session is without a chair**, we ask the last scheduled speaker to perform those duties.

- Speakers presenting **accepted papers** during the technical sessions are allocated **25 minutes** for each presentation, 20 minutes for set up and presentation, followed by 5 minutes for questions.
- Speakers in the **late breaking papers** sessions are allocated **15 minutes** for each presentation, 10 minutes for set up and presentation, followed by 5 minutes for questions.

Monday – Wednesday Sessions at a Glance

Tuesday 15 July

Room	8:30 – 10:10	10:10 – 10:40 Break	10:40 – 12:20	12:20 – 14:00 Lunch	14:00 – 15:40	15:40 – 16:10 Break	16:10 – 17:50
Georgia Ballroom West	Keynote: PZ Myers		GBML-1★				
Georgia Ballroom East			GA-4				
Atlanta Ballroom A			ACO-3		EMO-4		ACO-1★
Atlanta Ballroom B			RWA-1★		GP-5		RWA5
Atlanta Ballroom D			ECP-3		ECP-4		EMO-1★
Buckhead					EDA-2		GP-4
Lenox			LBP-2		GBML-3		BIO-1★
Roswell			SBSE-1★		GA-5		GBML-2
Peachtree			Theory-1★		ECO-1★		ECO-2
Atlanta Ballroom C	Open Meeting Room						
Piedmont	Open Meeting Room						

Wednesday 16 July

Room	8:30 – 10:10	10:10 – 10:40 Break	10:40 – 12:20	12:20 – 14:00 Lunch	14:00 – 15:40	15:40 – 16:10 Break	16:10 – 17:50
Georgia Ballroom West	Awards and SIGEVO meeting		GA-6		GA-7		GA-8
Georgia Ballroom East			EMO-3		RWA-9		GP-6
Atlanta Ballroom A			ESEP-2		ACO-4		
Atlanta Ballroom B			RWA-6		RWA-7		RWA-8
Atlanta Ballroom D			ECP-5		ECP-6		
Buckhead			ACO-5		EMO-5		SBSE-2
Lenox			ALIFE-4				
Roswell			Theory-2				
Peachtree			LBP-3		LBP-4		LBP-5
Atlanta Ballroom C						closed	2nd Annual Job Shop
Piedmont	Open Meeting Room						

Speaker: Martin I. Meltzer, Ph.D
Modeling for public health policy: Complexity and simplicity

Room: Georgia Ballroom

8:30–10:10 Keynote by Martin I. Meltzer, Ph.D of the DEISS/NCPDCID/CCID/CDC: (Division of Emerging Infections and Surveillance Services, National Center for the Prevention, Detection and Control of Infectious Diseases, Coordinating Center for Infectious Diseases, Centers for Disease Control and Prevention (CDC))

Public health policy makers face a wide array of planning problems, including how to prepare for the next influenza pandemic, assessing the value of vaccines and evaluating a variety of interventions.

This talk will present some examples of the mathematical models, ranging from complex (agent based models requiring super computers) to the simple (using spreadsheets), that have been used to help public health officials make decisions.

Also to be presented will be some suggested "rules of thumb" for producing mathematical models that public health officials may find useful.

About the speaker:

Dr. Martin I. Meltzer is the Senior Health Economist and a Distinguished Consultant, Division of Emerging Infections and Surveillance Services, CDC in Atlanta, GA.

He received his undergraduate degree from the University of Zimbabwe in 1982, and Masters and a Doctorate in Applied Economics from Cornell University, NY, in 1987 and 1990, respectively. From 1990 to mid 1995 he was on the faculty at the School of Veterinary Medicine at the University of Florida.

In 1995, he moved to CDC, where he was in the first class of Prevention Effectiveness (health economists) fellows.

Examples of his more recent research include the modeling of potential responses to smallpox as a bioterrorist weapon, examining the economics of vaccinating restaurant foodhandlers against hepatitis A, and assessing the economic impact of pandemic influenza.

Dr. Meltzer has published approximately 140 publications, including more than 80 articles in peer-reviewed journals, two U.S. patents and ten book chapters.

He also led teams which produced software, such as FluAid, FluSurge and FluWorkLoss, designed to help state and local public health officials plan and prepare of catastrophic infectious disease events.

He is an associate editor for Emerging Infectious Diseases. He also supervises a number of post-doctoral health economists at CDC.

Paper Presentations — Instructions for Session Chairs

Session Chairs help keep sessions on schedule and moderate question periods.
Thank you for your participation and cooperation.

If a session is without a chair, we ask the last scheduled speaker to perform those duties

Please keep the session on schedule:

- Please adhere to the scheduled order of talks, as well as presentation times. If a speaker is absent, we ask you to announce a short break until the next presentation is due to start. Do not start early, as participants may be moving between sessions/presentations.
- Introduce each speaker
- Moderate questions
- Arrive a few minutes early to check on room and equipment set-up. Please let conference organizers at the Registration Desk know immediately if problems arise or adjustments are needed.

GP-2: Applications I

Room: Georgia West

Session Chair: Nicholas Freitag McPhee (University of Minnesota, Morris)

10:40–11:05 **Automated Shape Composition Based on Cell Biology and Distributed Genetic Programming**

Linge Bai, Manolya Eyiyurekli, David E Breen

Shape Composition, Morphogenesis, Chemotaxis, Distributed Genetic Programming, Self-organization

Motivated by the ability of living cells to form specific shapes and structures, we present a computational approach using distributed genetic programming to discover cell-cell interaction rules for automated shape composition. The key concept is to evolve local rules that direct virtual cells to produce a self-organizing behavior that leads to the formation of a macroscopic, user-defined shape. The interactions of the virtual cells, called Morphogenic Primitives (MPs), are based on chemotaxis-driven aggregation behaviors exhibited by actual living cells. Cells emit a chemical into their environment. Each cell responds to the stimulus by moving in the direction of the gradient of the cumulative chemical field detected at its surface. MPs, though, do not attempt to completely mimic the behavior of real cells. The chemical fields are explicitly defined as mathematical functions and are not necessarily physically accurate. The functions are derived via a distributed genetic programming process. A fitness measure, based on the shape that emerges from the chemical-field-driven aggregation, determines which functions will be passed along to later generations. This paper describes the cell interactions of MPs and a distributed genetic programming method to discover the chemical fields needed to produce macroscopic shapes from simple aggregating primitives.

11:05–11:30 **Evolutionary Lossless Compression with GP-ZIP***

Ahmad Kattan, Riccardo Poli

Lossless data compression, GP-zip, AC, LZW, PPMD, RLE, Boolean Minimization. BWT, MTF, GP-zip*

In recent research we proposed GP-zip, a system which uses evolution to find optimal ways to combine standard compression algorithms for the purpose of maximally losslessly compressing files and archives. The system divides files into blocks of predefined length. It then uses a linear, fixed-length representation where each primitive indicates what compression algorithm to use for a specific data block. GP-zip worked well with heterogonous data sets, providing significant improvements in compression ratio compared to some of the best standard compression algorithms. In this paper we propose a substantial improvement, called GP-zip*, which uses a new representation and intelligent crossover and mutation operators such that blocks of different sizes can be evolved. Like GP-zip, GP-zip* finds what the best compression technique to use for each block is. The compression algorithms available in the primitive set of GP-zip* are: Arithmetic coding (AC), Lempel-Ziv-Welch (LZW), Unbounded Prediction by Partial Matching (PPMD), Run Length Encoding (RLE), and Boolean Minimization. In addition, two transformation techniques are available: the Burrows-Wheeler Transformation (BWT) and Move to Front (MTF). Results show that GP-zip* provides improvements in compression ratio ranging from a fraction to several tens of percent over its predecessor.

11:30–11:55 **Evolution of Hyperheuristics for the Biobjective 0/1 Knapsack Problem by Multiobjective Genetic Programming**

Rajeev Kumar, Ashwin H. Joshi, Krishna K. Banka, Peter I. Rockett

Optimization methods, multiobjective optimization, genetic algorithm, genetic programming, heuristics, combinatorial optimization, 0-1 knapsack problem, Pareto front

The 0/1 knapsack problem is one of the most exhaustively studied NP-hard combinatorial optimization problems. Many different approaches have been taken to obtain an approximate solution to the problem in polynomial time. Here we consider the biobjective 0/1 knapsack problem. The contribution of this paper is to show that a genetic programming system can evolve a set of heuristics that can give solutions on the Pareto front for multiobjective combinatorial problems. The genetic programming (GP) system outlined here evolves a heuristic which decides whether or not to add an item to the knapsack in such a way that the final solution is one of the Pareto optimal solutions. Moreover, the Pareto front obtained from the GP system is comparable to the front obtained from other human-designed heuristics. We discuss the issue of the diversity of the obtained Pareto front and the application of strongly-typed GP as a means of obtaining better diversity.

GA-1: Best Paper Nominees

Room: Georgia East

Session Chair: Martin Pelikan (University of Missouri in St. Louis)

10:40–11:05 ★**Optimal Sampling of Genetic Algorithms on Polynomial Regression**
Tian-Li Yu, Wei-Kai Lin

Genetic Algorithms, Optimal Sampling, Polynomial Regression, Fitness Relaxation, Function Mapping, Speedup Technique

This paper investigates the utility of sampling as an evaluation-relaxation technique in genetic algorithms (GAs). In many real-world applications, sampling can be used to generate a less accurate, but computationally inexpensive fitness evaluator to speed GAs up. This paper focuses on the problem of polynomial regression as an example of problems with positive dependency among genes. Via statistical analysis of the noise introduced by sampling, this paper develops facet-wise models for the optimal sampling size, and these models are empirically verified. The results show that when the population is sized properly, small sampling sizes are preferred for most applications. When a fixed population size is adopted, which is usually the case in real-world applications, an optimal sampling size exists. If the sampling size is too small, the sampling noise increases, and GAs would perform poorly because of an insufficiently large population. If the sampling size is too large, the GA would spend too much time in fitness calculation and cannot perform well either within limited run duration.

11:05–11:30 ★**Rank Based Variation Operators for Genetic Algorithms**
Jorge Cervantes, Christopher Rhodes Stephens

Rank GA, Robustness, Parameter Tuning

We show how and why using genetic operators that are applied with probabilities that depend on the fitness rank of a genotype or phenotype offers a robust alternative to the Simple GA and avoids some questions of parameter tuning without having to introduce an explicit encoded self-adaptation mechanism. We motivate the algorithm by appealing to previous theoretic analysis that show how different landscapes and population states require different mutation rates to dynamically optimize the balance between exploration and exploitation. We test the algorithm on a range of model landscapes where we can see under what circumstances this Rank GA is likely to outperform the Simple GA and how it outperforms standard heuristics such as $1/N$. We try to explain the reasons behind this behaviour.

11:30–11:55 ★**Theoretical Analysis of Diversity Mechanisms for Global Exploration**
Tobias Friedrich, Pietro S. Oliveto, Dirk Sudholt, Carsten Witt

diversity, runtime analysis, fitness sharing, deterministic crowding, exploration

Maintaining diversity is important for the performance of evolutionary algorithms. Diversity mechanisms can enhance global exploration of the search space and enable crossover to find dissimilar individuals for recombination. We focus on the global exploration capabilities of mutation-based algorithms. Using a simple bimodal test function and rigorous runtime analyses, we compare well-known diversity mechanisms like deterministic crowding, fitness sharing, and others with a plain algorithm without diversification. We show that diversification is necessary for global exploration, but not all mechanisms succeed in finding both optima efficiently.

11:55–12:20 ★**Rigorous Analyses of Fitness-Proportional Selection for Optimizing Linear Functions**
Edda Happ, Daniel Johannsen, Christian Klein, Frank Neumann

Running time analysis, Selection, Theory

Rigorous runtime analyses of evolutionary algorithms (EAs) mainly investigate algorithms that use elitist selection methods. Two algorithms commonly studied are Randomized Local Search (RLS) and the (1+1) EA and it is well known that both optimize any linear pseudo-Boolean function on n bits within an expected number of O(n log n) fitness evaluations. In this paper, we analyze variants of these algorithms that use fitness proportional selection. A well-known method in analyzing the local changes in the solutions of RLS is a reduction to the gambler's ruin problem. We extend this method in order to analyze the global changes imposed by the (1+1) EA. By applying this new technique we show that with high probability using fitness proportional selection leads to an exponential optimization time for any linear pseudo-Boolean function with non-zero weights. Even worse, all solutions of the algorithms during an exponential number of fitness evaluations differ with high probability in linearly many bits from the optimal solution.Our theoretical studies are complemented by experimental investigations which confirm the asymptotic results on realistic input sizes.

BIO-2: Bioinformatics and Computational Biology

Room: Atlanta A

Session Chair: Clare Bates Congdon (University of Southern Maine)

10:40–11:05 **Evolution of Discrete Gene Regulatory Models**

Afshin Esmaeili, Christian Jacob

Gene regulatory network, Random Boolean model, Systems biology, Evolutionary design

Gene regulatory networks (GRNs) are complex control systems that govern the interaction of genes, which ultimately control cellular processes at the protein level. GRNs can be represented using abstract models such as random Boolean networks (RBNs), where gene activities and their interactions are captured as nodes with associated Boolean functions, which receive activation or repressor signals from other nodes. We have developed an evolutionary model of gene regulatory networks using RBNs to study the dynamic behavior of these control systems. We explore a range of different network parameters such as excess graph, sensitivity, basin entropy, number of attractors and maximum length of attractors in RBNs. We investigate the effects of mutations and crossover on the fitness of RBNs, and we show that over the course of evolution, networks with a low level of damage spreading and a high tolerance to random perturbations can be produced. We also demonstrate that these networks are able to adapt to a range of different perturbations obtaining a high level of stability.

11:05–11:30 **Finding Consensus Trees by Evolutionary, Variable Neighborhood Search, and Hybrid Algorithms**

Sandro Pirkwieser, Günther R. Raidl

consensus tree problem, phylogenetics, memetic algorithm, variable neighborhood search, hybrid methods

The consensus tree problem arises in the domain of phylogenetics and seeks to find for a given collection of trees a single tree best representing it. Usually, such a tree collection is obtained by biologists for a given taxa set either via different phylogenetic inference methods or multiple applications of a non-deterministic procedure. There exist various consensus methods which often have the drawback of being very strict, limiting the resulting consensus tree in terms of its resolution and/or precision. A reason for this typically is the coarse granularity of the tree metric used. To find fully resolved (binary) consensus trees of high quality, we consider the fine-grained TreeRank similarity measure and extend a previously presented evolutionary algorithm (EA) to a memetic algorithm (MA) by including different variants of local search using neighborhoods based on moves of single taxa as well as subtrees. Furthermore, we propose a variable neighborhood search (VNS) with an embedded variable neighborhood descent (VND) based on the same neighborhood structures. Finally sequential and intertwined combinations of the EA and MA with the VNS/VND are investigated. We give results on real and artificially generated data indicating in particular the benefits of the hybrid methods.

11:30–11:55 **Rapid Evaluation and Evolution of Neural Models using Graphics Card Hardware**

Thomas F Clayton, Leena N Patel, Gareth Leng, Alan F Murray, Iain A B Lindsay

Bioinformatics, Modelling behaviours and ecosystems, Parameter tuning, Speedup technique, Evolutionary strategies

This paper compares three common evolutionary algorithms and our modified GA, a Distributed Adaptive Genetic Algorithm (DAGA). The optimal approach is sought to adapt, in near real-time, biological model behaviour to that of real biology within a laboratory. Near real-time adaptation is achieved with a Graphics Processing Unit (GPU). This, together with evolutionary computation, enables new forms of experimentation such as online testing, where biology and computational model are simultaneously stimulated and their responses compared. Rapid analysis and validation provide a platform that is required for rapid prototyping, and along with online testing, can provide new insight into the cause of biological behaviour. In this context, results demonstrate that our DAGA implementation is more efficient than the other three evolutionary algorithms due to its suitability to the adaptation environment, namely the large population sizes promoted by the GPU architecture.

RWA-2: Financial Engineering
Room: Atlanta B
Session Chair: Christopher D. Clack (University College London)

10:40–11:05 **Combatting Financial Fraud: A Coevolutionary Anomaly Detection Approach**
Shelly Xiaonan Wu, Wolfgang Banzhaf

Anomaly detection; Coevolutionary algorithms; Ecology; Self-nonself space pattern construction; Parisian Approach; Fuzzy logic; Financial Fraud

A major difficulty for anomaly detection lies in discovering boundaries between normal and anomalous behavior, due to the deficiency of abnormal samples in the training phase. In this paper, a novel coevolutionary algorithm which attempts to simulate territory establishment in ecology is conceived to tackle anomaly detection problems. Two species in normal and abnormal behavior pattern space coevolve competitively and cooperatively. Competition prevents individuals in one species from invading the other s territory; cooperation aims to achieve complete pattern coverage by adjusting the evolutionary environment according to the pressure coming from neighbors. In a sense, we extend the definition of cooperative coevolution from coupled fitness to interaction of the evolutionary environment . This coevolutionary algorithm, enhanced with features like niching inside of species, global and local fitness, and fuzzy sets, tries to balance overfitting and overgeneralization. This provides an accurate boundary definition. Experimental results on transactional data from a real financial institution show that this coevolutionary algorithm is more effective than the evolutionary algorithm in evolving normal or abnormal behavior patterns only.

11:05–11:30 **Learning to Optimize Profits Beats Predicting Returns - Comparing Techniques for Financial Portfolio Optimisation**
Wei Yan, Martin D. Sewell, Christopher D. Clack

GP, SVM, Robustness, Committee, Voting, Diversity, Finance, Dynamic Environment

Stock selection for hedge fund portfolios is a challenging problem that has previously been tackled by many machine-learning, genetic and evolutionary systems, including both Genetic Programming (GP) and Support Vector Machines (SVM). But which is the better? We provide a head-to-head evaluation of GP and SVM applied to this real-world problem, including both a standard comparison of returns on investment and a comparison of both techniques when extended with a "voting" mechanism designed to improve both returns and robustness to volatile markets. Robustness is an important additional dimension to this comparison, since the markets (the environment in which the GP or SVM solution must survive) are dynamic and unpredictable.Our investigation highlights a key difference in the two techniques, showing the superiority of the GP approach for this problem.

11:30–11:55 **GP Age-layer and Crossover Effects in Bid-Offer Spread Prediction**
Amy Willis, Suneer Patel, Christopher D. Clack

GP, Finance, Options, Spreads, Age Layers, ALPS, Crossover

The bid-offer spread on equity options is a key source of profits for market makers, and a key cost for those trading in the options. Spreads are influenced by dynamic market factors, but is there also a predictable element and can Genetic Programming be used for such prediction?We investigate a standard GP approach and two optimisations --- age-layering and a novel crossover operator. If both are beneficial as independent optimisations, will they be mutually beneficial when applied simultaneously? Our experiments show a degree of success in predicting spreads, we demonstrate significant benefits for each optimisation technique used individually, and we show that when both are used together significant detrimental over-fitting can occur.

Evolutionary Computation in Practice-1
Room: Atlanta D
Session Chair: Thomas Bäck

10:40–12:20 **Creating a Professional EA Project: Pitfalls, Caveats and Success Stories**
Jörn Mehnen, Thomas Bäck

The Evolutionary Computation in Practice (ECP) track is dedicated to the discussion of issues related to practical application of Evolutionary Computation. Since 2004, members from industry, governmental agencies and other public sectors have participated in presentations and discussions describing how evolution-related technologies are being used to solve real-world problems. Moreover, subjects on bridging academic training and real-world usage are also addressed. This session discusses EC from a project view; other topics in this year's ECP track include EC in Logistics and Supply Chain Management , EC in design and scheduling, Getting a Job in Evolutionary Computation (especially beneficial if you plan to attend the 2nd Annual Job Shop), and an "Ask the Experts" open panel discussion.

Competitions

Room: Buckhead

Session Chair: Terry Soule, Robert Heckendorn

10:40–12:20 **Solving Rubik's Cube ($1,000 prize), A 2D Packing Problem, Human Evaluation of Evolved L-System Images, Finding a Balanced Diet in Fractal World**

This year we mean to push the bounds of what is evolved by introducing some novel problems in fringe areas.

Solving Rubik's Cube ($1,000 prize)

In conjunction with Dr. Sean Luke of George Mason University and under a research grant from NASA, Parabon Computation, Inc. has developed the Origin™ Evolutionary SDK, an extension of Dr. Luke's ECJ framework that runs on Frontier. Contestants must evolve a Rubik's Cube solver. Entries must be submitted as a Java™ jar file with a class that supports a predefined Solver interface. Entries will be tested on randomly scrambled cubes. Winners will be based on the number of moves required to unscramble the test cubes and the quality of the evolutionary algorithm (quality includes factors such as autonomy, originality, and parsimony).

A 2D Packing Problem

This problem is a 2D variation of bin packing problems, which requires new ways to evolve with a 2D chromosome. The goal is to best pack a grid to maximize the sum of scores where every unique pair of adjacent numbers in the grid has its own score. Entrants must turn in their best grid and a brief summary of their evolutionary algorithm. The winner is based on the best score and the quality of the evolutionary algorithm.

Human Evaluation of Evolved L-System Images

The goal is to evolve an L-System that will recreate a series of images in a defined number of cycles. Entrants must turn in their L-System grammar, the series of images the L-System generates and a brief summary of their evolutionary algorithm. You are provided with restrictions on the L-system grammar, target images, and a function to generate the series of images for any valid L-System.. The submitted grammars will be run on the provided L-system generator and compared by human inspection for how close they are perceived to replicate features of the executed image. The judges may or may not know what an L-system is. A human panel will judge the quality of the images.

Finding a Balanced Diet in Fractal World

In a more complex variant of the Santa Fe trail, the goal is to evolve an agent to search a landscape and find as much as possible of two types of food. The landscape is a fractal with varying elevations and impassable regions. Problem details, including sample training maps, and the requirements for the function, including arguments and outputs, are defined through the details link. Entrants must turn in an ANSI C function representing the best evolved agent and a brief summary of their evolutionary algorithm. Scoring will be based on a fitness function that takes into account not only the amount of the two types of food collected but the balance between the two types of food. Submitted functions will be tested on a number of random, test maps. The quality of the evolutionary algorithm may be taken into account in the scoring.

ALIFE-1: Best Paper Nominees

Room: Lenox

Session Chair:

10:40–11:05 **★The Influence of Scaling and Assortativity on Takeover Times in Scale-Free Topologies**

Joshua L Payne, Margaret J Eppstein

Assortativity, Interaction Topologies, Mixing Patterns, Population Structure, Saturation Dynamics, Scale-Free, Spatial Structure, Takeover Time, Selective Pressure

In evolving systems, the topological characteristics of population structure have a pronounced impact on the rate of spread of advantageous alleles, and therefore affect selective pressure. One common method for quantifying the influence of population structure on selective pressure is through the analysis of the expected number of generations required for a single favorable allele to saturate an entire population (a.k.a. takeover time analysis). While takeover times have been thoroughly investigated in regular population structures, the selective pressures induced by irregular interaction topologies, such as scale-free graphs, have received much less attention. In this study, we systematically investigate the influence of scaling and assortativity, two frequently overlooked topological properties, on takeover times in scale-free population structures. Our results demonstrate that the scaling parameter and the magnitude and sign of assortativity have profound and unexpected nonlinear influences on takeover times in scale-free interaction topologies. We explore the reasons behind these results and suggest ways in which they may be exploited in future studies.

11:05–11:30 ★**Designing Multi-Rover Emergent Specialization**
Geoff Nitschke, Martijn Schut

neuro-evolution, specialization, multi-rover

We compare the efficacy of the Enforced Sub-Populations (ESP) and Collective Neuro-Evolution (CONE) methods for designing behavioral specialization in a multi-rover collective behavior task. These methods are tested for Artificial Neural Network (ANN) controller design in an extension of the multi-rover task, where behavioral specialization is known to benefit task performance. The task is for multiple simulated autonomous vehicles (rovers) to maximize the detection of points of interest (red rocks) in a virtual environment. The task requires rovers to collectively sense such points of interest in order for them to be detected. Results indicate that the CONE method facilitates a level of specialization appropriate for achieving a significantly higher task performance, comparative to rover teams evolved by the ESP method.

11:30–11:55 ★**A Multi-scaled Approach to Artificial Life Simulation With P Systems and Dissipative Particle Dynamics**
James Smaldon, Jonathan Blakes, Natalio Krasnogor, Doron Lancet

Artificial Life, Synthetic Biology, Systems Biology, P Systems, Dissipative Particle Dynamics

Compartmentalisation is thought to have been a crucial step in the origin of life. To help us bridge the gap between self-assembly processes behind the formation of bio-compartments and metabolic and information bearing processes we refer to DPD and P Systems Simulations. In this paper we outline a new software platform linking a high level abstract computational formalism (P Systems) with a molecular scale model (Dissipative Particle Dynamics) by linking the membranes which delimit the cellular regions within P Systems to self-assembled phospholipid based vesicles in DPD. We test the platform by modelling a passive transport process involving vesicles containing membrane inclusions similar to pore complexes such as ±-hemolysin. In doing so, we illustrate the usefulness of the modelling approach and derive a more realistic parameter set for the P system through the dissipative particle dynamics simulation.

11:55–12:20 ★**Modular Neuroevolution for Multilegged Locomotion**
Vinod K Valsalam, Risto Miikkulainen

Modular neuroevolution, coupled cell systems, multilegged robots, controllers, locomotion

Legged robots are useful in tasks such as search and rescue because they can effectively navigate on rugged terrain. However, it is difficult to design controllers for them that would be stable and robust. Learning the control behavior is difficult because optimal behavior is not known, and the search space is too large for reinforcement learning and for straightforward evolution. As a solution, this paper proposes a modular approach for evolving neural network controllers for such robots. The search space is effectively reduced by exploiting symmetry in the robot morphology, and encoding it into network modules. Experiments involving physically realistic simulations of a quadruped robot produce the same symmetric gaits, such as pronk, pace, bound and trot, that are seen in quadruped animals. Moreover, the robot can transition dynamically to more effective gaits when faced with obstacles. The modular approach also scales well when the number of legs or their degrees of freedom are increased. Evolved non-modular controllers, in contrast, produce gaits resembling crippled animals that are much less effective and do not scale up as a result. Hand-designed controllers are also less effective, especially on an obstacle terrain. These results suggest that the modular approach is effective for designing robust locomotion controllers for multilegged robots.

ESEP-1: Best paper nominees

Room: Roswell

Session Chair: Nikolaus Hansen (Evolution Strategies, Evolutionary Programming)

10:40–11:05 ★**Why Noise May be Good**
Silja Meyer-Nieberg, Hans-Georg Beyer

dynamical systems, evolution strategies, self-adaptation, ridge functions, noise

This paper considers self-adaptive (mu/mu_I, lambda)-evolution strategies on the noisy sharp ridge. The evolution strategy (ES) is treated as a dynamical system using the so-called evolution equations to model the ES's behavior. The approach requires the determinationof the one-generational expected changes of the state variables - the progress measures.For the analysis, the stationary state behavior of the ES on the sharp ridge is considered.Contrary to the usual perception of noise, it is shown that noise has a positive influence on the performance. An explanation for this astonishing behavior is given and conditions for the usefulness of noise in other fitness landscapes are discussed.

11:05–11:30 ★**Functionally Specialized CMA-ES: A Modification of CMA-ES based on the Specialization of the Functions of Covariance Matrix Adaptation and Step Size Adaptation**

Youhei Akimoto, Jun Sakuma, Isao Ono, Shigenobu Kobayashi

Evolution Strategy, Functional Specialization, Step Size Adaptation, Covariance Matrix Adaptation

This paper aims the design of efficient and effective optimization algorithms for function optimization. This paper presents a new framework of the derandomized evolution strategy with covariance matrix adaptation (CMA-ES). Recent studies modified the CMA-ES from the viewpoint of covariance matrix adaptation and resulted in drastic reduction of the number of generations. In addition to their modification, this paper modifies the CMA-ES from the viewpoint of step size adaptation. The main idea of modification is semantically specializing functions of covariance matrix adaptation and step size adaptation. This new method is evaluated on 8 classical unimodal and multimodal test functions and the performance is compared with standard CMA-ES. The experimental result demonstrates an improvement of the search performances in particular with large populations. This result is mainly because the proposed Hybrid-SSA instead of the existing CSA can adjust the global step length more appropriately under large populations and function specialization helps appropriate adaptation of the overall variance of the mutation distribution.

11:30–11:55 ★**Aiming for a Theoretically Tractable CSA Variant by Means of Empirical Investigations**

Jens Jägersküpper, Mike Preuss

Empirical Analysis, Evolution Strategies, Sphere Function

Evolution Strategies (ES) for black-box optimization of a function f:R^n->R are investigated. Namely, we consider the cumulative step-size adaptation (CSA) for the variance of multivariate zero-mean normal distributions, which are commonly used to sample new candidate solutions within Evolution Strategies (ES). Four simplifications of CSA are proposed and investigated empirically and evaluated statistically. The background for these four new CSA-derivatives, however, is NOT performance tuning, but our aim to accomplish a probabilistic/theoretical runtime analysis of an ES using some kind of a CSA in the near future, and a better understanding of this step-size control mechanisms. Therefore, we consider two test problems, namely the Sphere function without and with Gaussian noise.

EMO-2: Robustness and Scalability Issues

Room: Peachtree

Session Chair: El-Ghazali Talbi (INRIA)

10:40–11:05 **AMGA: An Archive-based Micro Genetic Algorithm for Multi-objective Optimization**

Santosh Tiwari, Patrick Koch, Georges Fadel, Kalyanmoy Deb

Multi-objective optimization, evolutionary algorithms, micro-

In this paper, we propose a new evolutionary algorithm for multi-objective optimization. The proposed algorithm benefits from the existing literature and borrows several concepts from existing multi-objective optimization algorithms. The proposed algorithm employs a new kind of selection procedure which benefits from the search history of the algorithm and attempts to minimize the number of function evaluations required to achieve the desired convergence. The proposed algorithm works with a very small population size and maintains an archive of best and diverse solutions obtained so as to report a large number of non-dominated solutions at the end of the simulation. Improved formulation for some of the existing diversity preservation techniques is also proposed. Certain implementation aspects that facilitate better performance of the algorithm are discussed. Comprehensive benchmarking and comparison of the proposed algorithm with some of the state-of-the-art multi-objective evolutionary algorithms demonstrate the improved search capability of the proposed algorithm.

11:05–11:30 **Embedded Evolutionary Multi-Objective Optimization for Worst Case Robustness**
Gideon Avigad, Jürgen Branke

Robustness, Multi-objective, Worst-case

In Multi-Objective Problems (MOPs) involving uncertainty, each solution might be associated with a cluster of performances in the objective space depending on the possible scenarios. Therefore, in MOPs, the worst case might not be a single scenario but rather a set of such worst case scenarios, depending on the user preferences. The evolution of solutions based on their related sets of worst case scenarios has been recently introduced. It has been termed: "worst case evolutionary multi-objective optimization." In the current paper the worst case evolutionary multi-objective optimization is further developed. In contrast to the former work where the number of possible scenarios is small and the set of worst cases can thus be easily determined, here, the number of scenarios is assumed to be large, and the worst cases are searched for by means of an embedded evolutionary search. This means that for each nominal solution, a worst set of scenarios has to be found. In the current study, the resulting front, consisting of sets of solutions' worst cases, is formally defined, and a new approach to support decision making based on it, is suggested. The new decision support poses the selection as an auxiliary MOP, highlighting the tradeoff which might result from the worst being a set and not a single point. An academic example and an engineering design problem are given in order to explain the methodology and to demonstrate its applicability to real life problems.

11:30–11:55 **Effectiveness of Scalability Improvement Attempts on the Performance of NSGA-II for Many-Objective Problems**
Hisao Ishibuchi, Noritaka Tsukamoto, Yasuhiro Hitotsuyanagi, Yusuke Nojima

Evolutionary multiobjective optimization, Many-objective optimization, Pareto dominance, Crowding distance, Knapsack problems, Balance between diversity and convergence

Recently a number of approaches have been proposed to improve the scalability of evolutionary multiobjective optimization (EMO) algorithms to many-objective problems. In this paper, we examine the effectiveness of those approaches through computational experiments on multiobjective knapsack problems with two, four, six, and eight objectives. First we briefly review related studies on evolutionary many-objective optimization. Next we explain why Pareto dominance-based EMO algorithms do not work well on many-objective optimization problems. Then we explain various scalability improvement approaches. We examine their effects on the performance of NSGA-II through computational experiments. Experimental results clearly show that the diversity of solutions is decreased by most scalability improvement approaches while the convergence of solutions to the Pareto front is improved. Finally we conclude this paper by pointing out future research directions.

11:55–12:20 **A Robust Evolutionary Framework for Multi-Objective Optimization**
Kalyanmoy Deb

Multi-objective optimization, Functional decomposition, Decision-making, Evolutionary optimization

Evolutionary multi-objective optimization (EMO) methodologies, suggested in the beginning of Nineties, focussed on the task of finding a set of well-converged and well-distributed set of solutions using evolutionary optimization principles. Of the EMO methodologies, the elitist non-dominated sorting genetic algorithm or NSGA-II, suggested in 2000, is now probably the most popularly used EMO procedure. NSGA-II follows three independent principles --domination principle, diversity preservation principle and elite preserving principle -- which make NSGA-II a flexible and robust EMO procedure in the sense of solving various multi-objective optimization problems using a common framework. In this paper, we describe NSGA-II through a functional decomposition following the implementation of these three principles and demonstrate how various multi-objective optimization tasks can be achieved by simply modifying one of the three principles. We argue that such a functionally decomposed and modular implementation of NSGA-II is probably the reason for it's popularity and robustness in solving various types of multi-objective optimization problems.

GP-3: Techniques

Room: Georgia West

Session Chair: Steven Gustafson (GE Global Research)

14:00–14:25 **Accelerating Genetic Programming by Frequent Subtree Mining**
Yoshitaka Kameya, Junichi Kumagai, Yoshiaki Kurata

genetic programming, building blocks, frequent subtree mining, probabilistic model building genetic programming

One crucial issue in genetic programming (GP) is how to acquire promising building blocks efficiently. In this paper, we propose a GP method (called GPTM, GP with Tree Mining) which protects the subtrees repeatedly appearing in superior individuals. Currently GPTM utilizes a FREQT-like efficient data mining method to find such subtrees. GPTM is evaluated by three benchmark problems, and the results indicate that GPTM is comparable to or better than POLE, one of the most advanced probabilistic model building GP methods, and finds the optimal individual earlier than the standard GP and POLE.

14:25–14:50 **Using Differential Evolution for Symbolic Regression and Numerical Constant Creation**
Brian M Cerny, Peter C Nelson, Chi Zhou

Differential Evolution, Constant Creation, Genetic Programming, Genetic Algorithms, Prefix Gene Expression Programming, Gene Expression Programming, Symbolic Regression, Neutral Mutations, Redundant Representations, Optimization, Combinatorial Search

One problem that has plagued Genetic Programming (GP) and its derivatives is numerical constant creation. Given a mathematical formula expressed as a tree structure, the leaf nodes are either variables or constants. Such constants are usually unknown in Symbolic Regression (SR) problems, and GP, as well as many of its derivatives, lack the ability to precisely approximate these values. This is due to the inherently discrete encoding of GP-like methods which are more suited to combinatorial searches than real-valued optimization tasks. Previously, several attempts have been made to resolve this issue, and the dominant solutions have been to either embed a real-valued local optimizer or to develop additional numerically oriented operators. In this paper, an entirely new approach is proposed for constant creation. Through the adoption of a robust, real-valued optimization algorithm known as Differential Evolution (DE), constants and GP-like programs will be simultaneously evolved in such a way that the values of the leaf nodes will be approximated as the tree structure is itself changing. Experimental results from several SR benchmarks are presented and analyzed. The results demonstrate the feasibility of the proposed algorithm and suggest that exotic or computationally expensive methods are not necessary for successful constant creation.

14:50–15:15 **An Analysis of Multi-Sampled Issue and No-Replacement Tournament Selection**
Huayang Xie, Mengjie Zhang, Peter Andreae, Mark Johnson

Tournament Selection, Multi-Sampled Issue, Modelling, Simulation

Standard tournament selection samples individuals with replacement. The sampling-with-replacement strategy has its advantages but also has issues. One of the commonly recognised issues is that it is possible to have the same individual sampled multiple times in a tournament. Although the impact of this multi-sampled issue on genetic programming is not clear, some researchers believe that it may lower the probability of some good individuals being sampled or selected. One solution is to use an alternative tournament selection (no-replacement tournament selection), which samples individuals in a tournament without replacement. This paper analyses no-replacement tournament selection to investigate the impact of the scheme and the importance of the issue. Theoretical simulations show that when common tournament sizes and population sizes are used, no-replacement tournament selection does not make the selection behaviour significantly different from that in the standard one and that the multi-sampled issue seldom occurs. In general, the issue is not crucial to the selection behaviour of standard tournament selection.

15:15–15:40 **Exploiting The Path Of Least Resistance In Evolution**
Gearoid Murphy, Conor Ryan

Genetic Programming, Bloat Control

Hereditary Repulsion (HR) is a selection method coupled with a fitness constraint that substantially improves the performance and consistency of evolutionary algorithms. This also manifests as improved generalisation in the evolved GP expressions. We examine the behaviour of HR on the difficult Parity 5 problem using a population size of only 24 individuals. The negative effects of convergence are amplified under these circumstances and we progress through a series of insights and experiments which dramatically improve the consistency of the algorithm, resulting in a 70% success rate with the same small population. By contrast, a steady state GP system using a population of 5000 only had a success rate of 8%. We then confirm the effectiveness of these results in a number of arbitrary problem domains.

GA-2: GA Theory and Interactive GAs

Room: Georgia East

Session Chair: Xavier Llorà (University of Illinois at Urbana-Champaign)

14:00–14:25 **Theory of the Simple Genetic Algorithm with alpha-Selection**
Andre Neubauer

Genetic algorithm, dynamical system model, random heuristic search, alpha-selection

Genetic algorithms are random heuristic search (RHS) algorithms with a wide range of applications in adaptation and optimisation problems. The most advanced approach for a general theory of genetic algorithms is offered by the dynamical system model which describes the stochastic trajectory of a population under the dynamics of a genetic algorithm with the help of an underlying deterministic heuristic function and its fixed points. However, even for the simple genetic algorithm (SGA) with fitness-proportional selection, crossover and mutation the determination of the population trajectory and the fixed points of the heuristic function is unfeasible for practical problem sizes. In order to simplify the mathematical analysis alpha-selection is introduced in this paper. Based on this selection scheme it is possible to derive the dynamical system model and the fixed points in closed form. Although the heuristic function is not compatible with the equivalence relation imposed by schemata in the strict sense a simple coarse-grained system model with a single exogenous parameter is derivable for a given schemata family. In addition to the theoretical analysis experimental results are presented which confirm the theoretical predictions.

14:25–14:50 **Theoretical Analysis of Genetic Algorithms in Noisy Environments based on a Markov Model**
Takehiko Nakama

Evolutionary computation, genetic algorithms, Markov chain analysis, noisy environments, additive noise, multiplicative noise, perturbed fitness functions, convergence

In this study, we take a first step towards theoretically analyzing genetic algorithms (GAs) in noisy environments using Markov chain theory. We explicitly construct a Markov chain that models GAs applied to fitness functions perturbed by either additive or multiplicative noise that takes on finitely many values, and we analyze the chain to investigate the transition and convergence properties of the GAs. For the additive case, our analysis shows that GAs eventually (i.e., as the number of iterations goes to infinity) find at least one globally optimal solution with probability 1. In contrast, GAs may eventually with probability 1 fail to do so in the multiplicative case, and we establish a condition that is both necessary and sufficient for eventually finding a globally optimal solution. In addition, our analysis shows that the chain has a stationary distribution that is also its steady-state distribution. Based on this property, we derive an upper bound for the number of iterations sufficient to ensure with certain probability that a GA has reached the set of globally optimal solutions and continues to include in each subsequent population at least one globally optimal solution whose observed fitness value is greater than that of any suboptimal solution.

14:50–15:15 **Comparing Global and Local Mutations on Bit Strings**
Benjamin Doerr, Thomas Jansen, Christian Klein

Evolutionary Computation, Randomized Local Search, Mutation, Analysis

Evolutionary algorithms operating on bit strings usually employ a global mutation where each bit is flipped independently with some mutation probability. Most often the mutation probability is set fixed in a way that on average exactly one bit is flipped in a mutation. A seemingly very similar concept is a local one realized by an operator that flips exactly one bit chosen uniformly at random. Most known results indicate that the global approach leads to run-times at least as good as the local approach. The draw-back is that the global approach is much harder to analyze. It would therefore be highly useful to derive general principles of when and how results for the local operator extend to the global ones. In this paper, we show that there is little hope for such general principles, even under very favorable conditions. We show that there is a fitness function such that the local operator from each initial search point finds the optimum in small polynomial time, whereas the global operator for almost all initial search points needs a weakly exponential time.

15:15–15:40 **Graph-Theoretic Measure for Active iGAs: Interaction Sizing and Parallel Evaluation Ensemble**
Xavier Llorà, Noriko Imafuji Yasui, David E Goldberg

Active interactive genetic algorithms, graph theory, graph density, modeling user preferences, partial-order graph, graph ensemble.

Since their inception, active interactive genetic algorithms have successfully combat user evaluation fatigue induced by repetitive evaluation. Their success originates on building models of the user preferences based on partial-order graphs to create a numeric synthetic fitness. Active interactive genetic algorithms can easily reduce up to seven times the number of evaluations required from the user by optimizing such a synthetic fitness. However, despite basic understanding of the underlying

mechanisms there is still a lack of principled understanding of what properties make a partial ordering graph a successful model of user preferences. Also, there has been little research conducted about how to integrate together the contributions of different users to successfully capitalize on parallelized evaluation schemes. This paper addresses both issues describing: (1) what properties make a partial-order graph successful and accurate, and (2) how partial-order graphs obtained from different users can be merged meaningfully.

Human- Competitive Results

Room: Atlanta A

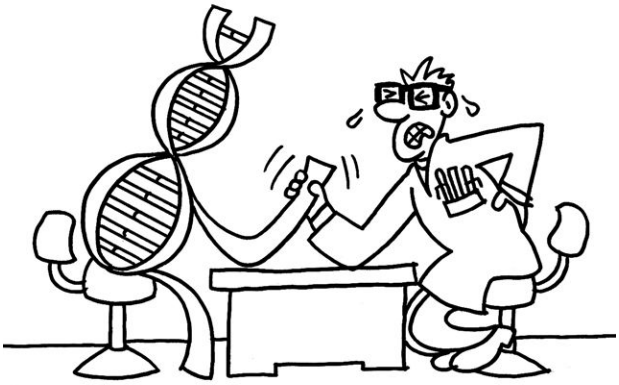
Session Chair: John Koza

14:00–15:40 **HUMIE Presentations**

Prizes Totaling $10,000 to be Awarded

Award prizes are sponsored by Third Millennium On-Line Products Inc.

Techniques of genetic and evolutionary computation are being increasingly applied to difficult real-world problems—often yielding results that are not merely interesting and impressive, but competitive with the work of creative and inventive humans.



Starting at the Genetic and Evolutionary Computation Conference (GECCO) in 2004, prizes were awarded for human-competitive results that had been produced by some form of genetic and evolutionary computation in the previous year.

Humie finalists will give short oral presentations about human-competitive results that they have produced by any form of genetic and evolutionary computation (e.g., genetic algorithms, genetic programming, evolution strategies, evolutionary programming, learning classifier systems, grammatical evolution, etc.).

Cash prizes of $5,000 (gold), $3,000 (silver), and bronze (either one prize of $2,000 or two prizes of $1,000) will be awarded for the best entries that satisfy the criteria for human-competitiveness.

The 2008 judging committee includes:

Wolfgang Banzhaf (Editor-in-Chief of Genetic Programming and Evolvable Hardware journal)
Darrell Whitley (Colorado State University)
Erik Goodman (Chair of SIGEVO)
Riccardo Poli (GECCO-2004 Chair)
John R. Koza (Vice Chair of SIGEVO)

Awards will be presented during Wednesday's plenary session, 8:30-10:10, in the Georgia Ballroom

RWA-3: Optimization I

Room: Atlanta B

Session Chair:

14:00–14:25 **The Gene Regulatory Network: An Application to Optimal Coverage in Sensor Networks**

Sanjoy Das, Praveen Koduru, Xinye Cai, Stephen Welch, Venkatesh Sarangan

Gene regulatory networks, sensors, heuristics

This paper proposes a new approach for biologically inspired computing on the basis of Gene Regulatory Networks. These networks are models of genes and dynamic interactions that take place between them. The differential equation representations of such networks resemble neural networks as well as idiotypic networks in immune system. Although several potential

applications have been outlined, an example, the problem of placing sensors optimally in a distributed environment is considered in detail. A comparison with NSGA-II suggest that the new method is able to accomplish near-optimal coverage of sensors in a network.

14:25–14:50 **Analysis of Multi-Objective Evolutionary Algorithms to Optimize Dynamic Data Types in Embedded Systems**
J. Ignacio Hidalgo, José L. Risco-Martín, David Atienza, Juan Lanchares

Multi-Objective Optimization, Pareto Optimal Front, Evolutionary Computation, Embedded Systems Design

New multimedia embedded applications are increasingly dynamic, and rely on Dynamically-allocated Data Types (DDTs) to store their data. The optimization of DDTs for each target embedded system is a time-consuming process due to the large design space of possible DDTs implementations. Thus, suitable exploration methods for embedded design metrics (memory accesses, memory usage and power consumption) need to be developed. In this work we present a detailed analysis of the characteristics of different types of Multi-Objective Evolutionary Algorithms (MOEAs) to tackle the optimization of DDTs in multimedia applications and compare them with other state-of-the-art heuristics. Our results with state-of-the-art MOEAs in two object-oriented multimedia embedded applications show that more sophisticated MOEAs (SPEA2 and NSGA-II) offer better solutions than simple schemes (VEGA). Moreover, the suitable sophisticated scheme varies according to the available exploration time, namely, NSGA-II outperforms SPEA2 in the first set of solutions (300-500 generations), while SPEA2 offers better solutions afterwards.

14:50–15:15 **Efficiency Optimization of a Multi-Pump Booster System**
Gerulf K. M. Pedersen, Zhenyu Yang

Pump optimization, Parallel pumps, Multi-objective optimization, NSGA-II

This paper discusses a way to optimize the speed settings for a multi-pump system such that it can operate with highest efficiency. A short description of an actual multi-pump system is given and the mathematical formulas for single pump and multi-pump systems are presented. Then a set of objectives are formulated which, when used in a Matlab toolbox implementation of NSGA-II, describe the most efficient distribution of speeds amongst the pumps in the system. The system is tested for a number of pressure references with good results.

15:15–15:40 **An Evolutionary Design Technique for Collective Communications on Optimal Diameter-Degree Networks**
Jiri Jaros, Vaclav Dvorak

Collective communications, Communication scheduling, Evolutionary design, Interconnection networks

Scheduling collective communications (CC) in networks based on optimal graphs and digraphs has been done with the use of the evolutionary techniques. Inter-node communication patterns scheduled in the minimum number of time slots have been obtained. Numerical values of communication times derived for illustration can be used to estimate speedup of typical applications that use CC frequently. The results show that evolutionary techniques often lead to ultimate scheduling of CC that reaches theoretical bounds on the number of steps. Analysis of fault tolerance by the same techniques revealed graceful CC performance degradation for a single link fault. Once the faulty link is located, CC can be re-scheduled during a recovery period.

Evolutionary Computation in Practice-2

Room: Atlanta D

Session Chair: David Davis

14:00–15:40 **EC in Logistics and Supply Chain Management**
Chris Turner, Andreas Trautmann, David Davis

ALIFE-2: Evolutionary Robotics

Room: Buckhead

Session Chair:

14:00–14:25 **Co-evolution of Active Sensing and Locomotion Gaits ofSimulated Snake-like Robot**

Ivan Tanev, Katsunori Shimohara

genetic programming, locomotion, Snakebot, active sensing, navigation

We propose an approach of automated co-evolution of the optimal values of attributes of active sensing (orientation, range and timing of activation of sensors) and the control of locomotion gaits of simulated snake-like robot (Snakebot) that result in a fast speed of locomotion in a confined environment. The experimental results illustrate the emergence of a contactless wall-following navigation of fast sidewinding Snakebots. The wall-following is accomplished by means of differential steering, facilitated by the evolutionary defined control sequences incorporating the readings of evolutionary optimized sensors.

14:25–14:50 **Neuro-Evolution for a Gathering and Collective Construction Task**

G.S. Nitschke, D.W.F van Krevelen

specialization, neuro-evolution, Collective Behavior

In this paper we apply three Neuro-Evolution (NE) methods as controller design approaches in a collective behavior task. These NE methods are Enforced Sub-Populations, Multi- Agent Enforced Sub-Populations, and Collective Neuro- Evolution. In the collective behavior task, teams of simulated robots search an unexplored area for objects that are to be used in a collective construction task. Results indicate that the Collective Neuro-Evolution method, a cooperative co-evolutionary approach that allows for regulated recombination between genotype populations is appropriate for deriving artificial neural network controllers in a set of increasingly difficult collective behavior task scenarios.

14:50–15:15 **Evolving Cooperative Control on Sparsely Distributed Tasks for UAV Teams Without Global Communication**

Gregory J Barlow, Choong K Oh, Stephen F Smith

Evolutionary robotics, Genetic programming, Multi-agent systems, Multi-objective optimization

For some tasks, the use of more than one robot may improve the speed, reliability, or flexibility of completion, but many other tasks can be completed only by multiple robots. This paper investigates controller design using multi-objective genetic programming for a multi-robot system to solve a highly constrained problem, where multiple unmanned aerial vehicles (UAVs) must monitor targets spread sparsely throughout a large area. UAVs have a small communication range, sensor information is limited and noisy, monitoring a target takes an indefinite amount of time, and evolved controllers must continue to perform well even as the number of UAVs and targets changes. An evolved task selection controller dynamically chooses a target for the UAV based on sensor information and communication. Controllers evolved using several communication schemes were compared in simulation on problem scenarios of varying size, and the results suggest that this approach can evolve effective controllers if communication is limited to the nearest other UAV.

EDA-1: Best paper nominees

Room: Lenox

Session Chair: Martin Pelikan (University of Missouri in St. Louis)

14:00–14:25 ★**Using Previous Models to Bias Structural Learning in the Hierarchical BOA**

Mark W Hauschild, Martin Pelikan, Kumara Sastry, David E. Goldberg

Hierarchical BOA, probabilistic model, model complexity, learning from experience, prior knowledge, estimation of distribution algorithms

Estimation of distribution algorithms (EDAs) are stochastic optimization techniques that explore the space of potential solutions by building and sampling probabilistic models of promising candidate solutions. While the primary goal of applying EDAs is to discover the global optimum (or an accurate approximation), any EDA also provides us with a sequence of probabilistic models, which hold a great deal of information about the problem. Although using problem-specific knowledge has been shown to significantly improve performance of EDAs and other evolutionary algorithms, this readily available source of information has been largely ignored by the EDA community. This paper takes the first step towards the use of probabilistic models obtained by

EDAs to speed up the solution of similar problems in the future. More specifically, we propose two approaches to biasing model building in the hierarchical Bayesian optimization algorithm (hBOA) based on knowledge automatically learned from previous runs on similar problems. We show that the methods lead to substantial speedups and argue that they should work well in other applications that require solving a large number of problems with similar structure.

14:25–14:50 ★**On the Effectiveness of Distributions Estimated by Probabilistic Model Building**
Chung-Yao Chuang, Ying-ping Chen

effective distribution, sensible linkage, model pruning, estimation of distribution algorithms, EDAs, extended compact genetic algorithm, ECGA, evolutionary computation

Estimation of distribution algorithms (EDAs) are a class of evolutionary algorithms that capture the likely structure of promising solutions by explicitly building a probabilistic model and utilize the built model to guide the further search. It is presumed that EDAs can detect the structure of the problem by recognizing the regularities of the promising solutions. However, in certain situations, EDAs are unable to discover the entire structure of the problem because the set of promising solutions on which the model is built contains insufficient information regrading some parts of the problem and renders EDAs incapable of processing those parts accurately. In this work, we firstly propose a general concept that the estimated probabilistic models should be inspected to reveal the effective search directions. Based on that concept, we design a practical approach which utilizes a reserved set of solutions to examine the built model for the fragments that may be inconsistent with the actual problem structure. Furthermore, we provide an implementation of the designed approach on the extended compact genetic algorithm (ECGA) and conduct numerical experiments. The experimental results indicate that the proposed method can significantly assist ECGA to handle problems comprising building blocks of disparate scalings.

14:50–15:15 ★**From Mating Pool Distributions to Model Overfitting**
Claudio F Lima, Fernando G Lobo, Martin Pelikan

Bayesian networks, Bayesian optimization algorithm, estimation of distribution algorithms, overfitting, selection

This paper addresses selection as a source of overfitting in

Bayesian estimation of distribution algorithms (EDAs). The purpose of the paper is twofold. First, it shows how the selection operator can lead to model overfitting in the Bayesian optimization algorithm (BOA). Second, the metric score that guides the search for an adequate model structure is modified to take into account the non-uniform distribution of the mating pool generated by tournament selection.

ACO-2: Ant Colony Optimization
Room: Roswell
Session Chair:

14:00–14:25 **Scaling Ant Colony Optimization with Hierarchical Reinforcement Learning Partitioning**
Erik J. Dries, Gilbert L. Peterson

Ant Colony Optimization, Hierarchical Reinforcement Learning, Swarm Intelligence

This paper merges hierarchical reinforcement learning (HRL) with ant colony optimization (ACO) to produce a HRL ACO algorithm capable of generating solutions for large domains. This paper describes two specific implementations of the new algorithm: the first a modification to Dietterich's MAXQ-Q HRL algorithm, the second a hierarchical ant colony system algorithm. These implementations generate faster results, with little to no significant change in the quality of solutions for the tested problem domains. The application of ACO to the MAXQ-Q algorithm replaces the reinforcement learning, Q-learning, with the modified ant colony optimization method, Ant-Q. This algorithm, MAXQ-AntQ, converges to solutions not significantly different from MAXQ-Q in 88\% of the time. This paper then transfers HRL techniques to the ACO domain and traveling salesman problem (TSP). To apply HRL to ACO, a hierarchy must be created for the TSP. A data clustering algorithm creates these subtasks, with an ACO algorithm to solve the individual and complete problems. This paper tests two clustering algorithms, k-means and G-means. The results demonstrate the algorithm with data clustering produces solutions 20 times faster with 5-10% decrease in solution quality due to the effects of clustering.

14:25–14:50 **Enhanced Generalized Ant Programming (EGAP)**
Amirali Salehi-Abari, Tony White

Automatic Programming, Ant Programming, Heuristic, Generalized Ant Programming, Enhanced Generalized Ant Programming

This paper begins by reviewing different methods of automatic programming while emphasizing the technique of Ant Programming (AP). AP uses an ant foraging metaphor in which ants generate a program by moving through a graph. Generalized Ant Programming (GAP) uses a context-free grammar and an Ant Colony System (ACS) to guide the program generation search process. There are two enhancements to GAP that are proposed in this paper. These are: providing a heuristic for path termination inspired by building construction and a novel pheromone placement algorithm. Three well-known problems -- Quartic symbolic regression, multiplexer, and an ant trail problem -- are experimentally compared using enhanced GAP (EGAP) and GAP. The results of the experiments show the statistically significant advantage of using this heuristic function and pheromone placement algorithm of EGAP over GAP.

14:50–15:15 **A Multi-Objective Ant Colony Approach for Pareto-Optimization Using Dynamic Programming**
Sascha Häckel, Marco Fischer, David Zechel, Tobias Teich

Multi-Objective Optimization, Hybridization, Ant Colony Optimization, Dynamic Programming, Shortest-Path Problem, Pareto-Optimization

This paper covers a multi-objective Ant Colony Optimization, which is applied to the NP-complete multi-objective shortest path problem in order to approximate Pareto-fronts. The efficient single-objective solvability of the problem is used to improve the results of the ant algorithm significantly. A dynamic program is developed which generates local heuristic values on the edges of the problem graph. These heuristic values are used by the artificial ants.

15:15–15:40 **Multivariate Ant Colony Optimization in Continuous Search Spaces**
Fabricio Olivetti de Franca, Guilherme Palermo Coelho, Romis R. de Faissol Attux, Fernando J. Von Zuben

Ant Colony Optimization, Continuous Optimization, Multivariate Normal Distribution

This work introduces an ant-inspired algorithm for optimization in continuous search spaces that is based on the generation of random vectors with multivariate Gaussian pdf. The proposed approach is called MACACO -- Multivariate Ant Colony Algorithm for Continuous Optimization -- and is able to simultaneously adapt all the dimensions of the random distribution employed to generate the new individuals at each iteration. In order to analyze MACACO's search efficiency, the approach was compared to a pair of counterparts: the Continuous Ant Colony System (CACS) and the approach known as Ant Colony Optimization in Re^n (ACO$_R). The comparative analysis, which involves well-known benchmark problems from the literature, has indicated that MACACO outperforms CACS and ACO_R in most cases as the quality of the final solution is concerned, and it is just about two times more costly than the least expensive contender.

GDS-1: Best Paper Nominees

Room: Peachtree

Session Chair: R. Paul Wiegand (Institute for Simulation and Training / UCF)

14:00–14:25 ★**Generative Encoding for Multiagent Learning**
David B. D'Ambrosio, Kenneth O. Stanley

Neural Networks, CPPNs, NEAT, HyperNEAT, Multiagent Systems

This paper argues that multiagent learning is a potential "killer application" for generative and developmental systems (GDS) because key challenges in learning to coordinate a team of agents are naturally addressed through indirect encodings and information reuse. For example, a significant problem for multiagent learning is that policies learned separately for different agent roles may nevertheless need to share a basic skill set, forcing the learning algorithm to reinvent the wheel for each agent. GDS is a good match for this kind of problem because it specializes in ways to encode patterns of related yet varying motifs. In this paper, to establish the promise of this capability, the Hypercube-based NeuroEvolution of Augmenting Topologies (HyperNEAT) generative approach to evolving neurocontrollers learns a set of coordinated policies encoded by a single genome representing a team of predator agents that work together to capture prey. Experimental results show that it is not only possible, but beneficial to encode a heterogeneous team of agents with an indirect encoding. The main contribution is thus to open up a significant new application domain for GDS.

14:25–14:50 ★**A Cellular Model for the Evolutionary Development of Lightweight Material with an Inner Structure**
Till Steiner, Yaochu Jin, Bernhard Sendhoff

artificial development, cell growth, multi-objective optimization, finite element stress analysis, inner structure, structural stability, structure optimization

We present a model of simulated evolutionary development on the basis of cells as building blocks for growth. In this model, cells grow and interact in a three-dimensional (3D) environment, where development is controlled by a simple genome. Using cell-cell interaction such as differential adhesion, cells sort and form complex arrangements. This developmental process is evolved using a multi-objective evolutionary algorithm to achieve lightweight and stable material with a complex inner structure.

GP-1: Best paper nominees
Room: Georgia West
Session Chair: Julian F. Miller (University of York)

16:10–16:35 ★**Parsimony Pressure Made Easyød:**
Riccardo Poli, Nicholas Freitag McPhee

Genetic Programming, Bloat, Parsimony pressure

The parsimony pressure method is perhaps the simplest and most frequently used method to control bloat in genetic programming. In this paper we first reconsider the size evolution equation for genetic programming developed in [26] and rewrite it in a form that shows its direct relationship to Price's theorem. We then use this new formulation to derive theoretical results that show how to practically and optimally set the parsimony coefficient dynamically during a run so as to achieve complete control over the growth of the programs in a population. Experimental results con rm the effectiveness of the method, as we are able to tightly control the average program size under a variety of conditions. These include such unusual cases as dynamically varying target sizes such that the mean program size is allowed to grow during some phases of a run, while being forced to shrink in others.

16:35–17:00 ★**The Impact of Population Size on Code Growth in GP:Analysis and Empirical Validation**
Riccardo Poli, Nicholas Freitag McPhee, Leonardo Vanneschi

Genetic Programming, Bloat, Population size

The crossover bias theory for bloat is a recent result which predicts that bloat is caused by the sampling of short, unfit programs. This theory is clear and simple, but it has some weaknesses: (1) it implicitly assumes that the population is large enough to allow sampling of all relevant program sizes (although it does explain what to expect in the many practical cases where this is not true, e.g., because the population is small); (2) it does not explain what is meant by its assumption that short programs are unfit. In this paper we discuss these weaknesses and propose a refined version of the crossover bias theory that clarifies the relationship between bloat and finite populations, and explains what features of the fitness landscape cause bloat to occur. The theory, in particular, predicts that smaller populations will bloat more slowly than larger ones. Additionally, the theory predicts that bloat will only be observed in problems where short programs are less fit than longer ones when looking at samples created by fitness-based importance sampling, i.e. samplings of the search space in which fitter programs have a higher probability of being sampled (e.g., the Metropolis-Hastings method). Experiments with two classical GP benchmarks fully corroborate the theory.

17:00–17:25 ★**Rapid Prediction of Optimum Population Size in Genetic Programming Using a Novel Genotype - Fitness Correlation**
David C Wedge, Douglas B Kell

landscape, real-world, genotype-fitness correlation, control parameters

The main aim of landscape analysis has been to quantify the hardness of problems. Early steps have been made towards extending this into Genetic Programming. However, few attempts have been made to extend the use of landscape analysis into the prediction of ways to make a problem easy, through the optimal setting of control parameters. This paper introduces a

new class of landscape metrics, which we call Genotype-Fitness Correlations . An example of this family of metrics is applied to six real-world regression problems. It is demonstrated that genotype-fitness correlations may be used to estimate optimum population sizes for the six problems. We believe that this application of a landscape metric as guidance in the setting of control parameters is an important step towards the development of an adaptive algorithm that can respond to the perceived landscape in real-time , i.e. during the evolutionary search process itself.

17:25–17:50 ★**Learning to Recognise Mental Activities: Genetic Programming of Stateful Classifiers for Brain-Computer Interfacing**
Alexandros Agapitos, Matthew Dyson, Simon M Lucas, Francisco Sepulveda

Brain Computer Interface, Classification on Raw Signal, Stateful Representation, Statistical Signal Primitives

Two families (stateful and stateless) of genetically programmed classifiers were tested on a five class brain-computer interface (BCI) data set of raw EEG signals. The ability of evolved classifiers to discriminate mental tasks from each other were analysed in terms of accuracy, precision and recall. A model describing the dynamics of state usage in stateful programs is introduced. An investigation of relationships between the model attributes and associated classification results was made. The results show that both stateful and stateless programs can be successfully evolved for this task, though stateful programs start from lower fitness and take longer to evolve.

GA-3: Parallel GAs, Performance Analysis and NK Landscapes
Room: Georgia East
Session Chair: Kumara Sastry (Intel Corp)

16:10–16:35 **Empirical Investigations on Parallel Competent Genetic Algorithms**
Miwako Tsuji, Masaharu Munetomo, Kiyoshi Akama

Linkage, Parallelization

This paper empirically investigates parallel competent genetic algorithms (cGAs). cGAs, such as BOA , LINC-GA, D5-GA, can solve GA-difficult problems by automatically learning problem structure as gene linkage. Parallel implementation of cGAs can reduce computational cost due to the linkage learning and give us problem solving environments for a wide spectrum of real-world problems. Although some parallel cGAs have been proposed, the effect of the parallelizations has not been investigated enough. This paper empirically discusses the applicability and property of parallel cGAs, including a new parallel cGA, parallel D5-GA.

16:35–17:00 **Voronoi-Initializated Island Models for Solving Real-Coded Deceptive Problems**
Santiago Muelas, José M Peña, Víctor Robles, Antonio LaTorre

Parallel Genetic Algorithms, Voronoi Initialization, Migration Topology, Deceptive Problems

Deceptive problems have always been considered difficult for Genetic Algorithms. To cope with this characteristic, the literature has proposed the use of Parallel Genetic Algorithms (PGAs), particularly multi-population island-based models. Although the existence of multiple populations encourages population diversity, these problems are still difficult to solve. This paper introduces a new initialization mechanism for each of the populations of the islands based on Voronoi cells. In order to analyze the results, a series of different experiments using several real-value deceptive problems and a set of representative parameters (migration ratio, migration frequency and connectivity) have been chosen. The results obtained suggest that the Voronoi initialization method improves considerably the performance obtained with a traditionally uniform random initialization.

17:00–17:25 **An Enhanced Statistical Approach for Evolutionary Algorithm Comparison**
Eduardo G. Carrano, Elizabeth F. Wanner, Ricardo H.C. Takahashi

evolutionary encoding schemes, algorithm comparison, evolutionary algorithm, tree network design

This paper presents an enhanced approach for comparing evolutionary algorithm. This approach is based on three statistical techniques: (a) Principal Component Analysis, which is used to make the data uncorrelated; (b) Bootstrapping, which is employed to build the probability distribution function of the merit functions; and (c) Stochastic Dominance Analysis, that is employed to make possible the comparison between two or more probability distribution functions. Since the approach proposed here is not based on parametric properties, it can be applied to compare any kind of quantity, regardless the probability distribution function. The results achieved by the proposed approach have provided more supported decisions than former approaches, when applied to the same problems.

17:25–17:50 **Analysis of Estimation of Distribution Algorithms and Genetic Algorithms on NK Landscapes**
Martin Pelikan

NK fitness landscape, hierarchical BOA, genetic algorithm, branch and bound, performance analysis, scalability, local search, crossover

This study analyzes performance of several genetic and evolutionary algorithms on randomly generated NK fitness landscapes with various values of n and k. A large number of NK problem instances are first generated for each n and k, and the global optimum of each instance is obtained using the branch-and-bound algorithm. Next, the hierarchical Bayesian optimization algorithm (hBOA), the univariate marginal distribution algorithm (UMDA), and the simple genetic algorithm (GA) with uniform and two-point crossover operators are applied to all generated instances. Performance of all algorithms is then analyzed and compared, and the results are discussed.

BIO-3: Invited Speakers
Room: Atlanta A
Session Chair:

16:10–17:50 **Invited speakers, discussion**

RWA-4: Optimization II
Room: Atlanta B
Session Chair:

16:10–16:35 **Optimizing Hierarchical Menus by Genetic Algorithm and Simulated Annealing**
Shouichi Matsui, Seiji Yamada

Hierarchical menu, optimization, genetic algorithm, simulated annealing.

Hierarchical menus are now ubiquitous. The performance of the menu depends on many factors: structure, layout, colors and so on. There has been extensive research on novel menus, but there has been little work on improving performance by optimizing the menu's structure. This paper proposes algorithms based on the genetic algorithm (GA) and the simulated annealing (SA) for optimizing the performance of menus. The algorithms aim to minimize the average selection time of menu items by considering the user's pointer movement and search/decision time. We will show the experimental results on a static hierarchical menu of a cellular phone as an example where a small screen and limited input device are assumed. We will also show performance comparison of the GA-based algorithm and the SA-based one by using wide varieties of usage patterns.

16:35–17:00 **Estimation of Pump-Curves using Genetic Algorithms**
Gerulf K. M. Pedersen, Zhenyu Yang

Pump curves, Parameter estimation, Curve fitting, Simple Genetic Algorithm

This paper presents a variety of different ways of estimating the general parameters for pump-curves. First a formulation is made that converts the problem into estimating four parameters in this general formulation. Then three different methods that utilize the general formulation are presented. The estimated parameters for each method are used in generating the desired pump-curves, and the quality of the estimates are determined. The paper finishes with a recommendation that, for estimation of the generalized parameters, the method utilizing speed differences is preferable over the other methods discussed in the paper.

17:00–17:25 **Evolutionary Algorithms for Automated Drug Design towards Target Molecule Properties**
Johannes W. Kruisselbrink, Thomas Bäck, Ad P. IJzerman, Eelke van der Horst

Evolutionary algorithms, molecules, drug design

This paper presents an evolutionary algorithm for the automated design of molecules that could be used as drugs. It is designed to provide the medicinal chemist with a number of candidate molecules that comply to pre-defined properties. These candidate molecules can be promising for further evaluation. The proposed algorithm is implemented as an extension to the so-called Molecule Evoluator [3] which implements an interactive evolutionary algorithm. The Molecule Evoluator is extended with an automated evolutionary algorithm that implements a variable sized population and bases its search on target-bounds that are set for a number of molecule properties. Moreover, the algorithm uses a selection procedure based on the notion of Pareto domination. The results show that it is indeed possible to apply the concept of evolutionary computation on automated molecule design using target-bounds for molecule properties as optimization goals. For practical usage, the presented algorithm could serve as a starting point, but should be further improved with respect to diversity within the generated set of molecules.

17:25–17:50 **Discovering Performance Bounds for Grid Scheduling by using Evolutionary Multiobjective Optimization**
Christian Grimme, Joachim Lepping, Alexander Papaspyrou

Multi-Objective Optimization, Scheduling, Grid Computing

In this paper, we introduce a methodology for the approximation of optimal solutions for a resource allocation problem in the domain of Grid scheduling on High Performance Computing systems. In detail, we review a real-world scenario with decentralized, equitable, and autonomously acting suppliers of compute power who wish to collaborate in the provision of their resources. We exemplarily apply NSGA-II in order to explore the bounds of maximum achievable benefit. To this end, appropriate encoding schemes and variation operators are developed while the performance is evaluated. The simulations are based upon recordings from real-world Massively Parallel Processing systems that span a period of eleven months and comprise approximately 100,000 jobs. By means of the obtained Pareto front we are able to identify bounds for the maximum benefit of Grid computing in a popular scenario. For the first time, this enables Grid scheduling researchers to rank their developed real-world strategies.

COEVOLUTION
Room: Atlanta D
Session Chair:

16:10–16:35 **★An Empirical Comparison of Evolution and Coevolution for Designing Artificial Neural Network Game Players**
Min Shi

Neuroevolution, Neurocoevolution, NE, NEAT, ESP, SANE, EEC, TTT, Gobang

In this paper, we compare two neuroevolutionary algorithms, namely standard NeuroEvolution (NE) and NeuroEvolution of Augmenting Topologies (NEAT), with three neurocoevolutionary algorithms, namely Symbiotic Adaptive Neuro-Evolution (SANE), Enforced Sub-Populations (ESP) and Evolving Efficient Connections (EEC). EEC is a novel neurocoevolutionary algorithm that we propose in this work, where the connection weights and the connection paths of networks are evolved separately. All these methods are applied to evolve players of two different board games. The results of this study indicate that neurocoevolutionary algorithms outperform neuroevolutionary algorithms for both domains. Our new method, especially, demonstrates that fully connected networks could generate noise which results in inefficient learning. The performance of standard NE model has been improved significantly through evolving connection weights and efficient connection paths in parallel in our method.

16:35–17:00 **Managing Team-Based Problem Solving with Symbiotic Bid-Based Genetic Programming**
P. Lichodzijewski, M. I. Heywood

Genetic Programming, supervised learning, classification, coevolution, active learning, efficiency, problem decomposition, teaming

Bid-based Genetic Programming (GP) provides an elegant mechanism for facilitating cooperative problem decomposition without an a priori specification of the number of team members. This is in contrast to existing teaming approaches where individuals learn a direct input-output map (e.g., from exemplars to class labels), allowing the approach to scale to problems with multiple outcomes (classes), while at the same time providing a mechanism for choosing an outcome from those suggested by team members. This paper proposes a symbiotic relationship that continues to support the cooperative bid-based process for

problem decomposition while making the credit assignment process much clearer. Specifically, team membership is defined by a team population indexing combinations of GP individuals in a separate team member population. A Pareto-based competitive coevolutionary component enables the approach to scale to large problems by evolving informative test points in a third population. The ensuing Symbiotic Bid-Based (SBB) model is evaluated on three large classification problems and compared to the XCS learning classifier system (LCS) formulation and to the support vector machine (SVM) implementation LIBSVM. On two of the three problems investigated the overall accuracy of the SBB classifiers was found to be competitive with the XCS and SVM results. At the same time, on all problems, the SBB classifiers were able to detect instances of all classes whereas the XCS and SVM models often ignored exemplars of minor classes. Moreover, this was achieved with a level of model complexity significantly lower than that identified by the SVM and XCS solutions.

17:00–17:25 **A No-Free-Lunch Framework for Coevolution**
Travis Service, Daniel Tauritz

No Free Lunch, Coevolution, Solution Concept

The No-Free-Lunch theorem is a fundamental result in the field of black-box function optimization. Recent work has shown that coevolution can exhibit free lunches. The question as to which classes of coevolution exhibit free lunches is still open. In this paper we present a novel framework for analyzing No-Free-Lunch like results for classes of coevolutionary algorithms. Our framework has the advantage of analyzing No-Free-Lunch like inquiries in terms of solution concepts and isomorphisms on the weak preference relation on solution configurations. This allows coevolutionary algorithms to be naturally classified by the type of solution they seek. Using the weak preference relation also permits us to present a simpler definition of performance metrics than that used in previous coevolutionary No-Free-Lunch work, more akin to the definition used in the original No-Free-Lunch theorem. The framework presented in this paper can be viewed as the combination of the ideas and definitions from two separate theoretical frameworks for analyzing search algorithms and coevolution consistent with the terminology of both. We also present a new instance of free lunches in coevolution which demonstrates the applicability of our framework to analyzing coevolutionary algorithms based upon the solution concept which they implement.

17:25–17:50 **Fitnessless Coevolution**
Wojciech Jaskowski, Krzysztof Krawiec, Bartosz Wieloch

Games, Selection methods, One-population coevolution

We introduce fitnessless coevolution (FC), a novel method of comparative one-population coevolution. FC plays games between individuals to settle tournaments in the selection phase and skips the typical phase of evaluation. The selection operator applies a single-elimination tournament to a randomly drawn group of individuals, and the winner of the final round becomes the result of selection. Therefore, FC does not involve explicit fitness measure. We prove that, under a condition of transitivity of the payoff matrix, the dynamics of FC is identical to that of the traditional evolutionary algorithm. The experimental results, obtained on a diversified group of problems, demonstrate that FC is able to produce solutions that are equally good or better than solutions obtained using fitness-based one-population coevolution with different selection methods.

ALIFE-3: Multi-Agent Systems
Room: Buckhead
Session Chair:

16:10–16:35 **Individual-Based Artificial Ecosystems for Design and Optimization**
Srinivasa Shivakar Vulli, Sanjeev Agarwal

Individual-based modeling, optimization, markov random fields, parameter estimation, artificial ecosystems

Individual-based modeling has gained popularity over the last decade, mainly due to its proven ability to address a variety of problems, including modeling complex systems from bottom-up, providing relationships between component level and system level parameters, and relating emergent system level behaviors from simple component level interactions. Availability of computational power to run simulation models with thousands to millions of agents is another driving force in the wide-spread adoption of individual-based modeling. In this paper, we propose an individual-based modeling approach to solve engineering design and optimization problems using artificial ecosystems (AES). The problem to be solved is "mapped" to an appropriate AES consisting of an environment and one or more evolving species. The AES is then allowed to evolve. The optimal solution emerges through the interactions of individuals amongst themselves and their environment. The fitness function or selection mechanism is internal to the ecosystem and is based on the interactions between individuals, which makes the proposed approach attractive for design and optimization in complex systems, where formulation of a global fitness function is often complicated. The efficacy of the proposed approach is demonstrated using the problem of parameter estimation for binary texture synthesis.

16:35–17:00 **Multi-Agent Task Allocation: Learning When to Say No**
Adam Campbell, Annie S. Wu, Randall Shumaker

multi-agent systems, task allocation, adaptive systems

This paper presents a communication-less multi-agent task allocation procedure that allows agents to use past experience to make non-greedy decisions about task assignments. Experimental results are given for problems where agents have varying capabilities, tasks have varying difficulties, and agents are ignorant of what tasks they will see in the future. These types of problems are difficult because the choice an agent makes in the present will affect the decisions it can make in the future. Current task-allocation procedures, especially the market-based ones, tend to side-step the issue by ignoring the future and assigning tasks to agents in a greedy way so that short-term goals are met. It is shown here that these short-sighted allocation procedures work well in situations where the ratio of task length to team size is small, but their performance decreases as this ratio increases. The adaptive method presented here is shown to perform well in a wide range of task-allocation problems, and because it requires no explicit communication, its computational costs are independent of team size.

17:00–17:25 **Selection for Group-Level Efficiency Leads to Self-Regulation of Population Size**
Benjamin E Beckmann, Philip K McKinley, Charles Ofria

Artificial life, digital evolution, self-regulation, multi-agent systems, selection, cooperative behavior

In general, a population will grow until a limiting factor, such as resource availability, is reached. However, increased task efficiency can also regulate the size of a population during task development. Through the use of digital evolution, we demonstrate that the evolution of a group-level task, requiring a small number of individuals, can cause a population to self-regulate its size, even in the presence of abundant energy. We also show that as little as a 1% transfer of energy from a parent group to its offspring produces significantly better results than no energy transfer. A potential application of this result is the configuration and management of real-world distributed agent-based systems.

17:25–17:50 **Modeling Ant Colony Foraging in Dynamic and Confined Environment**
Elton Bernardo Bandeira de Melo, Aluízio Fausto Ribeiro Araújo

Artificial Life, Ant Foraging Model

The collective foraging behavior of ants is an example of self-organization and

adaptation arising from the superposition of simple individual behavior. With the objective of understanding and modeling such interactions, experiments with the Argentine ants Linepithema humile were conducted into a relatively complex, artificial network. This consisted of interconnected branches and bifurcations, where the ants have to choose among fourteen different paths in order to reach a food source, and the branches can be blocked or unblocked at any time. Due mainly to stagnation problems, previous models did not accurately reproduce the behavior of ants in a changing environment. In this paper, a new model (ACF-DCM) is proposed, based on ACO principles and biological studies of insects. ACF-DCM succeeded in reproducing the behavior of ants in a confined and dynamic environment.

EDA-3: Multimodal and Dynamic Optimization

Room: Lenox

Session Chair: Claudio M F Lima (University of Algarve)

16:10–16:35 **UMDAs for Dynamic Optimization Problems**
Carlos M. Fernandes, Cláudio Lima, Agostinho C. Rosa

UMDA

This paper investigates how the Univariate Marginal Distribution Algorithm (UMDA) behaves in non-stationary environments when engaging in sampling and selection strategies designed to correct diversity loss. Although their performance when solving Dynamic Optimization Problems (DOP) is less studied than population-based Evolutionary Algorithms, UMDA and other Estimation of Distribution Algorithms may follow similar schemes when tracking moving optima: genetic diversity maintenance, memory schemes, niching methods, and even reinicialization of the probability vectors. This study is focused on diversity maintenance schemes. A new update strategy for UMDA s probability model, based on Ant Colony Optimization transition probability equations, is presented and empirically compared with other strategies recently published that aim to correct diversity loss in UMDA. Results demonstrate that loss correction strategies delay or avoid full convergence, thus increasing UMDA s adaptability to changing environments. However, the strategy proposed in this paper achieves a higher performance on the DOP test set when compared with other methods. In addition, the new strategy incorporates two parameters that control the diversity of the probability model.

16:35–17:00 **Investigating Restricted Tournament Replacement in ECGA for Non-Stationary Environments**
Claudio F Lima, Carlos Fernandes, Fernando G Lobo

estimation of distribution algorithms, genetic algorithms, restricted tournament replacement, niching, diversity preservation, non-stationary environments

This paper investigates the incorporation of restricted tournament replacement (RTR) in the extended compact genetic algorithm (ECGA) for solving problems with non-stationary optima. RTR is a simple yet efficient niching method used to maintain diversity in a population of individuals. While the original version of RTR uses Hamming distance to quantify similarity between individuals, we propose an alternative substructural distance to enforce the niches. The ECGA that restarts the search after a change of environment is compared with the approach of maintaining diversity, using both versions of RTR. Results on several dynamic decomposable test problems demonstrate the usefulness of maintaining diversity throughout the run over the approach of restarting the search from scratch at each change. Furthermore, by maintaining diversity no additional mechanisms are required to detect the change of environment, which is typically a problem-dependent and non-trivial task.

17:00–17:25 **Going for the Big Fishes: Discovering and Combining Large Neutral and Massively Multimodal Building-Blocks with Model Based Macro-Mutation**
David Iclanzan, D. Dumitrescu

Model based local-search, adaptive neighborhood structure, scalability, macro-mutation

A major challenge in the field of metaheuristics is to find ways to increase the size of problems that can be addressed reliably. Scalability of probabilistic model building methods, capable to rendering difficult, large problems feasible by identifying dependencies, have been previously explored but investigations had mainly concerned problems where efficient solving is possible with the exploitation of low order dependencies. This is due to the initial-supply population sizing, where the number of samples is lower bounded by the exponential of the order of dependencies covered by the probabilistic model. With an exponentially growing population, the impact of the model building on the overall complexity, can easily exceed the bound for the number of evaluations. In this paper we present a competent methodology, capable of efficiently detecting and combining large modules, even in the case of unfavorable genetic linkage and no intra-block fitness gradient to guide the search or deceptiveness. This is achieved by investing the function evaluations in a model based local-search with strong exploratory power and restricting the model building to a relatively small number of semi-converged samples.

Late Breaking Papers-1
Room: Roswell
Session Chair:

16:10–16:25 **Opportunistic Evolution: Efficient Evolutionary Computation on Large-Scale Computational Grids**
Keith Sullivan, Sean Luke, Curt Larock, Sean Cier, Steven Armentrout

Distributed Evolutionary Computation

We examine opportunistic evolution, a variation of master-slave distributed evaluation designed for deployment of evolutionary computation to very large grid computing architectures with limited communications, severe evaluation overhead, and wide variance in evaluation node speed. In opportunistic evolution, slaves receive some N individuals at a time, evaluate them, and then run those individuals through their own mini evolutionary loop until some fixed wall clock time has been exceeded. Our implementation of opportunistic evolution may be used in conjunction with either a generational or, for maximum throughput, an asynchronous steady-state evolutionary model in the master. Opportunistic evolution is strongly exploitative. We perform initial experiments comparing the technique with a traditional master/slave model, and suggest possible classes of problems for which it might be apropos.

16:25–16:40 **Evolutionary Facial Feature Selection**
Aaron Baughman

Application, Artificial Intelligence, Genetic algorithms, Pattern recognition and classification, Search

With the growing number of acquired physiological and behavioral biometric samples, biometric data sets are experiencing tremendous growth. As database sizes increase, exhaustive identification searches by matching with entire biometric feature sets become computationally unmanageable. An evolutionary facial feature selector chooses a set of features from prior contextual or meta face features that reduces the search space. This paper discusses and shows the results of an evolutionary computing approach with agglomerative k-means cluster spaces as input parameters into a LDA evaluation function to select facial features from the Carnegie Mellon University Pose, Illumination, and Expression database of human faces (PIE).

16:40–16:55 **Attack Analysis & Bio-Inspired Security Framework for IPMultimedia Subsystem**
Aliya Awais, Muddassar Farooq, Muhammad Younus Javed

Artificial Immune Systems, IP Multimedia Subsystem, Network Security

This paper analyzes the security vulnerabilities and requirements of IP Multimedia Subsystem (IMS), particularly the impact of Denial-of-Service (DoS) and Distributed DoS (DDoS)attacks on the IMS. We propose and develop an intelligent Bio-inspired, self-defending security framework for the IMS and Next Generation all-IP Networks. Our proposed framework will complement the existing authentication and encryption mechanisms to protect infrastructure nodes and subscribers against the attacks launched by the malicious nodes in the network. This framework is expected to become a cardinal component which can be integrated into any IMS converged network infrastructure to provide defense against wide variety of attacks particularly DoS and DDoS attacks.

16:55–17:10 **A Fuzzy-Genetic Approach to Network Intrusion Detection**
Terrence P. Fries

Genetic Algorithms, Fuzzy Sets, Security, Intrusion Detection

Computer networks have expanded significantly in use and numbers. This expansion makes them more vulnerable to attack by unwanted agents. Many current intrusion detection systems (IDS) are unable to identify unknown or mutated attack modes or are unable to operate in a dynamic environment as is necessary with mobile networks. As a result, it is necessary to find new ways to implement and operate intrusion detection systems. Genetic-based systems offer to ability to adapt to changing environments, robustness to noise and the ability to identify unknown attack methods. This paper presents a fuzzy-genetic approach to intrusion detection that is shown to increase the performance of an IDS.

17:10–17:25 **Developing Neural Structure of Two Agents that Play Checkers Using Cartesian Genetic Programming**
Gul Muhammad Khan, Julian Francis Miller, David M. Halliday

Cartesian Genetic Programming, Computational Development, Co-evolution, Artificial Neural Networks, Checkers

A developmental model of neural network is presented and evaluated in the game of Checkers. The network is developed using cartesian genetic programs (CGP) as genotypes. Two agents are provided with this network and allowed to co-evolve untill they start playing better. The network that occurs by running theses genetic programs has a highly dynamic morphology in which neurons grow, and die, and neurite branches together with synaptic connections form and change in response to situations encountered on the checkers board. The method has no board evaluation function, no explicit learning rules and no human expertise at playing checkers is used. The results show that, after a number of generations, by playing each other the agents begin to play much better and can easily beat agents that occur in earlier generations. Such learning abilities are encoded at a genetic level rather than at the phenotype level of neural connections.

GDS-2: Generative and Developmental Systems

Room: Peachtree

Session Chair: Kenneth Stanley (University of Central Florida)

16:10–16:35 **An Evolvability-enhanced Artificial Embryogeny for Generating Network Structures**
Hidenori Komatsu, Yasuhiro Hashimoto, Yu Chen, Hirotada Ohashi

Evolutionary Algorithm, Artificial Embryogeny, Mutation, Network Structure

Existing Artificial Embryogeny (AE) models are insufficient to generate a network structure because the possible links are limited to those connecting nodes with their predefined neighbors. We propose a novel network generating AE model capable of generating links connected to predefined neighbors as well those to non-neighbors. This mechanism provides additional flexibility in phenotypes than existing AE models. Our AE model also incorporates a heterogeneous mutation mechanism to accelerate the convergence to a high fitness value or enhance the evolvability. We conduct experiments to generate a typical 2D grid pattern as well as a robot with a network structure consisting of masses, springs and muscles. In both tasks, results show that our AE model has higher evolvability, sufficient to search a larger space than that of conventional AE models bounded by local neighborhood relationships.

16:35–17:00 **Measures of Complexity for Artificial Embryogeny**
Taras Kowaliw

Artificial Embryogeny, Developmental Systems, Complexity, Environment, Complexification, Cellular Automata

We aim for a more rigorous discussion of "complexity" for Artificial Embryogeny. Initially, we review several existing measures from Biology and Mathematics. We argue that measures which rank complexity through a Turing machine, or measures of information contained in a genome about an environment, are not desireable here; Instead, we argue for measures which provide the environment "for free", allowing us to quantify the capacity for a genome to exploit a provided area of growth. This leads to our definition of Environmental Kolmogorov Complexity and Logical Depth, along with our introduction of novel measures of functional complexity. Next, we attempt at defining an exceptionally simple model of embryogenesis, the Terminating Cellular Automata. The described measures are computed in this context, and contrasted.

17:00–17:25 **Evolutionary Design of Dynamic SwarmScapes**
Namrata Khemka, Scott Novakowski, Gerald Hushlak, Christian Jacob

Interactive evolutionary art, swarm-based painting, genetic programming, interactive evolution, swarm intelligence

This paper discusses interactive evolutionary algorithms and their application in swarm-based image generation. From an artist's perspective, the computer-generated patterns offer departure points for creative "Imagineering." Input into our evolutionary system comprises of ninety-six parameters that influence the behavior of swarm agents to create emerging "SwarmScapes" over time. This paper demonstrates how an evolutionary approach is used to create swarm-based animations, which at any point in time can be turned into electronic paintings and into high-resolution plots on canvas. As our team consists of three computer scientists and an artist, we also explore the collaborative relationships among the team members, and between the artist and the evolutionary system.

17:25–17:50 **Phenotypic, Developmental and Computational Resources: Scaling in Artificial Development**
Gunnar Tufte

Development, Cellular Computation, Evolvable Hardware

Developmental systems have inherent properties favourable for scaling. The possibility to generate very large scale structures combined with gene regulation opens for systems where the genome size do not reflect the size and complexity of the phenotype. Despite the presence of scalability in nature there is limited knowledge of what makes a developmental mapping scalable. As such, there is few artificial system that show true scaling. Scaling for any system, biological or artificial, is a question of resources. Toward an understanding of the challenges of scalability the issue of scaling is investigated in an aspect of resources within the developmental model itself. The resources are decompositioned into domains that can be scaled separately each may influence on the outcome of development. Knowledge of the domains influence on scaling provide insight in scaling limitation and what target problems that can be scaled. The resources are decompositioned into three domains; Phenotypic, Developmental and Computational (PDC). The domains are placed along three axes in a PDC-space. To illustrate the principles of scaling in a PDC-space an experimental approach is taken.

Keynote — Tuesday 8:30 – 10:10

Speaker: PZ Myers
Developmental Perspective for Understanding Evolution

Room: Georgia Ballroom

8:30–10:10 Keynote by PZ Myers Associate Professor of Biology, University of Minnesota, Morris

PZ Myers be discussing the importance of the developmental perspective for understanding evolution, with examples of specific instances where molecular genetics has contributed to understanding why particular patterns evolved.

About the Speaker:

For about a dozen years, PZ Myers has been among the fiercest, most public critics of the intelligent design movement.

An early convert to the internet, he first embarked on the mission by posting on a Usenet group called Talkorigins. Over the years, he has poked away at ID in other forums, too, most notably in a well-regarded evolution-themed group blog called the Panda's Thumb. But Myers owes most of his notoriety to the personal weblog he created two and a half years ago, Pharyngula.org. The blog's name is a reference to the stage in development of vertebrate embryos in which various species most resemble each other. Given the obscurity of the domain name—and the often esoteric subject matter—it is a minor miracle that Myers has been able to cultivate such a large and loyal following.

A Google search of his name yields more than a quarter of a million results. According to Alexa, the Amazon.com-owned website-ranking page, Pharyngula's idiosyncratic musings on science, culture, and politics—and his claw-hammer critiques of ID—have made him the most-read Minnesota blogger after the popular right-wing mainstays Power Line and Captain's Quarters.
http://scienceblogs.com/pharyngula/about.php

Paper Presentations — Tuesday 10:40 – 12:20

GBML-1: Best Paper + Applications of Genetics-Based Machine Learning
Room: Georgia West

Session Chair: Pier Luca Lanzi (Politecnico di Milano)

10:40–11:05 ★**Context-Dependent Predictions and Cognitive Arm Control with XCSF**
Martin V Butz, Oliver Herbort

Population Codes, Cognitive Systems, Sensorimotor Codes, XCSF, Bodyspaces

While John Holland has always envisioned learning classifier systems (LCSs) as cognitive systems, most work on LCSs has focused on classification, datamining, and function approximation. In this paper, we show that the XCSF classifier system can be very suitably modified to control a robot system with redundant degrees of freedom, such as a robot arm. Inspired by recent research insights that suggest that sensorimotor codes are nearly ubiquitous in the brain and an essential ingredient for cognition in general, the XCSF system is modified to learn classifiers that encode piecewise linear sensorimotor structures, which are conditioned on prediction-relevant contextual input. In the investigated robot arm problem, we show that XCSF partitions the (contextual) posture space of the arm in such a way that accurate hand movements can be predicted given particular motor commands. Furthermore, we show that the inversion of the sensorimotor predictive structures enables accurate goal-directed closed-loop control of arm reaching movements. Besides the robot arm application, we also investigate performance of the modified XCSF system on a set of artificial functions. All results point out that XCSF is a useful tool to evolve problem space partitions that are maximally effective for the encoding of sensorimotor dependencies. A final discussion elaborates on the relation of the taken approach to actual brain structures and cognitive psychology theories of learning and behavior.

11:05–11:30 **An Efficient SVM-GA Feature Selection Model for Large Healthcare Databases**
Rick Chow, Wei Zhong, Michael Blackmon, Richard Stolz, Marsha Dowell

Classifier systems, data mining, machine learning, optimization, parameter tuning, genetic algorithms, support vector machines.

This paper presents an efficient hybrid feature selection model based on Support Vector Machine (SVM) and Genetic Algorithm (GA) for large healthcare databases. Even though SVM and GA are robust computational paradigms, the combined iterative nature of a SVM-GA hybrid system makes runtime costs infeasible when using large databases. This paper utilizes hierarchical clustering to reduce dataset size and SVM training time, multi-resolution parameter search for efficient SVM model selection, and chromosome caching to avoid redundant fitness evaluations. This approach significantly reduces runtime and improves classification performance.

11:30–11:55 **Genetic-Guided Semi-Supervised Clustering Algorithm with Instance-Level Constraints**
Yi Hong, Sam Kwong, Hui Xiong, Qingsheng Ren

Genetic Algorithms, Semi-Supervised Clustering

Semi-supervised clustering with instance-level constraints is one of the most active research topics in the areas of pattern recognition, machine learning and data mining. Several recent studies have shown that instance-level constraints can significantly increase accuracies of a variety of clustering algorithms. However, instance-level constraints may split the search space of the optimal clustering solution into pieces, thus significantly compound the difficulty of the search task. This paper explores a genetic approach to solve the problem of semi-supervised clustering with instance-level constraints. In particular, a novel semi-supervised clustering algorithm with instance-level constraints, termed as the hybrid genetic-guided semi-supervised clustering algorithm with instance-level constraints (Cop-HGA), is proposed. Cop-HGA uses a hybrid genetic algorithm to perform the search task of a high quality clustering solution that is able to draw a good balance between predefined clustering criterion and available instance-level background knowledge. The effectiveness of Cop-HGA is confirmed by experimental results on several real data sets with artificial instance-level constraints.

GA-4: Applications 1

Room: Georgia East

Session Chair: Conor Ryan (University of Limerick)

10:40–11:05 **A Transformation-Based Approach to Static Multiprocessor Scheduling**
Alan Sheahan, Conor Ryan

Problem Solving, Control Methods, Search

This paper describes a novel Genetic Algorithm (GA) approach to scheduling. Although the particular problems examined are all multi-processor scheduling types it can, because the algorithm takes a DAG (Directed Acyclic Graph) as input, be applied to any scheduling problem represented by a DAG. The algorithm works by calculating the mobility of each node in the graph and using this to constrain the search space in a useful way, that is, nodes can be scheduled using a larger range of levels in the final schedule than those obtained by a simple levelling of the DAG. The GA itself operates by evolving sequences of transformations which build up ever increasing lists of task associations, using two simple transformations. We show that our algorithm can outperform standard methods, both traditional and GA based, at considerably lower costs.

11:05–11:30 **Adapting Palettes to Color Vision Deficiencies by Genetic Algorithm**
Luigi Troiano, Cosimo Birtolo, Maria Miranda

Accessibility, Vision Impaired, Search Based Software Engineering

In choosing a color palette, it is necessary to take into the account the needs of color vision impaired users, in order to make information and services accessible to a broader audience. This means to search the space of color palettes aimed to find a color combination representing a good trade-off between aesthetics and accessibility requirements. In this paper, we present a solution based on genetic algorithms. Experimental results highlight this approach to be an efficient but effective way to assist UI designers by suggesting appropriate variations of color palettes.

11:30–11:55 **On the Genetic Programming of Time-Series Predictors for Supply Chain Management**
Alexandros Agapitos, Matthew Dyson, Jenya Kovalchuk, Simon Mark Lucas

Prediction/Forecasting, Statistical Time-Series Features, Single-Step Prediction, Iterated Single-Step Prediction

Single and multi-step time-series predictors were evolved for forecasting minimum bidding prices in a simulated supply chain management scenario. Evolved programs were allowed to use primitives that facilitate the statistical analysis of historical data. An investigation of the relationships between the use of such primitives and the induction of both accurate and predictive solutions was made, with the statistics calculated based on three input data transformation methods: integral, differential, and rational. Results are presented showing which features work best for both single-step and multi-step predictions.

11:55–12:20 **Genetic Algorithm Approach for Solving a Cell Formation Problem in Cellular Manufacturing**
Iraj Mahdavi, Mohammad Mahdi Paydar, Armaghan Heidarzade, Maghsud Soleimanpur

Cell formation, Cellular manufacturing, Mathematical model, Genetic algorithm, Group efficacy

Cellular manufacturing (CM) is an industrial application of group technology concept. One of the problems encountered in the implementation of CM is the cell formation problem (CFP). The CFP attempted here is to group machines and parts in dedicated manufacturing cells so that the number of voids and exceptional elements in cells are minimized. The proposed model, with nonlinear terms and integer variables, cannot be solved for real sized problems efficiently due to its NP-hardness. To solve the model for real-sized applications, a genetic algorithm is proposed. Numerical examples show that the proposed method is efficient and effective in searching for optimal solutions. The results also indicate that the proposed approach performs well in terms of group efficacy compared to the well-known existing cell formation methods.

12:20–12:45 **On Selecting the Best Individual in Noisy Environments**
Wojciech Jaskowski, Wojciech Kotlowski

Evolutionary Algorithms, Evolutionary Computation, Noise, Robustness, Uncertainty, Approximation Models

In evolutionary algorithms, the typical post-processing phase involves selection of the best-of-run individual, which becomes the final outcome of the evolutionary run. Trivial for deterministic problems, this task can get computationally demanding in noisy environments. A typical naive procedure used in practice is to repeat the evaluation of each individual for the fixed number of times and select the one with the highest average. In this paper, we consider several algorithms that can adaptively choose individuals to evaluate basing on the results evaluations which have already been performed. The procedures are designed without any specific assumption about noise distribution. In the experimental part, we compare our algorithms with the naive and optimal procedures, and find out that the performance of typically used naive algorithm is poor even for relatively moderate noise. We also show that one of our algorithms is nearly optimal for most of the examined situations.

ACO-3: Artificial Immune Systems and Probability

Room: Atlanta A

Session Chair:

10:40–11:05 **Improving Accuracy of Immune-inspired Malware Detectors by using Intelligent Features**
M. Zubair Shafiq, Syed Ali Khayam, Muddassar Farooq

Artificial Immune System, Dendritic Cell Algorithm, Adaptive Neuro Fuzzy Inference System, Negative Selection, Network Endpoints, Support Vector Machines

In this paper, we show that a Bio-inspired classifier s accuracy can be dramatically improved if it operates on intelligent features. We propose a novel set of intelligent features for the well-known problem of malware portscan detection. We compare the performance of three well-known Bio-inspired classifiers operating on the proposed intelligent features: (1) Real Valued Negative Selection (RVNS) based on the adaptive immune system; (2) Dendritic Cell Algorithm (DCA) based on the innate immune system; and (3) Adaptive Neuro Fuzzy Inference System (ANFIS). To empirically evaluate the improvements provided by the intelligent features, we use a network traffic dataset collected on diverse endpoints for a period of 12 months. The endpoints traffic is infected with well-known malware. For unbiased performance comparison, we also include a machine learning algorithm, Support Vector Machine (SVM), and two state-of-the-art statistical malware detectors, Rate-Limiting (RL) and Maximum-Entropy (ME). To the best of our knowledge, this is the first study in which RVNS and DCA are not only compared with each other but also with several other classifiers on a comprehensive real-world dataset. The experimental results indicate that our proposed features significantly improve the TP rate and FP rate of both RVNS and DCA.

11:05–11:30 **Optimizing Task Schedules Using An Artificial Immune System Approach**
Han Yu

Artificial Immune Systems, Parallel Computing, Task Scheduling

Multiprocessor task scheduling is a widely studied optimization problem in the field of parallel computing. Many heuristic-based approaches have been applied to finding schedules that minimize the execution time of computing tasks on parallel processors. In this paper, we design an algorithm based on Artificial Immune Systems (AIS) to scheduling for heterogeneous computing environments. This approach distinguishes itself from many existing approaches in two aspects. First, it restricts the use of AIS to find optimal task-processor mapping, while taking advantage of heuristics used by deterministic scheduling approaches for task sequence assignment. Second, the calculation of the affinity takes into account both the solution quality and the distribution of population in the solution space. Empirical studies on benchmark task graphs show that this algorithm significantly outperforms HEFT, a deterministic algorithm. Further experiments also indicate that the algorithm is able to maintain high quality search even though a wide range of parameter settings are used.

11:30–11:55 **A Sense of Danger: Dendritic Cells Inspired Artificial Immune System for MANET Security**
Nauman Mazhar, Muddassar Farooq

Artificial Immune Systems, Dendritic Cells, Mobile Ad Hoc Networks, Misbehavior Detection, Self Organization

AIS-based intrusion detection systems classically utilize the paradigm of self/non-self discrimination. In this approach, an algorithm learns self during a learning phase, therefore, such algorithms do not have the ability to cope with scenarios in which self is continuously changing with time. This situation is encountered once malicious nodes are to be detected in a Mobile Ad Hoc Network (MANET). Consequently, it becomes a challenge to differentiate a valid route change due to mobility from an illegal one due to tampering of routing information by malicious nodes. In this paper, we propose a dendritic cell based distributed misbehavior detection system, BeeAIS-DC, for a Bio/Nature inspired MANET routing protocol, BeeAdHoc. Our proposed system inspires from the danger theory and models the function and behavior of dendritic cells to detect the presence or absence of danger and provides a tolerogenic or immunogenic response. The proposed detection system is implemented in a well-known ns-2 simulator. Our results indicate that our detection system not only enables BeeAIS-DC to dynamically adapt its detector set to cater for a changing self due to mobility of nodes, but also is robust enough to provide significantly smaller false positives as compared to self/non-self based AIS. Moreover, the danger theory related overhead of BeeAIS-DC is minimal, and as a result, it does not degrade traditional performance metrics of BeeAdHoc. This behavior is vital for battery/bandwidth constrained mobile nodes.

11:55–12:20 **Discriminating Self from Non-Self with Finite Mixtures of Multivariate Bernoulli Distributions**
Thomas Stibor

Statistical modeling, Multivariate Bernoulli Distributions, EM-algorithm

Affinity functions are the core components in negative selection to discriminate self from non-self. It has been shown that affinity functions such as the r-contiguous distance and the Hamming distance are limited applicable for discrimination problems such as anomaly detection. We propose to model self as a discrete probability distribution specified by finite mixtures of multivariate Bernoulli distributions. As by-product one also obtains information of non-self and hence is able to discriminate with probabilities self from non-self. We underpin our proposal with a comparative study between the two affinity functions and the probabilistic discrimination.

RWA-1: Best Paper Nominees

Room: Atlanta B

Session Chair: Daniel Howard (QinetiQ)

10:40–11:05 ★**Speeding Online Synthesis via Enforced Selecto-Recombination**
Shunsuke Saruwatari, Xavier Llora, Noriko Imafuji Yasui, Hiroshi Tamura, Kumara Sastry, David E. Goldberg

Innovation, creativity, brainstorming, online discussion, human-based genetic algorithms, superficiality on online communication

Brainstorming has been greatly used as a method to generate a large number of ideas by variety of each participant's knowledge. However, brainstorming does not always work well because of spatial and communication limitations. Moreover, brainstorming techniques present limited scalability. Meanwhile, genetics algorithms have been mostly regarded as an engineering or technological tool. However, the innovation intuition suggests that genetic algorithms may be also regarded as models of human innovation and creativity. This paper focuses on online creativity sessions. Modeling those creative efforts using selecto-

recombinative mechanism can provide three times more novel ideas, increase the posting frequency by a 2.6 factor, and help overcome superficiality on online communications by favoring synthetic thinking.

11:05–11:30 ★**Evolved Bayesian Networks as a Versatile Alternative to Partin Tables for Prostate Cancer Management**
Ratiba Kabli, John McCall, Frank Herrmann, Eng Ong

Genetic Algorithms, Bayesian Networks, Greedy Search, Medical Decision Support, Real-World Applications

In this paper, we report on work done evolving Bayesian Networks with Genetic Algorithms. We use a Chain Model GA to induce a Bayesian network model for the real world problem of Prostate Cancer management. Bayesian networks can and have been used in a wide range of complex domains, notably in medicine. In fact, they have shown powerful capabilities in representing and dealing with the uncertainties generally inherent in the clinical practice. In this study, we investigate those capabilities by testing the evolved model's predictive power and exploring its potential use as a more versatile alternative to the widely used Partin tables for prostate cancer pathology staging.

11:30–11:55 ★**Genetic Algorithms for Mentor-Assisted Evaluation Function Optimization**
Omid David-Tabibi, Moshe Koppel, Nathan S. Netanyahu

Computer chess, Fitness evaluation, Games, Genetic algorithms, Parameter tuning

In this paper we demonstrate how genetic algorithms can be used to reverse engineer an evaluation function's parameters for computer chess. Our results show that using an appropriate mentor, we can evolve a program that is on par with top tournament-playing chess programs, outperforming a two-time World Computer Chess Champion. This performance gain is achieved by evolving a program with a smaller number of parameters in its evaluation function to mimic the behavior of a superior mentor which uses a more extensive evaluation function. In principle, our mentor-assisted approach could be used in a wide range of problems for which appropriate mentors are available.

11:55–12:20 **Multiobjective Robustness for Portfolio Optimization in Volatile Environments**
Ghada Hassan, Christopher D. Clack

GP, Multiobjective Optimisation, Robustness, Portfolio Optimisation, Finance, Dynamic Environment

Multiobjective methods are ideal for evolving a set of portfolio optimisation solutions that span a range from high-return/high-risk to low-return/low-risk, and an investor can choose her preferred point on the risk-return frontier. However, there are no guarantees that a low-risk solution will remain low-risk --- if the environment changes, the relative positions of previously identified solutions may alter. A low-risk solution may become high-risk and vice versa. The robustness of a Multiobjective Genetic Programming (MOGP) algorithm such as SPEA2 is vitally important in the context of the real-world problem of portfolio optimisation. We explore robustness in this context, providing new definitions and a statistical measure to quantify the robustness of solutions. A new robustness measure is incorporated into a MOGP fitness function to bias evolution towards more robust solutions. This new system ("R-SPEA2") is compared against the original SPEA2 and we present our results.

Evolutionary Computation in Practice-3
Room: Atlanta D
Session Chair: Jörn Mehnen

10:40–12:20 **EC in design**
Thomas Bäck, Kalyanmoy Deb, Wolfgang Banzhaf

Late Breaking Papers-2
Room: Lenox
Session Chair:

10:40–10:55 **Potential Fitness for Genetic Programming**
Krzysztof Krawiec, PrzemysBaw Polewski

Genetic Programming, Evolutionary Computation, Semantics, Context

We introduce potential fitness, a variant of fitness function that operates in the space of schemata and is applicable to tree-based genetic programing. The proposed evaluation algorithm estimates the maximum possible gain in fitness of an individual's direct

offspring. The value of the potential fitness is calculated by analyzing the context semantics and subtree semantics for all contexts (schemata) of the evaluated tree. The key feature of the proposed approach is that a tree is rewarded for the correctly classified fitness cases, but it is not penalized for the incorrectly classified ones, provided that such errors are recoverable by substitution of an appropriate subtree (which is however not explicitly considered by the algorithm). The experimental evaluation on a set of seven boolean benchmarks shows that the use of potential fitness may lead to better convergence and higher success rate of the evolutionary run.

10:55–11:10 **Multi-Task Code Reuse in Genetic Programming**
Wojciech Jaskowski, Krzysztof Krawiec, Bartosz Wieloch

Code Reuse, Genetic Programming, Multi-Task Learning

We propose a method of knowledge reuse between evolutionary processes that solve different optimization tasks. We define the method in the framework of tree-based genetic programming (GP) and implement it as code reuse between GP trees that evolve in parallel in separate populations delegated to particular tasks. The technical means of code reuse is a crossbreeding operator which works very similar to standard tree-swapping crossover. We consider two variants of this operator, which differ in the way they handle the incompatibility of terminals between the considered problems. In the experimental part we demonstrate that such code reuse is usually beneficial and leads to success rate improvements when solving the common boolean benchmarks.

11:10–11:25 **Multi-objective Memetic Approach for Flexible Process Sequencing Problems**
Jian-Hong Chen, Jian-Hung Chen

process planning, flexible manufacturing systems, multi-objective optimization, memetic algorithms, fitness inheritance

This paper describes a multi-objective memetic approach for solving multi-objective flexible process sequencing problems in flexible manufacturing systems (FMSs). FMS can be described as an integrated manufacturing system consisting of machines, computers, robots, tools, and automated guided vehicles (AGVs).FMSs usually pose complex problems on process sequencing of operations among multiple parts. An efficient multi-objective memetic algorithm with fitness inheritance mechanism is proposed to solve flexible process problems (FPSs) with the consideration the machining time of operations and machine workload load balancing. The experimental results demonstrate that our approach can efficiently solve FPSs and fitness inheritance can speed up the convergence speed of the proposed algorithm in solving FPSs.

11:25–11:40 **A Synergistic Approach for Evolutionary Optimization**
Maumita Bhattacharya

Premature convergence, evolutionary algorithm, population

One of the major causes of premature convergence in Evolutionary Algorithm (EA) is loss of population diversity, which pushes the search space to a homogeneous or a near-homogeneous configuration. In particular, this can be a more complicated issue in case of high dimensional complex problem domains. In [13, 14], we presented two novel EA frameworks to curb premature convergence by maintaining constructive diversity in the population. The COMMUNITY_GA or COUNTER_NICHING_GA in [13] uses an informed exploration technique to maintain constructive diversity. In addition to this, the POPULATION_GA model in [14] balances exploration and exploitation using a hierarchical multi-population approach. The current research presents further investigation on the later model which synergistically uses an exploration controlling mechanism through informed genetic operators along with a multi-tier hierarchical dynamic population architecture, which allows initially less fit individuals a fair chance to survive and evolve. Simulations using a set of popular benchmark test functions showed promising results.

11:40–11:55 **Handling Uncertainty with a Real-coded EA**
Maumita Bhattacharya

Premature convergence, evolutionary algorithm, uncertainty

Presence of uncertainty in the search environment of Evolutionary algorithms (EA) interferes with the evaluation and the selection process of EA and adversely affects the performance of the algorithm. Presence of noise also means fitness function can not be evaluated and it has to be estimated instead. Of the various approaches which been tried to handle uncertainty in EA search environment, the more familiar approaches are: introduction of diversity (hyper mutation, random immigrants, special operators); and incorporation of memory of the past (diploidy, case based memory) [6]. In [2], we proposed a method, DPGA (distributed population evolutionary algorithm) that uses a distributed population architecture to simulate a distributed, self-adaptive memory of the solution space. Local regression is used in each sub-population to estimate the fitness. In the current research, we further investigate performance of DPGA for noisy fitness function i.e. fitness of any solution is altered by the addition of a noise term . Noisy versions of few standard benchmark problems have been considered in the simulation runs of the DPGA algorithm.

11:55–12:10 **Reduced Computation for Evolutionary Optimization in Noisy Environment**
Maumita Bhattacharya

Evolutionary algorithm, uncertainty, approximation

Evolutionary Algorithms (EAs) application to real world optimization problems often involves expensive fitness function evaluation. Naturally this has a crippling effect on the performance of any population based search technique such as EA. Estimating the fitness of individuals instead of actually evaluating them is a workable approach to deal with this situation. Optimization problems in real world often involve expensive fitness. In [14] and [15] we presented two EA models, namely DAFHEA (Dynamic Approximate Fitness based Hybrid Evolutionary Algorithm) and DAFHEA-II respectively. The original DAFHEA framework [14] reduces computation time by controlled use of meta-models generated by Support Vector Machine regression to partly replace actual fitness evaluation by estimation. DAFHEA-II [15] is an enhancement to the original framework in that it can be applied to problems that involve uncertainty. DAFHEA-II, incorporates a multiple-model based learning approach for the support vector machine approximator to filter out effects of noise [15]. In this paper we present further investigation on the performance of DAFHEA and DAFHEA-II.

SBSE-1: SBSE Verification and Validation + Best paper nominees

Room: Roswell

Session Chair: Giuliano Antoniol (Ecole Polytechnique de Montreal)

10:40–11:05 ★**Empirical Analysis of a Genetic Algorithm-based Stress Test Technique**
Vahid Garousi

Empirical Analysis, Genetic Algorithms, Stress Testing

Evolutionary testing denotes the use of evolutionary algorithms, e.g., Genetic Algorithms (GAs), to support various test automation tasks. Since evolutionary algorithms are heuristics, their performance and output efficiency can vary across multiple runs. Therefore, there is a strong need to empirically investigate the capacity of evolutionary test techniques to achieve the desired objectives (e.g., generate stress test cases) and their scalability in terms of the complexity of the System Under Test (SUT), the inputs, and the control parameters of the search algorithms. In a previous work, we presented a GA-based UML-driven, stress test technique aimed at increasing chances of discovering faults related to network traffic in distributed real-time software. This paper reports a carefully-designed empirical study which was conducted to analyze and improve the applicability, efficiency and effectiveness of the above GA-based stress test technique. Detailed stages and objectives of the empirical analysis are reported. The findings of the study are furthermore used to better calibrate the parameters of the GA-based stress test technique.

11:05–11:30 ★**Fitness Calculation Approach for the Switch-Case Construct in Evolutionary Testing**
Yan Wang, Zhiwen Bai, Miao Zhang, Wen Du, Ying Qin, Xiyang Liu

Fitness Function, Evolutionary Testing, Switch-Case Construct

A well-designed fitness function is essential to the effectiveness and efficiency of evolutionary testing. Fitness function design has been researched extensively. For fitness calculation, so far the switch-case construct has been regarded as a nested if-else structure with respect to the control flow. Given a target embraced in a case branch, test data taking different case branches receive different approximation levels. Since the approximation levels received by test data do not evaluate their suitability accurately, the guidance provided by the existing approach to evolutionary search is misleading or lost. Despite the switch-case construct's wide use in industrial applications, no previous work has addressed this problem. In this paper, a Flattened Control Flow Graph and a Flattened Control Dependence Graph for the switch-case construct are first presented, and a unified fitness calculation approach based on Alternative Critical Branches is proposed for the switch-case and other constructs. The concept of Alternative Critical Branches is extended from the single critical branch. Experiments on several large-scale open source programs demonstrate that this approach contributes a much better guidance to evolutionary search.

11:30–11:55 ★**Searching for Liveness Property Violations in Concurrent Systems with ACO**
Francisco Chicano, Enrique Alba

Liveness properties, HSF-SPIN, SPIN, Ant Colony Optimization, Metaheuristics

Liveness properties in concurrent systems are, informally, those properties that stipulate that something good eventually happens during execution. In order to prove that a given system satisfies a liveness property, model checking techniques are utilized. However, most of the model checkers found in the literature use exhaustive deterministic algorithms that require huge amounts of memory if the concurrent system is large. Here we propose the use of an algorithm based on ACOhg, a new kind of Ant Colony Optimization algorithm, for searching for liveness property violations in concurrent systems. We also take into account

the structure of the liveness property in order to improve the efficacy and efficiency of the search. The results state that our algorithmic proposal, called ACOhg-live, is able to obtain very short error trails in faulty concurrent systems using a low amount of resources, outperforming by far the results of Nested-DFS and Improved-Nested-DFS, two algorithms used in the literature for this task in the model checking community. This fact makes ACOhg-live a very suitable algorithm for finding liveness errors in large faulty concurrent systems, in which traditional techniques fail because of the model size.

11:55–12:20 **Handling Dynamic Data Structures in Search Based Testing**
Kiran Lakhotia, Mark Harman, Phil McMinn

Automated test data generation, concolic testing, symbolic execution

There has been little attention to search based test data generation in the presence of pointer inputs and dynamic data structures, an area in which recent concolic methods have excelled. This paper introduces a search based testing approach which is able to handle pointers and dynamic data structures. It combines an alternating variable hill climb with a set of constraint solving rules for pointer inputs. The result is a lightweight and efficient method, as shown in the results from a case study, which compares the method to CUTE, a concolic unit testing tool.

THEORY-1: Best-Paper Nominees

Room: Peachtree

Session Chair: Benjamin Doerr (MPI Saarbruecken)

10:40–11:05 ★**Computing Minimum Cuts by Randomized Search Heuristics**
Frank Neumann, Joachim Reichel, Martin Skutella

evolutionary algorithms, minimum s-t-cuts, multi-objective optimization, randomized search heuristics

We study the minimum s-t-cut problem in graphs with costs on the edges in the context of evolutionary algorithms. Minimum cut problems belong to the class of basic network optimization problems that occur as crucial subproblems in many real-world optimization problems and have a variety of applications in several different areas. We prove that there exist instances of the minimum s-t-cut problem that cannot be solved by standard single-objective evolutionary algorithms in reasonable time. On the other hand, we develop a bi-criteria approach based on the famous maximum-flow minimum-cut theorem that enables evolutionary algorithms to find an optimum solution in expected polynomial time.

11:05–11:30 ★**Memetic Algorithms with Variable-Depth Search to Overcome Local Optima**
Dirk Sudholt

Memetic algorithms, Runtime analysis, Combinatorial optimization, Kernighan-Lin, Variable-depth search, Simulated annealing

Variable-depth search (shortly VDS) is well-known as Lin-Kernighan strategy for the TSP and Kernighan-Lin for graph partitioning. The basic idea is to make a sequence of local moves and to freeze all moved combinatorial objects to prevent the search from looping. VDS stops when no further local move is possible and returns a best found solution. We analyze memetic algorithms with VDS for three binary combinatorial problems: Mincut, Knapsack, and Maxsat. More precisely, we focus on simply structured problem instances containing local optima that are very hard to overcome. Many common trajectory-based algorithms fail to find a global optimum: the (1+1)EA, iterated local search, and simulated annealing need exponential time with high probability. However, memetic algorithms using VDS easily manage to find a global optimum in expected polynomial time. These results strengthen the usefulness of memetic algorithms with VDS from a theoretical perspective.

11:30–11:55 ★**Precision, Local Search and Unimodal Functions**
Martin Dietzfelbinger, Jonathan E Rowe, Ingo Wegener, Philipp Woelfel

local search, precision, computational complexity, unimodal functions

We investigate the effects of precision on the efficiency of various local search algorithms on 1-D unimodal functions. We present a (1+1)-EA with adaptive step size which finds the optimum in O(\log n) steps, where *n* is the number of points used. We then consider binary and Gray representations with single bit mutations. The standard binary method does not guarantee locating the optimum, whereas using Gray code does so in O((\log n)2) steps. A (1+1)-EA with a fixed mutation probability distribution is then presented which also runs in O((\log n)2). Moreover, a recent result shows that this is optimal (up to some constant scaling factor), in that there exist unimodal functions for which a lower bound of Omega((\log n)2) holds regardless of the choice of mutation distribution. Finally, we show that it is not possible for a black box algorithms to efficiently optimise unimodal functions for two or more dimensions (in terms of the precision used).

EMO-4: Global Optimization and Decision Making

Room: Atlanta A

Session Chair: Eckart Zitzler (ETH Zurich)

14:00–14:25 **Integrating User Preferences with Particle Swarms for Multi-objective Optimization**

Upali K Wickramasinghe, Xiaodong Li

Particle swarm optimization, Multi-objective problems, User-preference methods, Reference point method, Non-dominated sorting, Maximin strategy

This paper proposes a method to use reference points as preferences to guide a particle swarm algorithm to search towards preferred regions of the Pareto front. A decision maker can provide several reference points, specify the extent of the spread of solutions on the Pareto front as desired, or include any bias between the objectives as preferences within a single execution. We incorporate the reference point method into two multi-objective particle swarm algorithms, the non-dominated sorting PSO, and the maximinPSO. This paper first demonstrates the usefulness of the proposed reference point based particle swarm algorithms, then compare the two algorithms using a hyper-volume metric. Both particle swarm algorithms are able to converge to the preferred regions of the Pareto front using several feasible or infeasible reference points.

14:25–14:50 **Reference Point Based Multi-Objective Evolutionary Algorithms for Group Decisions**

Jella Pfeiffer, Uli Golle, Franz Rothlauf

Multi-objective optimization, preference-based optimization, decision making, group decisions, reference points.

While in the past decades research on multi-objective evolutionary algorithms (MOEA) has aimed at finding the whole set of Pareto optimal solutions, current approaches focus on only those parts of the Pareto front which satisfy the preferences of the decision maker (DM). Therefore, they integrate the DM early on in the optimization process instead of leaving him/her alone with the final choice of one solution among the whole Pareto optimal set. In this paper, we address an aspect which has been neglected so far in the research on integrating preferences: in most real-world problems, there is not only one DM, but a group of DMs trying to find one consensus decision all participants are willed to agree to. Therefore, our aim is to introduce methods which focus on the part of the Pareto front which satisfies the preferences of several DMs concurrently. We assume that the DMs have some vague notion of their preferences a priori the search in form of a reference point or goal. Thus, we present and compare several reference point based approaches for group decisions and evaluate them on three ZDT and two flow shop problems.

GP-5: Applications III

Room: Atlanta B

Session Chair: Riccardo Poli (University of Essex)

14:00–14:25 **Coevolution of Data Samples and Classifiers Integrated with Grammatically-based Genetic Programming for Data Classification**

Douglas A Augusto, Helio J.C. Barbosa, Nelson F.F. Ebecken

Genetic Programming, Data Classification, Context-free Grammar, Competitive Coevolution

The present work treats the data classification task by means of evolutionary computation techniques using three ingredients: genetic programming, competitive coevolution, and context-free grammar. The robustness and symbolic/interpretative qualities of the genetic programming are employed to construct classification trees via Darwinian evolution. The flexible formal structure of the context-free grammar replaces the standard genetic programming representation and describes a language which encodes trees of varying complexity. Finally, competitive coevolution is used to promote competitions between data samples and classification trees in order to create and sustain an evolutionary arms-race for improved solutions.

14:25–14:50 **Multiobjective Design of Operators that Detect Points of Interest in Images**

Leonardo Trujillo, Gustavo Olague, Evelyne Lutton, Francisco Fernández de Vega

Multiobjective optimization, Interest point detection

In this paper, a multiobjective (MO) learning approach to image feature extraction is described, where Pareto-optimal interest point (IP) detectors are synthesized using genetic programming (GP). IPs are image pixels that are unique, robust to changes during image acquisition, and convey highly descriptive information. Detecting such features is ubiquitous to many vision applications, e.g. object recognition, image indexing, stereo vision, and content based image retrieval. In this work, candidate IP

operators are automatically synthesized by the GP process using simple image operations and arithmetic functions. Three experimental optimization criteria are considered: 1) the repeatability rate; 2) the amount of global separability between IPs; and 3) the information content captured by the set of detected IPs. The MO-GP search considers Pareto dominance relations between candidate operators, a perspective that has not been contemplated in previous research devoted to this problem. The experimental results suggest that IP detection is an illposed problem for which a single globally optimum solution does not exist. We conclude that the evolved operators outperform and dominate, in the Pareto sense, all previously man-made designs.

14:50–15:15 **Genetic Programming for Finite Algebras**
Lee Spector, David M. Clark, Ian Lindsay, Bradford Barr, Jon Klein

ECJ, genetic programming, finite algebras, PushGP

We describe the application of genetic programming (GP) to a problem in pure mathematics, in the study of finite algebras. We document the production of human-competitive results in the discovery of particular algebraic terms, namely discriminator, Pixley, majority and Mal'cev terms, showing that GP can exceed the performance of every prior method of finding these terms in either time or size by several orders of magnitude. Our terms were produced using the ECJ and PushGP genetic programming systems in a variety of configurations. We compare the results of GP to those of exhaustive search, random search, and algebraic methods.

Evolutionary Computation in Practice-4
Room: Atlanta D
Session Chair: David Davis

14:00–15:40 **EC in scheduling**

EDA-2: BOA, hBOA, and EDNA
Room: Buckhead
Session Chair: Tian-Li Yu (National Taiwan University)

14:00–14:25 **iBOA: The Incremental Bayesian Optimization Algorithm**
Martin Pelikan, Kumara Sastry, David E. Goldberg

Bayesian optimization algorithm, incremental BOA, incremental model update, estimation of distribution algorithms, evolutionary computation, BOA, iBOA, EDA

This paper proposes the incremental Bayesian optimization algorithm (iBOA), which modifies standard BOA by removing the population of solutions and using incremental updates of the Bayesian network. iBOA is shown to be able to learn and exploit unrestricted Bayesian networks using incremental techniques for updating both the structure as well as the parameters of the probabilistic model. This represents an important step toward the design of competent incremental estimation of distribution algorithms that can solve difficult nearly decomposable problems scalably and reliably.

14:25–14:50 **Finding Ground States of Sherrington-Kirkpatrick Spin Glasses with Hierarchical BOA and Genetic Algorithms**
Martin Pelikan, Katzgraber G. Helmut, Sigismund Kobe

Sherrington-Kirkpatrick spin glass, SK spin glass, hierarchical BOA, hBOA, genetic algorithm, estimation of distribution algorithms, evolutionary computation, branch and bound, EDA

This study focuses on the problem of finding ground states of random instances of the Sherrington-Kirkpatrick (SK) spin-glass model with Gaussian couplings. While the ground states of SK spin-glass instances can be obtained with branch and bound, the computational complexity of branch and bound yields instances of not more than approximately 90 spins. We describe several approaches based on the hierarchical Bayesian optimization algorithm (hBOA) to reliably identify ground states of SK instances intractable with branch and bound, and present a broad range of empirical results on such problem instances. We argue that the proposed methodology holds a big promise for reliably solving large SK spin-glass instances to optimality with practical time complexity. The proposed approaches to identifying global optima reliably can also be applied to other problems and can be used with many other evolutionary algorithms. Performance of hBOA is compared to that of the genetic algorithm with two common crossover operators.

14:50–15:15 **Improved EDNA (Estimation of Dependency Networks Algorithm) Using Combining Function with Bivariate Probability Distributions**
José A. Gámez, Juan L. Mateo, José M. Puerta

Estimation of Distribution Algorithms, Dependency Networks, Probability Combining Function, Combinatorial Optimization, Scalability

One of the key points in Estimation of Distribution Algorithms (EDAs) is the learning of the probabilistic graphical model used to guide the search: the richer the model the more complex the learning task. Dependency networks-based EDAs have been recently introduced. On the contrary of Bayesian networks, dependency networks allow the presence of directed cycles in their structure. In a previous work the authors proposed EDNA, an EDA algorithm in which a multivariate dependency network is used but approximating its structure learning by considering only bivariate statistics. EDNA was compared with other models from the literature with the same computational complexity (e.g., univariate and bivariate models). In this work we propose a modified version of EDNA in which not only the structural learning phase is limited to bivariate statistics, but also the simulation and the parameter learning task. Now, we extend the comparison employing multivariate models based on Bayesian networks (EBNA and hBOA). Our experiments show that the modified EDNA is more accurate than the original one, being its accuracy comparable to EBNA and hBOA, but with the advantage of being faster specially in the more complex cases.

GBML-3: Evolution and Genetics-Based Machine Learning
Room: Lenox
Session Chair: Lashon Booker (The MITRE Corporation)

14:00–14:25 **Evolving Neural Networks for Fractured Domains**
Nate Kohl, Risto Miikkulainen

NEAT, neuroevolution, RBF networks

Evolution of neural networks, or neuroevolution, bas been successful on many low-level control problems such as pole balancing, vehicle control, and collision warning. However, high-level strategy problems that require the integration of multiple sub-behaviors have remained difficult for neuroevolution to solve. This paper proposes the hypothesis that such problems are difficult because they are fractured: the correct action varies discontinuously as the agent moves from state to state. This hypothesis is evaluated on several examples of fractured high-level reinforcement learning domains. Standard neuroevolution methods such as NEAT indeed have difficulty solving them. However, a modification of NEAT that uses radial basis function (RBF) nodes to make precise local mutations to network output is able to do much better. These results provide a better understanding of the different types of reinforcement learning problems and the limitations of current neuroevolution methods. Thus, they lay tgroundwork for creating the next generation of neuroevolution algorithms that can learn strategic high-level behavior in fractured domains.

14:25–14:50 **Accelerating Neuroevolutionary Methods Using a Kalman Filter**
Yohannes Kassahun, Jose de Gea, Mark Edgington, Jan Hendrik Metzen, Frank Kirchner

Neuroevolution, Kalman Filter

In recent years, neuroevolutionary methods have shown great promise in solving learning tasks, especially in domains that are stochastic, partially observable, and noisy. In this paper, we show how the Kalman filter can be exploited (1) to efficiently find an optimal solution (i.\, e. reducing the number of evaluations needed to find the solution), (2) to find solutions that are robust against noise, and (3) to recover or reconstruct missing state variables, traditionally known as state estimation in control engineering community. Our algorithm has been tested on the double pole balancing without velocities benchmark, and has achieved significantly better results on this benchmark than the published results of other algorithms to date.

14:50–15:15 **Hierarchical Evolution of Linear Regressors**
Francesc Teixidó-Navarro, Albert Orriols-Puig, Ester Bernadó-Mansilla

Genetic algorithms, Machine Learning, Function Approximation, Regression

We propose an algorithm for function approximation that evolves a set of hierarchical piece-wise linear regressors.

The algorithm, named HIRE-Lin, follows the iterative rule learning approach. %This is characterized by evolving a single rule in each iteration, and %its associated domain is removed from further searches which allows %for progressively reduced search spaces. A genetic algorithm is iteratively called to find a partition of the search space where a linear regressor can accurately fit

the objective function. The resulting ruleset performs an approximation to the objective function formed by a hierarchy of locally trained linear regressors. The approach is evaluated in a set of objective functions and compared to other regression techniques.

GA-5: Applications 2

Room: Roswell

Session Chair: Kalyanmoy Deb (IIT Kanpur)

14:00–14:25 **A Tree-based GA Representation For The Portfolio Optimization Problem**
Claus C. Aranha, Hitoshi Iba

Finance, Representation, Genetic Algorithm, Optimization

Recently, a number of works have been done on how to use Genetic Algorithms to solve the Portfolio Optimization problem, which is an instance of the Resource Allocation problem class. Almost all these works use a similar genomic representation of the portfolio: An array, either real, where each element represents the weight of an asset in the portfolio, or binary, where each element represents the presence or absence of an asset in the portfolio. In this work, we explore a novel representation for this problem. We use a tree structure to represent a portfolio for the Genetic Algorithm. Intermediate nodes represent the weights, and the leaves represent the assets. We argue that while the Array representation has no internal structure, the Tree approach allows for the preservation of building blocks, and accelerates the evolution of a good solution. The initial experimental results support our opinions regarding this new genome representation. We believe that this approach can be used for other instances of Resource Allocation problems.

14:25–14:50 **In Search of No-loss Strategies for the Game of Tic-Tac-Toe using a Customized Genetic Algorithm**
Anurag Bhatt, Pratul Varshney, Kalyanmoy Deb

Tic-tac-toe, evolutionary games, learning strategies

The game of Tic-tac-toe is one of the most commonly known games. This game does not allow one to win all the time and a significant proportion of games played results in a draw. Thus, the best a player can hope is to not lose the game. This study is aimed at evolving a number of no-loss strategies using genetic algorithms and comparing them with existing methodologies. To efficiently evolve no-loss strategies, we have developed innovative ways of representing and evaluating a solution, initializing the GA population, developing GA operators including an elite preserving scheme. Interestingly, our GA implementation is able to find more than 72 thousands no-loss strategies for playing the game. Moreover, an analysis of these solutions has given us insights about how to play the game to not lose it. Based on this experience, we have developed specialized efficient strategies having a high win-to-draw ratio. The study and its results are interesting and can be encouraging for the techniques to be applied to other board games for finding efficient strategies.

14:50–15:15 **An Asynchronous Hybrid Genetic-Simplex Search for Modeling the Milky Way Galaxy Using Volunteer Computing**
Travis Desell, Boleslaw Szymanski, Carlos Varela

Genetic Algorithms, Simplex Method, Volunteer Computing

This paper examines the use of a probabilistic simplex operator for asynchronous genetic search on the BOINC volunteer computing framework. This algorithm is used to optimize a computationally intensive function with a continuous parameter space: finding the optimal fit of an astronomical model of the Milky Way galaxy to observed stars. The asynchronous search using a BOINC community of over 1,000 users is shown to be comparable to a synchronous continuously updated genetic search on a 1,024 processor partition of an IBM BlueGene/L supercomputer. The probabilistic simplex operator is also shown to be highly effective and the results demonstrate that increasing the parents used to generate offspring improves the convergence rate of the search. Additionally, it is shown that there is potential for improvement by refining the range of the probabilistic operator, adding more parents, and generating offspring differently for volunteered computers based on their typical speed in reporting results. The results provide a compelling argument for the use of asynchronous genetic search and volunteer computing environments, such as BOINC, for computationally intensive optimization problems and, therefore, this work opens up interesting areas of future research into asynchronous optimization methods.

15:15–15:40 **Strategic Positioning in Tactical Scenario Planning**
James M. Whitacre, Hussein A. Abbass, Ruhul Sarker, Axel Bender, Stephen Baker

evolutionary algorithms, scenarios, uncertainty, decision support, strategic planning, military planning

Capability planning problems are pervasive throughout many areas of human interest with prominent examples found in defense and security. Planning provides a unique context for optimization that has not been explored in great detail and involves

a number of interesting challenges which are distinct from traditional optimization research. Planning problems demand solutions that can satisfy a number of competing objectives on multiple scales related to robustness, adaptiveness, risk, etc. The scenario method is a key approach for planning. Scenarios can be defined for long-term as well as short-term plans. This paper introduces computational scenario-based planning problems and proposes ways to accommodate strategic positioning within the tactical planning domain. We demonstrate the methodology in a resource planning problem that is solved with a multi-objective evolutionary algorithm. Our discussion and results highlight the fact that scenario-based planning is naturally framed within a multi-objective setting. However, the conflicting objectives occur on different system levels rather than within a single system alone. This paper also contends that planning problems are of vital interest in many human endeavors and that Evolutionary Computation may be well positioned for this problem domain.

ECO-1: Best paper nominees

Room: Peachtree

Session Chair: Frank Neumann (Max-Planck-Institut fuer Informatik)

14:00–14:25 **Understanding Elementary Landscapes**
Darrell Whitley, Andrew M Sutton, Adele E Howe

Combinatorial Optimization, Local Search

The landscape formalism unites a finite candidate solution set to a neighborhood topology and an objective function. This construct can be used to model the behavior of local search on combinatorial optimization problems. A landscape is elementary when it possesses a unique property that results in a relative smoothness and decomposability to its structure. In this paper we explain elementary landscapes in terms of the expected value of solution components which are transformed in the process of moving from an incumbent solution to a neighboring solution. We introduce new results about the properties of elementary landscapes and discuss the practical implications for search algorithms.

14:25–14:50 **Hyper-heuristics for the Dynamic Variable Ordering in Constraint Satisfaction Problems**
H. Terashima-Marín, J. C. Ortiz-Bayliss, P. Ross, M. Valenzuela-Rendón

Evolutionary Computation, Hyper-heuristics, Constraint Satisfaction Problems, Dynamic Variable Ordering

The idea behind hyper-heuristics is to discover some combination of straightforward heuristics to solve a wide range of problems. To be worthwhile, such combination should outperform the single heuristics. This paper presents a GA-based method that produces general hyper-heuristics for the dynamic variable ordering within Constraint Satisfaction Problems. The GA uses a variable-length representation, which evolves combinations of condition-action rules producing hyper-heuristics after going through a learning process which includes training and testing phases. Such hyper-heuristics, when tested with a large set of benchmark problems, produce encouraging results for most of the cases. The testebed is composed of problems randomly generated using an algorithm proposed by Prosser.

14:50–15:15 ★**A Study of NK Landscapes' Basins and Local Optima Networks**
Gabriela Ochoa, Marco Tomassini, Sebastien Verel, Christian Darabos

Landscape Analysis, Network Analysis, Complex Networks, Local Optima, NK Landscapes

We propose a network characterization of combinatorial fitness landscapes by adapting the notion of inherent networks proposed for energy surfaces (Doye, 2002). We use the well-known family of NK landscapes as an example. In our case the inherent network is the graph where the vertices are all the local maxima and edges mean basin adjacency between two maxima. We exhaustively extract such networks on representative small NK landscape instances, and show that they are 'small-worlds'. However, the maxima graphs are not random, since their clustering coefficientsare much larger than those of corresponding random graphs. Furthermore, the degree distributions are close to exponential instead of Poissonian. We also describe the nature of the basins of attraction and their relationship with the local maxima network.

15:15–15:40 ★**Crossover Can Provably be Useful in Evolutionary Computation**
Benjamin Doerr, Edda Happ, Christian Klein

Evolutionary Computation, Crossover, Analysis, Combinatorial Optimization

We show that the natural evolutionary algorithm for the all-pairs shortest path problem is significantly faster with a crossover operator than without. This is the first theoretical analysis proving the usefulness of crossover for a non-artificial problem.

ACO-1: Best Paper Nominees

Room: Atlanta A

Session Chair:

16:10–16:35 ★**Collective Intelligence and Bush Fire Spotting**
David Howden, Tim Hendtlass

Collective Intelligence, Experimentation

Bush fires cause major damage each year in many areas of the world and the earlier that they can be detected the easier it is to minimize this damage. This paper describes a collective intelligence algorithm that performs localized rather than centralized control of a number of unmanned aerial vehicles (UAV) that can survey complex areas for fires, devoting attention in proportion to the user specified importance of each area. Simulation shows that not only is the algorithm able to perform this action successfully, it is also able to automatically adapt to a simulated malfunction in one of the UAVs.

16:35–17:00 ★**Convergence Behavior of the Fully Informed Particle Swarm Optimization Algorithm**
Marco A. Montes de Oca, Thomas Stützle

Particle Swarm Optimization, Swarm Intelligence, Experiments

The fully informed particle swarm optimization algorithm (FIPS) is very sensitive to changes in the population topology. The velocity update rule used in FIPS considers all the neighbors of a particle to update its velocity instead of just the best one as it is done in most variants. It has been argued that this rule induces a random behavior of the particle swarm when a fully connected topology is used. This argument could explain the often observed poor performance of the algorithm under that circumstance. In this paper we study experimentally the convergence behavior of the particles in FIPS when using topologies with different levels of connectivity. We show that the particles tend to search a region whose size decreases as the connectivity of the population topology increases. We therefore put forward the idea that spatial convergence, and not a random behavior, is the cause of the poor performance of FIPS with a fully connected topology. The practical implications of this result are explored.

17:00–17:25 ★**Evolutionary Swarm Design of Architectural Idea Models**
Sebastian von Mammen, Christian Jacob

Swarm Grammar, Constructive Swarm, Generative Representation, Swarm Model, Stigmergy, Boids, Complexity

In this paper we present a swarm grammar system that makes use of bio-inspired mechanisms of reproduction, communication and construction in order to build three-dimensional structures. Ultimately, the created structures serve as idea models that lend themselves to inspirations for architectural designs. Appealing design requires structural complexity. In order to computationally evolve swarm grammar configurations that yield interesting architectural models, we observe their productivity, coordination, efficiency, and their unfolding diversity during the simulations. In particular, we measure the numbers of collaborators in each swarm individual's neighborhood, and we count the types of expressed swarm agents and built construction elements. At the end of the simulation the computation time is saved and the created structures are rated with respect to their approximation of pre-defined shapes. These ratings are incorporated into the fitness function of a genetic algorithm. We show that the conducted measurements are useful to direct an evolutionary search towards interesting yet well-constrained architectural idea models.

17:25–17:50 ★**Theoretical and Empirical Study of Particle Swarms with Additive Stochasticity and Different Recombination Operators**
Jorge Peña

Swarm intelligence, Optimization, Recombination Operators, Theory, Empirical Study

Standard particle swarms exhibit both multiplicative and additive stochasticity in their update equations. Recently, a simpler particle swarm with just additive stochasticity has been proposed and studied using a new theoretical approach. In this paper we extend the main results of that study to a large number of existing particle swarm optimisers by defining a general update rule from which actual algorithms can be instantiated via the choice of specific recombination operators. In particular, we derive the stability conditions and the dynamic equations for the first two moments of the sampling distribution during stagnation, and show how they depend on the used recombination operator. Finally, the optimisation efficiency of several particle swarms with additive stochasticity is compared in a suite of 16 benchmark functions.

RWA-5 Prediction and Control

Room: Atlanta B

Session Chair:

16:10–16:35 **Design of Fractional Order PID Controllers with an Improved Differential Evolution**

Ajith Abraham, Arijit Biswas, Swagatam Das, Sambarta Dasgupta

Fractional Order Controller, PID controller, Differential Evolution, Swarm Intelligence

Differential Evolution (DE) has recently emerged as a simple yet very powerful technique for real parameter optimization. This article describes an application of DE for the design of Fractional-Order Proportional-Integral-Derivative (FOPID) Controllers involving fractional order integrator and fractional order differentiator. FOPID controllers parameters are composed of the proportionality constant, integral constant, derivative constant, derivative order and integral order, and its design is more complex than that of conventional integer order PID controller. Here the controller synthesis is based on user-specified peak overshoot and rise time and has been formulated as a single objective optimization problem. In order to digitally realize the fractional order closed loop transfer function of the designed plant, Tustin operator-based CFE (continued fraction expansion) scheme was used in this work. Simulation examples as well as comparisons of DE with two other state-of-the-art optimization techniques (Particle Swarm Optimization and Bacterial Foraging Optimization Algorithm) over the same problems demonstrate the superiority of the proposed approach especially for actuating fractional order plants.

16:35–17:00 **Branch Predictor On-line Evolutionary System**

Karel Slany

branch prediction, finite automata predictors

In this work a branch prediction system which utilizes evolutionary techniques is introduced. It allows the predictor to adapt to the executed code and thus to improve its performance on the fly. Experiments with the predictor system were performed and the results display how various parameters can impact its performance on various executed code. It is evident that a one-level predictor can be evolved whose performance is better than comparable predictors of the same class. The dynamic prediction system predicts with a relative high accuracy and outperforms any static predictor of the same class.

17:00–17:25 **An Analysis of Adaptive Windowing for Time Series Forecasting in Dynamic Environments: Further Tests of The DyFor GP Model**

Neal Wagner, Zbigniew Michalewicz

Genetic programming, forecasting, uncertain environments, time series, dynamic

Genetic Programming (GP) has proved its applicability for time series forecasting in a number of studies. The Dynamic Forecasting Genetic Program (DyFor GP) model builds on the GP technique by adding features that are tailored for the forecasting of time series whose underlying data-generating processes are non-static. Such time series often appear for real-world forecasting concerns in which environmental conditions are constantly changing. In a previous study the DyFor GP model was shown to improve upon the performance of GP and other benchmark models for a set of simulated and real time series. The distinctive feature of DyFor GP is its adaptive data window adjustment. This feedback-driven window adjustment is designed to automatically hone in on the currently active process in an environment where the generating process varies over time. This study further investigates this adaptive windowing technique and provides an analysis of its dynamics for constructed time series with non-static data-generating processes. Results show that DyFor GP is able to capture the moving processes more accurately than standard GP and offer insight for further improvements to DyFor GP.

17:25–17:50 **Fault Tolerant Control using Cartesian GeneticProgramming**

Yoshikazu Hirayama, Tim Clarke, Julian Francis Miller

Genetic Programming Fault Tolerance Robotics

The paper focuses on the evolution of algorithms for control of a machine in the presence of sensor faults, using Cartesian Genetic Programming. The key challenges in creating training sets and a ¯tness function that encourage a general solution are discussed. The evolved algorithms are analysed and discussed. It was found that highly novel, mathemati- cally elegant and hitherto unknown solutions were found.

EMO-1: Best Paper Nominees

Room: Atlanta D

Session Chair: Kalyanmoy Deb (IIT Kanpur)

16:10–16:35 ★**A New Memetic Strategy for the Numerical Treatment of Multi-Objective Optimization Problems**

Oliver Schuetze, Gustavo Sanchez, Carlos A. Coello Coello

memetic algorithm, hill climber, Pareto set, multi-objective optimization

In this paper we propose a novel iterative search procedure for multi-objective optimization problems. The iteration process -- though derivative free -- utilizes the geometry of the directional cones of such optimization problems, and is capable both of moving toward and along the (local) Pareto set depending on the distance of the current iterate toward this set. Next, we give one possible way of integrating this local search procedure into a given EMO algorithm resulting in a novel memetic strategy. Finally, we present some numerical results on some well-known benchmark problems indicating the strength of both the local search strategy as well as the new hybrid approach.

16:35–17:00 ★**Introducing MONEDA: Scalable Multiobjective Optimization with a Neural Estimation of Distribution Algorithm**

Luis Martí, Jesús García, Antonio Berlanga, José Manuel Molina

Multiobjective Optimization, Estimation of Distribution Algorithms (EDAs), Growing Neural Gas (GNG)

In this paper we explore the model-building issue of multiobjective optimization estimation of distribution algorithms. We argue that model--building has some characteristics that differentiate it from other machine learning tasks. A novel algorithm called multiobjective neural estimation of distribution algorithm (MONEDA) is proposed to meet those characteristics. This algorithm uses a custom version of the growing neural gas (GNG) network specially meant for the model--building task. As part of this work, MONEDA is assessed with regard to other classical and state-of-the-art evolutionary multiobjective optimizers when solving some community accepted test problems.

17:00–17:25 ★**Pattern Identification in Pareto-Set Approximations**

Tamara Ulrich, Dimo Brockhoff, Eckart Zitzler

decision making, heuristics, multi-objective optimization, representations

In a multiobjective setting, evolutionary algorithms can be used to generate a set of compromise solutions. This makes decision making easier for the user as he has alternative solutions at hand which he can directly compare. However, if the number of solutions and the number of decision variables which define the solutions are large, such an analysis may be difficult and corresponding tools are desirable to support a human in separating relevant from irrelevant information. In this paper, we present a method to extract structural information from Pareto-set approximations which offers the possibility to present and visualize the trade-off surface in a compressed form. The main idea is to identify modules of decision variables that are strongly related to each other. Thereby, the set of decision variables can be reduced to a smaller number of significant modules. Furthermore, at the same time the solutions are grouped in a hierarchical manner according to their module similarity. Overall, the output is a dendrogram where the leaves are the solutions and the nodes are annotated with modules. As will be shown on knapsack problem instances and a network processor design application, this method can be highly useful to reveal hidden structures in compromise solution sets.

17:25–17:50 ★**Benefits and Drawbacks for the Use of epsilon-Dominance in Evolutionary Multi-Objective Optimization**

Christian Horoba, Frank Neumann

Running time analysis, Multi-objective optimization

Using diversity mechanisms in evolutionary algorithms for multi-objective optimization problems is considered as an important issue for the design of successful algorithms. This is in particular the case for problems where the number of non-dominated feasible objective vectors is exponential with respect to the problem size. In this case the goal is to compute a good approximation of the Pareto front. We investigate how this goal can be achieved by using the diversity mechanism of epsilon-dominance and point out where this concept is provably helpful to obtain a good approximation of an exponentially large Pareto front in expected polynomial time. Afterwards, we consider the drawbacks of this approach and point out situations where the use of epsilon-dominance slows down the optimization process significantly.

GP-4: Applications II

Room: Buckhead

Session Chair: Christopher D. Clack (University College London)

16:10–16:35 **A Genetic Programming Approach to Business Process Mining**
Chris J Turner, Ashutosh Tiwari, Jorn Mehnen

Business process mining, Genetic programming, Graph based representation

The aim of process mining is to identify and extract process patterns from data logs to reconstruct an overall process flowchart. As business processes become more and more complex there is a need for managers to understand the processes they already have in place. To undertake such a task manually would be extremely time consuming so the practice of process mining attempts to automatically reconstruct the correct representation of a process based on a set of process execution traces. This paper outlines an alternative approach to business process mining utilising a Genetic Programming (GP) technique coupled with a graph based representation. The graph based representation allows greater flexibility in the analysis of process flowchart structure and offers the possibility of mining complex business processes from incomplete or problematic event logs. A number of event logs have been mined by the GP technique featured in this paper and the results of the experimentation point towards the potential of this novel process mining approach.

16:35–17:00 **Discovering Causes of Financial Distress by Combining Evolutionary Algorithms and Artificial Neural Networks**
Antonio M. Mora García, Eva Alfaro Cid, Pedro A. Castillo Valdivieso, Juan J. Merelo Guervós, Anna I. Esparcia-Alcázar, Ken Sharman

Financial distress prediction, Artificial Neural Networks, Self-Organizing Maps, Genetic Programming

In this work we compare two soft-computing methods for producing models that are able to predict whether a company is going to have book losses: artificial neural networks (ANNs) and genetic programming (GP). In order to build prediction models that can be applied to an extensive number of practical cases, we need simple models which require a small amount of data. Kohonen's self-organizing map (SOM) is a non-supervised neural network that is usually used as a clustering tool. In our case a SOM has been used to reduce the dimensions of the prediction problem. Traditionally, ANNs have been considered able to produce better classifier structures than GP. In this work we merge the capability of GP for generating classification trees and the feature extraction abilities of SOM, obtaining a classification tool that beats the results yielded using an evolutionary ANN method.

17:00–17:25 **Analysis of a Genetic Programming Algorithm for Association Studies**
Robin Nunkesser

Genetic Programming, Association Studies, Logic Minimization

In this paper a Genetic Programming algorithm for genetic association studies is reconsidered. It is shown, that the application field of the algorithm is not restricted to genetic association studies, but that the algorithm can also be applied to logic minimization problems. In the context of multi-valued logic minimization on incompletely specified truth tables it outperforms existing algorithms. In addition, the facilities of the algorithm in the original application field are complemented by new results and experiments. This includes answers to the open questions of how to automatically choose the best individual in the last population and whether crossover is necessary for the algorithm.

17:25–17:50 **Evolutionary Synthesis of Low-Sensitivity Equalizers Using Adjacency Matrix Representation**
Leonardo Bruno Sá, Antonio Mesquita

synthesis, digital filters, genetic algorithms, circuit

An evolutionary synthesis method to design low-sensitivity IIR filters with linear phase in the passband is presented. The method uses a chromosome coding scheme based on the graph adjacency matrix. It is shown that the proposed chromosome representation enables to easily verify invalid individuals during the evolutionary process. The efficiency of the proposed algorithm is tested in the synthesis of a fourth-order linear phase elliptic lowpass digital filter.

BIO-1: Best-Paper Nominees

Room: Lenox

Session Chair: Jason Moore (Dartmouth College)

16:10–16:35 ★**An Efficient Probabilistic Population-Based Descent for the Median Genome Problem**

Adrien Goeffon, Macha Nikolski, David J. Sherman

Median Genome Problem, probabilistic neighborhood, local search

We present a novel population-based local search

algorithm for the median genome problem. The primary result of this article is that this probabilistic approach significantly improves the performance of ancestral genome reconstruction compared to existing methods, making it possible to tackle problems where the contemporary genomes may contain many hundreds of markers. Moreover, our method is not limited to triples of genomes, and thus solves the median genome problem in its generality. We show that in real application cases the computational results are highly robust, suggesting that we can interpret the computed median genomes as candidates carrying the semantics of ancestral architectures.

16:35–17:00 ★**Structure and Parameter Estimation for Cell Systems Biology Models**

Francisco J. Romero-Campero, Hongqing Cao, Miguel Camara, Natalio Krasnogor

Systems Biology, Synthetic Biology, Modular Biology, P Systems, Memetic Algorithm, Genetic Algorithms

In this work we present a new methodology for structure and parameter estimation in cell systems biology modelling. Our modelling framework is based on P systems, an unconventional computational paradigm that abstracts from the structure and functioning of the living cell. The process of designing models, consisting of both the optimisation of the modular structure and of the stochastic kinetic parameters, is performed using a memetic algorithm. Specically, we use a nested evolutionary algorithm where the first layer evolves rule structures while the inner layer, implemented also as a genetic algorithm (GA), fine tunes the parameters of the model. Our approach consists of an incremental methodology. Starting from very simple P system modules specifying basic molecular interactions, more complicated modules are produced to model more complex molecular systems. These newly found modules are in turn added to the library of available P systems modules so as to be used subsequently to develop more intricate and circuitous cellular models. The effectiveness of the algorithm was tested on three case studies, namely, molecular complexation, enzymatic reactions and autoregulation in transcriptional networks.

17:00–17:25 ★**Mask Functions for the Symbolic Modeling of Epistasis Using Genetic Programming**

Ryan J Urbanowicz, Nate Barney, Bill C White, Jason H Moore

Genetic Analysis, Genetic Epidemiology, Genetic Programming, Symbolic Discriminant Analysis, Symbolic Regression, Function Set, Two-Locus Model, Genetic Mask

The study of common, complex multifactorial diseases in genetic epidemiology is complicated by nonlinearity in the genotype-to-phenotype mapping relationship that is due, in part, to epistasis or gene-gene interactions. Symobolic discriminant analysis (SDA) is a flexible modeling approach which uses genetic programming (GP) to evolve an optimal predictive model using a predefined collection of mathematical functions, constants, and attributes. This has been shown to be an effective strategy for modeling epistasis. In the present study, we introduce the genetic mask as a novel building block which exploits expert knowledge in the form of a pre-constructed relationship between two attributes. The goal of this study was to determine whether the availability of mask building blocks improves SDA performance. The results of this study support the idea that pre-processing data improves GP performance.

GBML-2: Foundations of Learning Classifier Systems

Room: Roswell

Session Chair: Stewart W. Wilson (Prediction Dynamics)

16:10–16:35 **Self-Adaptive Constructivism in Neural XCS and XCSF**

G D Howard, Larry Bull, Pier-Luca Lanzi

Constructivism, Learning Classifier Systems, Neural Networks, Reinforcement Learning, Self-Adaptation

For artificial entities to achieve high degrees of autonomy they will need to display appropriate adaptability. In this sense adaptability includes representational flexibility guided by the environment at any given time. This paper presents the use of constructivism-inspired mechanisms within a neural learning classifier system which exploits parameter self-adaptation as an

approach to realize such behaviour. The system uses a rule structure in which each is represented by an artificial neural network. It is shown that appropriate internal rule complexity emerges during learning at a rate controlled by the system. Further, the use of computed predictions is shown possible.

16:35–17:00 **Self-Adaptive Mutation in XCSF**
Martin V. Butz, Patrick Stalph, Pier Luca Lanzi

LCS, XCS, Mutation, Self-Adaptation

Recent advances in XCS technology have shown that self-adaptive mutation can be highly useful to speed-up the evolutionary progress in XCS. Moreover, recent publications have shown that XCS can also be successfully applied to challenging real-valued domains including datamining, function approximation, and clustering. In this paper, we combine these two advances and investigate self-adaptive mutation in the XCS system for function approximation with hyperellipsoidal condition structures, referred to as XCSF in this paper. It has been shown that XCSF solves function approximation problems with an accuracy, noise robustness, and generalization capability comparable to other statistical machine learning techniques and that XCSF outperforms simple clustering techniques to which linear approximations are added. This paper shows that the right type of self-adaptive mutation can further improve XCSF's performance solving problems more parameter independent and more reliably. We analyze various types of self-adaptive mutation and show that XCSF with self-adaptive mutation ranges, differentiated for the separate classifier condition values, yields most robust performance results. Future work may further investigate the properties of the self-adaptive values and may integrate advanced self-adaptation techniques.

17:00–17:25 **An Analysis of Matching in Learning Classifier Systems**
Martin V Butz, Pier Luca Lanzi, Xavier Llorà, Daniele Loiacono

LCS, XCS, RL, Matching

We investigate rule matching in learning classifier systems for problems involving binary and real inputs. We consider three rule encodings: the widely used character-based encoding, a specificity-based encoding, and a binary encoding used in Alecsys. We compare the performance of the three algorithms both on matching alone and on typical test problems. The results on matching alone show that the population generality influences the performance of the matching algorithms based on string representations in different ways. Character-based encoding becomes slower and slower as generality increases, specificity-based encoding becomes faster and faster as generality increases. The results on typical test problems show that the specificity-based representation can halve the time required for matching but also that binary encoding is about ten times faster on the most difficult problems. Moreover, we extend specificity-based encoding to real-inputs and propose an algorithm that can halve the time require for matching real inputs using an interval-based representation.

ECO-2:
Room: Peachtree
Session Chair: Tobias Friedrich (MPI Saarbrücken)

16:10–16:35 **Feasibility-Preserving Crossover for Maximum k-Coverage Problem**
Yourim Yoon, Yong-Hyuk Kim, Byung-Ro Moon

Maximum k-coverage, feasibility-preserving crossover, genetic algorithms

The maximum k-coverage problem is a generalized version of covering problems. We introduce the problem formally and analyze its property in relation to the operators of genetic algorithm. Based on the analysis, we propose a new crossover tailored to the maximum k-coverage problem. While traditional n-point crossovers have a problem of requiring repair steps, the proposed crossover has an additional advantage of always producing feasible solutions. We give a comparative analysis of the proposed crossover through experiments.

16:35–17:00 **Orientation Matters: How to Efficiently Solve OCST Problems with Problem-specific EAs**
Wolfgang Steitz, Franz Rothlauf

optimal communications spanning tree, heuristics, evolutionary algorithm, recombination operators

The optimal communication spanning tree (OCST) problem is a well known NP-hard combinatorial optimization problem which seeks a spanning tree that satisfies all given communication requirements for minimal total costs. It has been shown that optimal solutions of OCST problems are biased towards the much simpler minimum spanning tree (MST) problem. Therefore, problem-specific representations for EAs like heuristic variants of edge-sets that are biased towards MSTs show high performance. In this paper, additional properties of optimal solutions for Euclidean variants of OCST problems are studied. Experimental results show that not only edges in optimal trees are biased towards low-distance weights but also edges which are

directed towards the graph's center are overrepresented in optimal solutions. Therefore, efficient heuristic search algorithms for OCST should be biased towards edges with low distance weight and edges that point towards the center of the graph. Consequently, we extend the recombination operator of edge-sets such that the orientation of the edges is considered for constructing offspring solutions. Experimental results show a higher search performance in comparison to EAs using existing crossover strategies of edge-sets. As a result, we suggest to consider not only the distance weights but also the orientation of edges in heuristic solution approaches for the OCST problem.

17:00–17:25 **An Iterated Greedy Algorithm for the Node Placement Problem in Bidirectional Manhattan Street Networks**

Fubito Toyama, Kenji Shoji, Juichi Miyamichi

Iterated greedy, Metaheuristics

Wavelength Division Multiplexing (WDM) is a technology which multiplexes optical carrier signals on a single optical fiber by using different wavelengths. Lightwave networks based on WDM are promising ones for high-speed communication. If network nodes are equipped with tunable transmitters and receivers, a logical topology can be changed by reassigning wavelengths to tunable transceivers of nodes. Network performance is influenced by the logical node placements. Therefore, an efficient algorithm to obtain the optimal node placement to achieve the best network performance is necessary. In this paper, an iterated greedy algorithm is proposed for this node placement problem. The proposed iterated greedy algorithm consists of two phases, construction and destruction phases. As a local search algorithm, variable depth search is applied after the construction phase. The computational results showed that this iterated greedy algorithm outperformed the best metaheuristic algorithm for this problem.

17:25–17:50 **Enhancing Solution Quality of the Biobjective Graph Coloring Problem Using Hybridization of EA**

Rajeev Kumar, Paresh Tolay, Siddharth Tiwary

Optimization methods, multi-objective optimization, genetic algorithm, evolutionary algorithm, heuristics, combinatorial optimization, soft graph coloring, Pareto front

We consider a formulation of the biobjective soft graph coloring problem so as to simultaneously minimize the number of colors used as well as the number of edges that connect vertices of the same color. We solve this problem using well-known multiobjective evolutionary algorithms (MOEA), and observe that they show good diversity and (local) convergence. Then, we consider and adapt the single objective heuristics to yield a Pareto-front and observe that the quality of solutions obtained by MOEAs is much inferior. We incorporate the problem specific knowledge into representation and reproduction operators, in an incremental way, and get good quality solutions using MOEAs too. The spin-off point we stress with this work is that, for real world applications of unknown nature, it is indeed difficult to realize how good/bad the quality of the solutions obtained is.

Poster Session
Room: Georgia Ballroom

17:00 **Poster presenters may set up their posters in the Georgia Ballroom on Tuesday beginning at 17:00.**
Thank you for your participation and cooperation.

18:30–21:00 **Posters accepted as a result of the double-blind review and posters of accepted Graduate Student and Undergraduate Student Workshops papers are on display. Poster authors will be available to discuss their posters beginning at 19:00.**
*Remember to **bring your Badge** and Poster Session **beverage tickets**.*

Ant Colony Optimization, Swarm Intelligence, and Artificial Immune Systems

Particle Swarm Clustering Ensemble
Abbas Ahmadi, Fakhri Karray, Mohamed Kamel

Particle Swarm Optimization, Data Clustering, Clustering Ensemble, Multiple Cooperative Swarms

Attack Analysis & Bio-Inspired Security Framework for IPMultimedia Subsystem.
Aliya Awais, Muddassar Farooq, Muhammad Younus Javed

Artificial Immune Systems, IP Multimedia Subsystem, Network

Heterogeneous Sensitive Ant Model for Combinatorial Optimization
Camelia Chira, D. Dumitrescu, Camelia M. Pintea

ant colony search, metaheuristics, stigmergy, sensitivity, heterogeneous system, search diversification

Magnifier Particle Swarm Optimization For Numerical Optimization
Junqi Zhang, Kun Liu, Ying Tan, Xingui He

Particle Swarm Optimization(PSO), Swarm Intelligence, Global Numerical Optimization.

Allocation of Local and Global Search Capabilities of Particle in Canonical PSO
Junqi Zhang, Kun Liu, Ying Tan, Xingui He

Particle Swarm Optimization (PSO), Sampling Distribution, Global Search, Local Search, Allocation, Guide.

Genetic Algorithms and Grid Computing for Artificial life
Sylvain Cussat-Blanc, Fabien Viale, Herve Luga, Yves Duthen, Denis Caromel

Genetic algorithms, Grid computing, Artificial embryogeny

Evolving Stable Behavior in a Spino-neuromuscular System Model
Stan Gotshall, Terry Soule

Neural Networks, Genetic Algorithms, Robotics

Nested Evolution of an Autonomous Agent Using Descriptive Encoding
Jae-Yoon Jung, James A. Reggia

descriptive encoding, neuroevolution, reinforcement learning

Towards Efficient Evolution of Morphology and Control
Peter Krcăh

Artificial life, Computer aided/automated design, Evolutionary robotics, Evolving virtual creatures

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Reconfigurable Analogue Hardware Evolution of Adaptive Spiking Neural Network Controllers
Brian Mc Ginley, Patrick Rocke, Fearghal Morgan, John Maher

FPAA Hardware Evolution, Spiking Neural Networks, Analogue Neural Networks.

EIN-WUM: An AIS-based Algorithm for Web Usage Mining
Adel Torkaman Rahmani, B. Hoda Helmi

Artificial immune system, Web usage mining, Directed mutation, Danger theory.

Genetic Programming Based Automatic Gait Generation for Quadruped Robots
Kisung Seo, Soohwan Hyun

Genetic Programming, Quadruped Robot, Automatic Gait Generation, Elite Archive Mechanism

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A GP Algorithm for Efficient Synthesis of Gm-C Filters on a Hexagonal FPAA Structure
Stanis Trendelenburg, Joachim Becker, Fabian Henrici, Yiannos Manoli

evolvable hardware, filter synthesis, genetic programming, microelectronics

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Behavior-based Speciation for Evolutionary Robotics
Leonardo Trujillo, Gustavo Olague, Evelyne Lutton, Francisco Fernández de Vega

Evolutionary Robotics, Speciation

Protein-Protein Functional Association Prediction Using Genetic Programming
Beatroz Garcia Jimenez, Ricardo Aler Mur, Agapito Ledezmaespino, Araceli Sanchis De Miguel

Protein interaction prediction, Genetic Programming, Data Integration, Bioinformatics, Evolutionary computation, classifier system, Control Bloat, Machine Learning

Warping Search: A New Metaheuristic Applied to the Protein Structure Prediction
Richard Gonçalves, Marco Goldbarg, Elizabeth Goldbarg, Myriam Delgado

Warping Search, Protein Structure Prediction, Metaheuristics

Using Expert Knowledge in Initialization for Genome-wide Analysis of Epistasis Using Genetic Programming
Casey S Greene, Bill C White, Jason H Moore

Genetic Analysis, Genetic Programming, Expert Knowledge, Initialization

A Balanced Accuracy Fitness Function Leads to Robust Analysis using Grammatical Evolution Neural Networks in the Case of Class Imbalance
Nicholas E Hardison, Theresa J. Fanelli, Scott M. Dudek, David M Reif, Marylyn D. Ritchie, Alison A. Motsinger-Reif

neural networks, grammatical evolution, gene-gene interactions, single nucleotide polymorphism

Coevolution

Co-Optimization Algorithms
Travis Service, Daniel Tauritz

Coevolution, Simulated Annealing, Gradient Ascent

A Coevolution Archive based on Problem Dimension
Liping Yang, Houkuan Huang, Yabin Liu

Coevolution, archive, reliability, dimension, structure-archive

An Application of a Multivariate Estimation of Distribution Algorithm to Cancer Chemotherapy
Alexander E I Brownlee, Martin Pelikan, John A W McCall, Andrei Petrovski

Estimation of Distribution Algorithms, Complexity, Medical Applications

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Optimisation and Fitness Modelling of Bio-control in Mushroom Farming using a Markov Network EDA
Alexander E I Brownlee, Yanghui Wu, John A W McCall, Paul M Godley, David E Cairns, Julie Cowie

Estimation of Distribution Algorithms, Real-world applications, Modelling

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Improving the Efficiency of the Extended Compact Genetic Algorithm
Thyago S. P. C. Duque, David E. Goldberg, Kumara Sastry

Estimation of Distribution Algorithms, ECGA, Model Building, Efficiency Enhancement

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An Estimation Distribution Algorithm with the Spearman's Rank Correlation Index
Arturo Hernández-Aguirre, Enrique Villa-Diharce, Selma Barba-Moreno

Estimation Distribution Algorithm, Rank Correlation

Data Clustering Using Virtual Population based Incremental Learning Algorithm with Similarity Matrix Encoding Strategy
Yi Hong, Sam Kwong, Hui Xiong, Qingsheng Ren

Data Clustering, Similarity Matrix Encoding Strategy, Virtual Population based Incremental Learning Algorithm

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The Directional EDA for Global Optimization
Pedro P. Mayorga-Alvarez, Arturo Hernández-Aguirre

Estimation Distribution Algorithm, Convergence, Optimization

An EDA based on local Markov property and Gibbs sampling
Siddhartha Shakya, Roberto Santana

Estimation of Distribution Algorithms, Probabilistic graphical models, Markov Networks, Evolutionary Computation

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Designing EDAs by using the Elitist Convergent EDA Concept and the Boltzmann Distribution
Sergio Ivvan Valdez, Arturo Hernandez-Aguirre, Salvador Botello-Rionda

Boltzmann distribution, Estimation of distribution algorithms, Kullback-Leibler divergence, Performance analysis

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Evolution Strategies, Evolutionary Programming

Non-Monotone Differential Evolution
Michael G Epitropakis, Vassilis P Plagianakos, Michael N Vrahatis

Evolutionary Algorithms, Differential Evolution, Non-Monotone Differential Evolution, Global Optimization

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A Comparison of Speciation, Extinction, and Complexification in Neuroevolution With and Without Selection Pressure
Derek James

Speciation, extinction, complexification, neuroevolution, selection pressure, neutral theory

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A Hybrid Method for Tuning Neural Network for Time Series Forecasting
Aranildo Rodrigues Lima Junior, Tiago Alessandro Espínola Ferreira

Evolutionary Strategies, Neural Network, Time Series, Forecasting, GRASP method

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Maintaining population diversity by maintaining family structures
John Nicholson, Mark White

evolutionary strategy, diversity, selection

Multiobjective Evolution of a Fuzzy Controller in a Sewage Treatment Plant
Patrick Stalph, Marc Ebner, Martin Michel, Bernd Pfaff, Roland Benz

evolution strategies, multi-objective optimization, fuzzy controller, sewage treatment plant optimization

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Levy Walk Evolution for Global Optimization
Onay Urfalioglu, Ahmet Enis Cetin, Ercan Engin Kuruoglu

Evolutionary Optimization, Global Optimization, Alpha-Stable Distribution, Heavy Tailed Distribution, Levy Walk

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Evolutionary Combinatorial Optimization

Distributed Problem Solving by Memetic Networks
Ricardo M Araujo, Luis C Lamb

Meme, Network, Multi-parent recombination

Evolving Heuristics with Genetic Programming
Mohamed Bahy Bader-El-Den, Riccardo Poli

Genetic Programming, Hyper-Heuristic, Inc*, SAT, Heuristics.

A Parallel evolutionary Algorithm for Unconstrained Binary Quadratic Problems
Istvan Borgulya

Binary quadratic programming; evolutionary algorithm; island model; EC-memory

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A Tabu History driven Crossover Operator Design for Memetic Algorithm applied to Max-2SAT-Problems
Markus Borschbach, Andre Exeler

Memetic Algorithms, Max-2SAT, Tabu Search

An Evolutionary Algorithm for Some Cases of the Single-Source Constrained Plant Location Problem
Bryant A Julstrom

Plant location, warehouse location, facility location, single-source, capacitated, permutation coding, evolutionary algorithm

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Subheuristic Search and Scalability in a Hyperheuristic
Robert E Keller, Riccardo Poli

hyperheuristic

Greedy Heuristics and Evolutionary Algorithms for the Bounded Minimum-Label Spanning Tree Problem
Arindam Khaled, Bryant A Julstrom

Labeled spanning trees, bounded labels, greedy heuristics, genetic algorithms, local search

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A Multi-Start Quantum-Inspired Evolutionary Algorithm for Solving Combinatorial Optimization Problems
Parvaz Mahdabi, Saeed Jalili, Mahdi Abadi

Quantum Computing, Evolutionary Algorithms, Combinatorial Optimization, Knapsack Problem

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Complexity of MAX-SAT Using Stochastic Algorithms
Mohamed Qasem, Adam Prugel-Bennett

Satisfiability, Maximum Satisfiability, Phase Transition, Hill-climbing.

Evolutionary Multiobjective Optimization

Solving Constrained Multi-Objective Problemsby Objective Space Analysis
Gideon Avigad, Carlos Coello Coello

Multi-objective, Constraints, Reliability

Testing Parallelization Paradigms for MOEAs

Philip F Hingston, Sadeesha Gamhewa

Multi-objective evolutionary algorithms, parallelization, test problem characteristics

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Parallel Hyperheuristic

Coromoto Leon, Gara Miranda, Carlos Segura

Multi-objective Optimization, Evolutionary Algorithms, Island-Based Models, Hyperheuristics, Hybrid Algorithms

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On the Possibility to Create a Compatible--Complete Unary Comparison Method for Evolutionary Multiobjective Algorithms

Giovanni Lizarraga-Lizarraga, Arturo Hernandez-Aguirre, Salvador Botello-Rionda

Multiobjective optimization, performance measures, Pareto optimality

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Speed-up Techniques for Solving Large-scale bTSP with the Two-Phase Pareto Local Search

Thibaut Lust

Multiobjective combinatorial optimization, tsp, local search, speed-up techniques

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Hybridizing Surrogate Techniques, Rough Sets and Evolutionary Algorithms to Efficiently Solve Multi-Objective Optimization Problems

Luis V. Santana-Quintero, Carlos A. Coello Coello, Alfredo G. Hernandez-Diaz

Multi-objective optimization, surrogates, hybrid algorithms

Single-Objective Front Optimization: Application to RF Circuit Design

E. J. Solteiro Pires, Luís Mendes, P. B. de Moura Oliveira, J. A. Tenreiro Machado, N. M. Fonseca Ferreira, João Vaz, Maria Rosário

Single-Objective Front, Multi-Objective Evolutionary Algorithm, Radio Frequency Circuit Design

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A Novel Approach to Route Selection in Car Navigation Systems by a Multiobjective Genetic Algorithm

Feng Wen, Xiaohao Gao, Mitsuo Gen

multicriterion route selection problem (mRSP), Intelligent Transport System (ITS), multiobjective genetic algorithm (moGA)

Hybridizing an Evolutionary Algorithm with Mathematical Programming Techniques for Multi-Objective Optimization

Saúl Zapotecas Martínez, Carlos A. Coello Coello

Multi-objective optimization, NSGA-II, hybrid algorithms, Nelder-Mead method

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How Generative Encodings Fare on Less Regular Problems
Jeff Clune, Charles Ofria, Robert T. Pennock

regularity, Evolution, modularity, ANN, NEAT, HyperNEAT

Unsupervised Learning of Echo State Networks: Balancing the Double Pole
Fei Jiang, Hugues Berry, Marc Schoenauer

Echo State Networks, Evolution Strategies, CMA-ES

Growth Control and Disease Mechanisms in Computational Embryogeny
Or Yogev, Andrew A. Shapiro, Erik K Antonsson

Genetic Algorithm, Indirect Encoding, Stresses, Finite Element

Genetic Algorithms

Genetic Algorithms with Local Search Optimization for Protein Structure Prediction Problem
Igor Berenboym, Mireille Avigal

Genetic Algorithms, Protein Folding, Lattice HP Model, Global Energy, Pull Move, Local Search

Cryptanalysis using Genetic Algorithms
Karel P Bergmann, Renate Scheidler, Christian Jacob

Genetic algorithms, cryptanalysis, security

Self-Adaptive Mutation Rates in Genetic Algorithm for Inverse Design of Cellular Automata
Ron Breukelaar, Thomas Baeck

Self Adaptation, Genetic Algorithms, Cellular Automata

Evolving Machine Microprograms
P. A. Castillo, J. J. Merelo, Antonio Mora

computer architecture, microprogramming, microarchitecture, evolutionary computation techniques, optimization, automatic design

The Effects of Mutation and Directed Intervention Crossover when applied to Scheduling Chemotherapy
Paul M Godley, David E Cairns, Julie Cowie, John McCall, Kevin M Swingler

Genetic Algorithms, Time Series, Chemotherapy, Crossover

Analysis of the Performance of Genetic Multi-Step Search in Interpolation and Extrapolation Domain

Yoshiko Hanada, Tomoyuki Hiroyasu, Mitsunori Miki

Genetic Algorithm, Local Search, Combinatorial Optimization, NK Model

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Learning Offspring Optimizing Mate Selection

Ekaterina A. Holdener, Daniel R. Tauritz

Mate selection, Parent selection, offspring optimization

Maintaining the Diversity of Solutions by Non-Geometric Binary Crossover: A Worst One-Max Solver Competition Case Study

Hisao Ishibuchi, Noritaka Tsukamoto, Yusuke Nojima

Binary crossover, Genetic algorithms, Non-geometric crossover, Diversity maintenance

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Deriving Evaluation Metrics for Applicability of Genetic Algorithms to Optimization Problems

Hsin-yi Jiang, Carl K. Chang

Applicability, Evaluation Metric

Convergence Analysis of Quantum-inspired Genetic Algorithms with the Population of a Single Individual

Mehrshad Khosraviani, Saadat Pour-Mozafari, Mohammad Mehdi Ebadzadeh

Quantum-inspired Genetic Algorithm, Markov Chain Model, Global Convergence

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Linear Transformation in Pseudo-Boolean Functions

Yong-Hyuk Kim

pseudo-boolean function, coordinate-change, nonsingular binary matrix

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Using Multiple Offspring Sampling to Guide Genetic Algorithms to Solve Permutation Problems

Antonio LaTorre, José M. Peña, Víctor Robles, Santiago Muelas

Genetic Algorithms, Hybrid Evolutionary Methods, Multiple Offspring Sampling, Permutation Problems, Traveling Salesman Problem

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Optinformatics for Schema Analysis of Binary Genetic Algorithms

Minh Nghia Le, Yew Soon Ong, Quang Huy Nguyen

Genetic Algorithms, Frequent Pattern Mining, Schema Theory, Royal Road problem

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A Practical Search Index and Population Size Analysis Based on the Building Block Hypothesis

Zhenhua Li, Erik Goodman

genetic algorithm, building blocks, search space, practical search index, building block sampling, population size, GA hardness

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The Micro-genetic Operator in the Search of Global Trends
Flávio V C Martins, Eduardo G Carrano, Elizabeth F Wanner, Ricardo H C Takahashi

genetic algorithms, micro genetic algorithm, local search

Maintaining Diversity through Adaptive Selection, Crossover and Mutation
Brian Mc Ginley, Fearghal Morgan, Colm O Riordan

Adaptive Genetic Algorithm (AGA), adaptive selection, weighted population diversity, parameter adaptation

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Using PCA to Improve Evolutionary Cellular Automata Algorithms
Mehran Najafi, Hamid Beigy

Genetic Algorithms, Evolutionary Cellular Automata, Improvement in test strategies, Principal Component Analysis

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Comparing Genetic Algorithm and Guided Local Search Methods by Symmetric TSP Instances
Mehrdad Nojoumian, Divya Nair

Genetic Algorithm, Guided Local Search

Parameter-Less Evolutionary Search
Gregor Papa

Parameter-less, Evolution, Search

Evolving sequence patterns for prediction of sub-cellular locations of eukaryotic proteins
Gregory Paperin

Genetic Algorithm, Protein Localisation, Classifier Learning

Community Detection in Social Networks with Genetic Algorithms
Clara Pizzuti

genetic algorithm, data mining, clustering, social networks

Solving Discrete Deceptive Problems with EMMRS
José L. Risco-Martín, J. Ignacio Hidalgo, Juan Lanchares, Oscar Garnica

Genetic algorithms, deceptive problems, genotype and phenotype mapping

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Genetic Algorithms for Self-Spreading Nodes in MANETs
Cem Safak Sahin, Elkin Urrea, M. Umit Uyar, Ibrahim Hokelek, Michael Conner, Giorgio Bertoli, Christian Pizzo

Genetic Algorithms, MANET, Mobile Agents

Improving Small Population Performance under Noise with Viral Infection + Tropism
Yuji Sato, David Goldberg, Kumara Sastry

Genetic Algorithms, Virus Infection, Tropism, Building Block, Deceptive Problem, Multimodality, Noisy Optimization

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Image Registration Using Genetic Algorithms
Flavio Luiz Seixas, Luiz Satoru Ochi, Aura Conci, Débora Muchaluat Saade

Image registration, genetic algorithm, matching, mapping, affine transformation

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Is Best-So-Far" a Good Algorithmic Performance Metric?"
Nathaniel P Troutman, Brent E Eskridge, Dean F Hougen

Empirical study, Genetic algorithms, Machine learning, Performance analysis, Working principles of evolutionary computing

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Coordinate Change Operators for Genetic Algorithms
Elizabeth F Wanner, Eduardo G Carrano, Ricardo H. C. Takahashi

genetic algorithms, coordinate change, quadratic approximation, principal component analysis

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Modularity and Symmetry in Computational Embryogeny
Or yogev, Andrew A. Shapiro, Erik K. Antonsson

Genetic Algorithm, Indirect Encoding, Stresses, Finite Element,

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Comparing Genetic Algorithms to Principal Component Analysis and Linear Discriminant Analysis in Reducing Feature Dimensionality for Speaker Recognition
Maider Zamalloa, Luis Javier Rodriguez-Fuentes, Mikel Peñagarikano, Germán Bordel, Juan Pedro Uribe

Feature Dimensionality Reduction, Speaker Recognition, Genetic Algorithms

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Genetic Programming

Generalization Performance of Vision Based Controllers for Mobile Robots Evolved with Genetic Programming
Renaud Barate, Antoine Manzanera

Vision, Obstacle avoidance, Robotic simulation, Generalization

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Combining Cartesian Genetic Programming with an Estimation of Distribution Algorithm
Janet Clegg

Cartesian Genetic Programming, optimization, crossover techniques

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A Formulation for the Relative Permittivity of Water and Steam to High Temperatures and Pressures Evolved Using Genetic Programming

Sergey V Fogelson, Walter D Potter

Relative Permittivity, Genetic Programming

Measuring Rate of Evolution in Genetic Programming Using Amino Acid to Synonymous Substitution Ratio ka/ks

Ting Hu, Wolfgang Banzhaf

Rate of Evolution, Genetic Programming, ka/ks Ratio

TREAD: A New Genetic Programming Representation Aimed at Research of Long Term Complexity Growth

Tony E Lewis, George D Magoulas

Genetic Programming, Representations, Artificial Intelligence

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Stress-based Crossover Operator for Structure Topology Optimization using Small Population Size and Variable Length Chromosome

Cuimin Li, Tomoyuki Hiroyasu, Mitsunori Miki

Genetic Algorithm, stress-based crossover, structurnal topology optimization

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Elitism Reduces Bloat in Genetic Programming

Riccardo Poli, Nicholas Freitag McPhee, Leonardo Vanneschi

Genetic Programming, Bloat, Elitism

A Swarm-based Crossover Operator for Genetic Programming

Tony White, Amirali Salehi-Abari

automatic programming, genetic programming, swarm-based algorithms, ant colony optimization, evolutionary computation

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Experiments with Indexed FOR-Loops in Genetic Programming

Gayan Wijesinghe, Vic Ciesielski

genetic programming, machine learning, philosophical aspects of evolutionary computing, representations, theory

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Fast Rule Representation for Continuous Attributes in Genetics-Based Machine Learning

Jaume Bacardit, Natalio Krasnogor

Genetics-Based Machine Learning, Fast Rule Representation, Large Datasets

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Overfitting in the Selection of Classifier Ensembles: a Comparative Study Between PSO and GA

Eulanda M. Dos Santos, Luiz S. Oliveira, Robert Sabourin, Patrick Maupin

overfitting, Classifier ensembles selection, GA, PSO

Towards Efficient Online Reinforcement Learning Using Neuroevolution
Jan Hendrik Metzen, Mark Edgington, Yohannes Kassahun, Frank Kirchner

Neuroevolution, Reinforcement Learning, Online-Learning

Genetics-Based Machine Learning and Learning Classifier Systems

Genetic Local Search for Rule Learning
Cristiano Grijó Pitangui, Gerson Zaverucha

Genetic Algorithm, Rule Learning, Stochastic Local Search

Real-Time Imitation-Based Adaptation of Gaming Behaviour in Modern Computer Games
Steffen Priesterjahn, Alexander Weimer, Markus Eberling

Artificial Intelligence, Games, Machine Learning, Multiagent Systems, Online Algorithms

Imitation-Based Evolution of Artificial Players in Modern Computer Games
Steffen Priesterjahn

Artificial Intelligence, Entertainment and Media, Games, Heuristics, Machine Learning

A New Approach to Fuzzy LCSs in Two-Dimensional Continuous Multistep Environment with Continuous Vector Actions
José A. Ramírez-Ruiz, Manuel Valenzuela-Rendón, Hugo Terashima-Marín

Learning Classifier Systems, Fuzzy Classifier Systems, Fuzzy Logic, Genetic Algorithms, Induction Theory

Fine-Grained Population Diversity Estimation for Genetic Programming Based Structure Identification
Stephan M. Winkler, Michael Affenzeller, Stefan Wagner

Genetic Programming, Data Mining, Machine Learning, Population Diversity Analysis, System Identification

Real-World Applications

The Study for Transportation Planning Considered the Inventory Using Hybrid Genetic Algorithm
Shinichiro Ataka, Mitsuo Gen

Transportation Planning, Inventory, Priority-based encoding, hybrid Genetic Algorithm

On the Partitioning of Dynamic Scheduling Problems -- Assigning Technicians to Areas
Yossi Borenstein, Nazaraf Shah, Edward Tsang, Raphaël Dorne, Abdullah Alsheddy, Christos Voudouris

noisy fitness functions, multiobjective optimization

Construction of Portfolio Optimization System using Genetic Network Programming with Control Nodes
Yan Chen, Shingo Mabu, Kaoru Shimada, Kotaro Hirasawa

Portfolio Optimization, Genetic Network Programming, Control Node, Reinforcement Learning

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Automatic Circle Detection on Images with an Adaptive Bacterial Foraging Algorithm
Sambarta Dasgupta, Arijit Biswas, Swagatam Das, Ajith Abraham

Object recognition, swarm intelligence, bacterial foraging

An Evolutionary Approach for Competency-based Curriculum Sequencing
Luis de-Marcos, José-Javier Martínez, Jose-Antonio Gutierrez, Roberto Barchino, José-María Gutiérrez

e-Learning, Learning Object Sequencing, Competency, Particle Swarm Optimization (PSO), Genetic Algorithm (GA)

Evolution Strategy Based Optimization of On-Demand Dependent Data Broadcast Scheduling
Rinku Dewri, Darrell Whitley, Indrakshi Ray, Indrajit Ray

Scheduling, Data Broadcasting, Evolution Strategy

Automatic Generation of XSLT Stylesheets Using Evolutionary Algorithms
P García-Sánchez, JJ Merelo, JP Sevilla, JLJ Laredo, AM Mora, PA Castillo

Stylesheets, XML, XSLT, Evolutionary Computation Techniques

Genetic Algorithm in Removing Local NURBS Surface Irregularities Using Highlight Lines
Gyorgy Gyurecz

Highlight Lines, NURBS surface, RCGA

Applicability of Genetic Algorithms to Reconstruction of Projected Data from Ultrasonic Tomography
Shyam P Kodali, Sunith Bandaru, K Deb, Prabhat Munshi, N N Kishore

Genetic Algorithms, Reconstruction, Ultrasonic Tomography, Time of Flight, Block Crossover

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Designing a multistage Reverse Logistics Network Problem by Hybrid Genetic Algorithm
Jeong-eun Lee, Mitsuo Gen, Kyong-gu Rhee

Genetic Algorithm; multistage reverse Logistics Network Problem; priority-based encoding method; Weight Mapping Crossover

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Stock Trading Strategies by Genetic Network Programming with Flag Nodes
Shingo Mabu, Yan Chen, Etsushi Ohkawa, Kotaro Hirasawa

Genetic Programming, decision making, technical analysis, stock trading model

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Genetic Algorithms and Solutions of an Interesting Differential Equation
Paul E. MacNeil

Genetic algorithm, Schrodinger equation, differential equation

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A Hybrid System Using PSO and Data Mining forDetermining the Ranking of a New Participant inEurovision
Alberto Ochoa, Angel E Muñoz Zavala, Arturo Hernández Aguirre

PSO, Data Mining

Varying Portfolio Construction of Stocks Using Genetic Network Programming with Control Nodes
Etsushi Ohkawa, Yan Chen, Shingo Mabu, Kaoru Shimada, Kotaro Hirasawa

Genetic Network Programming, evolutionary computation, Candlestick Chart, buying and selling stocks.

Evolutionary Algorithm for Decryption of Monoalphabetic Homophonic Substitution Ciphers Encoded as Constraint Satisfaction Problems
David Oranchak

Evolutionary computing, genetic algorithms, Zodiac killer, Zodiac murder ciphers, codebreaking, cryptography, constraint satisfaction, homophonic substitution

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IGAP: Interactive Genetic Algorithm Peer to Peer
Juan C Quiroz, Amit Banerjee, Sushil J Louis

interactive genetic algorithm, floorplanning, collaboration, peer to peer network

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Dependencies on Player Formation in Event-driven Hybrid Learning Classifier Systems for Soccer Video Games
Yuji Sato, Ryosuke Suzuki, Yosuke Akatsuka

Learning classifier systems, Event-driven, Real-time learning, Soccer game, Video-game

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A Domain-Specific Crossover and a Helper Objective for Generating Minimum Weight Compliant Mechanisms

Deepak Sharma, Kalyanmoy Deb, N. N. Kishore

GA, Compliant Mechanisms, Helper objective.

Prediction of Retention Times for a Large Set of Pesticides Based on Improved Gene Expression Programming

Kejun Zhang, Shouqian Sun, Hongzong Si

dsfasdfsadf dsafdsaf sdfsadfdsa sdafdsaf sasadfsd dsafdsa, Improved Gene Expression Programming; Heuristic Method; Quantitative structure-retention relationship; Retention times

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Search-Based Software Engineering

Strongly-Typed Genetic Programming and Purity Analysis: Input Domain Reduction for Evolutionary Testing Problems

José Carlos Bregieiro Ribeiro, Mário Alberto Zenha-Rela, Francisco Fernandéz de Vega

Search-Based Test Case Generation, Strongly-Typed Genetic Programming, Input Domain Reduction

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Agent-based Support for Interactive Search in Conceptual Software Engineering Design

Christopher L Simons, Ian C Parmee

Evolutionary algorithms, conceptual software design, search, agents

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Awards and SIGEVO Meeting — Wednesday 8:30 – 10:10

SIGEVO Business Meeting, Awards Presentations

Room: Georgia West

Session Chair:

8:30–10:10 **Best Paper Awards, Competition Winners, and HUMIE Awards will be announced. A meeting of the members of SIGEVO follows the awards. All are welcome.**

Paper Presentations — Wednesday 10:40 – 12:20

GA-6: Representations, Adaptive Operators

Room: Georgia West

Session Chair: Ying-ping Chen (National Chiao Tung University, TAIWAN)

10:40–11:05 **CrossNet: A Framework for Crossover with Network-based Chromosomal Representations**
Forrest Stonedahl, William Rand, Uri Wilensky

Genetic Algorithms, Recombination, Crossover, Linkage, Networks, Graphs

We propose a new class of crossover operators for genetic algorithms (CrossNet) which use a network-based (or graph-based) chromosomal representation. We designed CrossNet with the intent of providing a framework for creating crossover operators that take advantage of domain-specific knowledge for solving problems. Specifically, GA users supply a network which defines the epistatic relationships between genes in the genotype. CrossNet-based crossover uses this information with the goal of improving linkage. We performed two experiments that compared CrossNet-based crossover with one-point and uniform crossover. The first experiment involved the density classification problem for cellular automata (CA), and the second experiment involved fitting two randomly generated hyperplane-defined functions (hdf's). Both of these exploratory experiments support the hypothesis that CrossNet-based crossover can be useful, although performance improvements were modest. We discuss the results and remain hopeful about the successful application of CrossNet to other domains. We conjecture that future work with the CrossNet framework will provide a useful new perspective for investigating linkage and chromosomal representations.

11:05–11:30 **The Node-Depth Encoding: Analysis and Application to the Bounded-Diameter Minimum Spanning Tree Problem**
Telma W. Lima, Franz Rothlauf, Alexandre C. B. Delbem

Genetic Algorithms, Representations, Performance Analysis

The node-depth encoding has elements from direct and indirect encoding for trees which encodes trees by storing the depth of nodes in a list. Node-depth encoding applies specific search operators that is a typical characteristic for direct encodings. An investigation into the bias of the initialization process and the mutation operators of the node-depth encoding shows that the initialization process has a bias to solutions with small depths and diameters, and a bias towards stars. This investigation, also, shows that the mutation operators are unbiased. The performance of node-depth encoding is investigated for the bounded-diameter minimum spanning tree problem. The results are presented for Euclidean instances presented in the literature. In contrast with the expectation, the evolutionary algorithm using the biased initialization operator does not allow evolutionary algorithms to find better solutions compared to an unbiased initialization. In comparison to other evolutionary algorithms for the bounded-diameter minimum spanning tree evolutionary algorithms using the node-depth encoding have a good performance.

11:30–11:55 **Adaptive Operator Selection with Dynamic Multi-Armed Bandits**
Luis DaCosta, Alvaro Fialho, Marc Schoenauer, Michèle Sebag

Adaptivity, Op erator selection, Multi-Armed Bandit

An important step toward self-tuning Evolutionary Algorithms is to design efficient Adaptive Operator Selection procedures. Such a procedure is made of two main components: a credit assignment mechanism, that computes a reward for each operator at hand based on some characteristics of the past offspring; and an adaptation rule, that modifies the selection mechanism based on the rewards of the different operators. This paper is concerned with the latter, and proposes a new approach for it based on the well-known Multi-Armed Bandit paradigm. However, because the basic Multi-Armed Bandit methods have been developed for static frameworks, a specific Dynamic Multi-Armed Bandit algorithm is proposed, that hybridizes an optimal Multi-Armed Bandit algorithm with the statistical Page-Hinkley test, which enforces the efficient detection of changes in time series. This original Operator Selection procedure is then compared to the state-of-the-art rules known as Probability Matching and Adaptive Pursuit on several artificial scenarios, after a careful sensitivity analysis of all methods. The Dynamic Multi-Armed Bandit method is found to outperform the other methods on a scenario from the literature, while on another scenario, the basic Multi-Armed Bandit performs best.

11:55–12:20 **Adaptive Discretization on Multidimensional Continuous Search Spaces**
Jiun-Jiue Liou, Ying-ping Chen

Adaptive discretization, split-on-demand, SoD, multidimensional split-on-demand, mSoD, extended compact genetic algorithm, ECGA, real-parameter optimization

This paper extends an adaptive discretization method, Split-on-Demand (SoD), to be capable of handling multidimensional continuous search spaces. The proposed extension is called multidimensional Split-on-Demand (mSoD), which considers multiple dimensions of the search space as a whole instead of independently discretizing each dimension as SoD does. In this study, we integrate mSoD and SoD with the extended compact genetic algorithm (ECGA) to numerically examine the effectiveness and performance of mSoD and SoD on the problems with and without linkage among dimensions of the search space. The experimental results indicate that mSoD outperforms SoD on both types of the test problems and that mSoD can offer better scalability, stability, and accuracy. The behavior of mSoD is discussed, followed by the potential future work.

EMO-3: Algorithm Development

Room: Georgia East

Session Chair: Carlos A. Coello Coello (CINVESTAV-IPN)

10:40–11:05 **G-Metric: an M-ary Quality Indicator for the Evaluation of Non-dominated Sets**
Giovanni Lizarraga-Lizarraga, Arturo Hernandez-Aguirre, Salvador Botello-Rionda

Multiobjective optimization, performance measures, Pareto optimality

An open problem in multiobjective optimization using the Pareto optimality criteria, is how to evaluate the performance of different evolutionary algorithms that solve multi-objective problems. As the output of these algorithms is a non-dominated set (NS), this problem can be reduced to evaluate what NS is better than the others based on their projection on the objective space. In this work we propose a new performance measure for the evaluation of non-dominated sets, that ranks a set of NSs based on their convergence and dispersion. Its evaluations of the NSs agree with intuition. Also, we introduce a benchmark of test cases to evaluate performance measures, that considers several topologies of the Pareto Front.

11:05–11:30 **A Pareto Following Variation Operator for Fast-Converging Multiobjective Evolutionary Algorithms**
A.K.M. Khaled Ahsan Talukder, Michael Kirley, Rajkumar Buyya

Evolutionary Multiobjective Optimization, Variation Operator, Dynamic System Identification, Function Evaluation

One of the major difficulties when applying Multiobjective Evolutionary Algorithms (MOEA) to real world problems is the large number of objective function evaluations. Approximate (or surrogate) methods offer the possibility of reducing the number of evaluations, without reducing solution quality. Artificial Neural Network (ANN) based models are one approach that have been used to approximate the future front from the current available fronts with acceptable accuracy levels. However, the associated computational costs limit their effectiveness. In this work, we introduce a simple approach that has comparatively smaller computational cost and we have developed this model as a variation operator that can be used in any kind of multiobjective optimizer. When designing this model, we have considered the whole search procedure as a dynamic system that takes available objective values in current front as input and generates approximated design variables for the next front as output. Initial simulation experiments have produced encouraging results in comparison to NSGA-II. Our motivation was to increase the speed of the hosting optimizer. We have compared the performance of the algorithm with respect to the total number of function evaluation and Hypervolume metric. This variation operator has worst case complexity of O(nkN^3), where N is the population size, n and k is the number of design variables and objectives respectively.

11:30–11:55 **Computing Finite Size Representations of the Set of Approximate Solutions of an MOP with Stochastic Search Algorithms**
Oliver Schuetze, Carlos A. Coello Coello, Emilia Tantar, El-Ghazali Talbi

multi-objective optimization, convergence, Pareto set, approximate solution, stochastic search algorithms

In this work we study the convergence of generic stochastic search algorithms toward the entire set of approximate solutions of continuous multi-objective optimization problems. Since the dimension of the set of interest is typically equal to the dimension of the parameter space, we focus on obtaining a finite and tight approximation, measured by the Hausdorff distance. Under mild assumptions about the process to generate new candidate solutions, the limit approximation set will be determined entirely by the archiving strategy. We propose and investigate a novel archiving strategy theoretically and empirically. For this, we analyze the convergence behavior of the algorithm, yielding bounds on the obtained approximation quality as well as on the cardinality of the resulting approximation, and present some numerical results.

11:55–12:20 **Objective Reduction Using a Feature Selection Technique**
Antonio López Jaimes, Carlos A Coello Coello, Debrup Chakraborty

many-objective problems, objective reduction, nonessential objectives, Multiobjective Optimization, feature selection

This paper introduces two new algorithms to reduce the number of objectives in a multiobjective problem by identifying the most conflicting objectives. The proposed algorithms are based on a feature selection technique proposed by Mitra et. al. One algorithm is intended to determine the minimum subset of objectives that yields the minimum error possible, while the other finds a subset of objectives of a given size that yields the minimum error. To validate these algorithms we compare their results against those obtained by two similar algorithms recently proposed. The comparative study shows that our algorithms are very competitive with respect to the reference algorithms. Additionally, our approaches require a lower computational time. Also, in this study we propose to use the inverted generational distance to evaluate the quality of a subset of objectives.

ESEP-2:
Room: Atlanta A
Session Chair: Anne AUGER (INRIA)

10:40–11:05 **Mutative σ-Self-Adaptation Can Beat Cumulative Step Size Adaptation when Using Weighted Recombination**
Hans-Georg Beyer, Alexander Melkozerov

Weighted mutlirecombination, evolution strategy, mutation strength self-adaptation, cumulative step length adaptation

This paper proposes the σ-self-adaptive weighted multirecombination evolution strategy} (ES) and presents a performance analysis of this newly engineered ES. The steady state behavior of this strategy is investigated on the sphere model and a formula for the optimal choice of the learning parameter is derived allowing the ES to reach maximal performance. A comparison between weighted multirecombination ES with σ-self-adaptation (σ SA) and with cumulative step size adaptation (CSA) shows that the σ -self-adaptive ES can exhibit the same performance and can even outperform its CSA counterpart for a range of learning parameters.

11:05–11:30 **Performance Analysis of Derandomized Evolution Strategies in Quantum Control Experiments**
Ofer M. Shir, Jonathan Roslund, Thomas Baeck, Herschel Rabitz

Derandomized Evolution Strategies, Experimental Quantum Control, Laser Pulse Shaping, CMA-ES

Genetic Algorithms (GAs) are historically the most commonly used optimization method in Quantum Control (QC) experiments. We transfer specific Derandomized Evolution Strategies (DES) that have performed well on noise-free theoretical Quantum Control calculations, including the Covariance Matrix Adaptation (CMA-ES) algorithm, into the noisy environment of Quantum Control experiments. We study the performance of these DES variants in laboratory experiments, and reveal the underlying strategy dynamics of first- versus second-order landscape information. It is experimentally observed that global maxima of the given QC landscapes are located when only first-order information is used during the search. We report on the disruptive effects to which DES are exposed in these experiments, and study covariance matrix learning in noisy versus noise-free environments. Finally, we examine the characteristic behavior of the algorithms on the given landscapes, and draw some conclusions regarding the use of DES in QC laboratory experiments.

11:30–11:55 **Application Domain Study of Evolutionary Algorithms in Optimization Problems**
P. Caamano, F. Bellas, J. A. Becerra, R. J. Duro

Evolutionary Algorithms, Algorithm Characterization, Optimization Benchmarks, Comparison Tests, Error Measures

This paper deals with the problem of comparing and testing evolutionary algorithms, that is, the benchmarking problem, from an analysis point of view. A practical study of the application domain of four representative evolutionary algorithms is carried out using a relevant set of real-parameter function optimization benchmarks. The four selected algorithms are the Covariance Matrix Adaptation Evolution Strategy (CMA-ES) and the Differential Evolution (DE), due to their successful results in recent studies, a Genetic Algorithm with real parameter operators, used here as a reference approach because it is probably the most familiar to researchers, and the Macroevolutionary algorithm (MA), which is not widely known but it shows a very remarkable behavior in some problems. The algorithms have been compared running several tests over the benchmark function set to analyze their capabilities from a practical point of view, in other words, in terms of their usability. The characterization of the algorithms is based on accuracy, stability and time consumption parameters thus establishing their operational scope and the type of optimization problems they are more suitable for.

RWA-6 Telecommunications and Image Processing
Room: Atlanta B
Session Chair:

10:40–11:05 **Metaheuristics for Solving a Real-World Frequency Assignment Problem in GSM Networks**
Francisco Luna, César Estébanez, Coromoto León, José M. Chaves-González, Enrique Alba, Ricardo Aler, Carlos Segura, Miguel A. Vega-Rodríguez, Antonio J. Nebro

Automatic Frequency Planning, Metaheuristics

The Frequency Assignment Problem (FAP) is one of the key issues in the design of GSM networks (Global System for Mobile communications), and will remain important in the foreseeable future. There are many versions of FAP, most of them benchmarking-like problems. We use a formulation of FAP, developed in published work, that focuses on aspects which are relevant for real-world GSM networks. In this paper, we have designed, adapted, and evaluated several types of metaheuristic for di®erent time ranges. After a detailed statistical study, results indicate that these metaheuristics are very appropriate for this FAP. New interference results have been obtained, that signi¯cantly improve those published in previous research.

11:05–11:30 **VoIP Speech Quality Estimation in a Mixed Context with Genetic Programming**
Adil Raja, R. Muhammad Atif Azad, Colin Flanagan, Conor Ryan

E-Model, Genetic Programming, Symbolic Regression, PESQ-WB, Speech Quality, VoIP, Ie, WB, eff

Voice over IP (VoIP) speech quality estimation is crucial to providing optimal Quality of Service (QoS). This paper seeks to provide improved speech quality estimation models with better prediction accuracy by considering a richer set of input features than the current International Telecommunications Union-Telecommunication (ITU-T) recommendations. It addresses a transitional phase, where wideband (WB) networks are becoming available. However, they have to co-exist with the existing narrowband (NB) setups for the time being. Quality estimation becomes a challenge in such a mixed context. The ITU-T recommendation (termed E-Model) has recently been extended to deal with the mixed context. However, it evaluates the speech degradation in the WB scenario based solely on codec related distortions (only a subset of factors affecting the speech quality on a VoIP network). The extension is derived out of speech signals evaluated by human subjects: an expensive and difficult to reproduce exercise. This paper innovates by considering a number of other network distortion types as well to produce generalised models that predict the quality degradation to a higher accuracy. To this end, an extensive set of speech samples is subjected to a wide variety of distortions. The degraded signals are evaluated by the currently best available algorithmic approximation of human evaluation of speech to produce quality scores. Using the distortions as the input features and targeting the quality scores, we employ Genetic Programming to produce parsimonious models that show considerable prediction gain compared to the E-Model. As against some existing approaches, where the models are tailored to various telephony codecs, the evolved models generalise across a variety of modern codecs.

11:30–11:55 **Robust Method of Detecting Moving Objects in Videos Evolved by Genetic Programming**
Andy Song, Danny Fang

Genetic Programming, Video Analysis, Object Detection, Tracking, Motion Detection, Real Time, Robosoccer

In this paper we investigated the use of Genetic Programming (GP) to evolve programs which could detect moving objects in videos. Two main approaches under the paradigm were proposed and investigated, single-frame approach and multi-frame approach. The former is based on analyzing individual video frames and treat them independently while the latter approach consider a sequence of frames. In the single-frame approach, three methods are investigated including using pixel intensity, pixel hue value and feature values. The experiments on Robosoccer field show that GP could detect the target under different lighting conditions and could even handle arbitrary camera positions. Although there was no domain knowledge had been provided during evolution, GP was able to produce moving object detectors that were robust and fast.

Evolutionary Computation in Practice-5
Room: Atlanta D
Session Chair: Thomas Bartz-Beielstein

10:40–12:20 **Getting a Job in Evolutionary Computation: What to do and what not to do**
Marc Schoenauer, Aaron Baughman (IBM), Thomas Bartz-Beielstein

ACO-5: Particle Swarm Optimization
Room: Buckhead
Session Chair:

10:40–11:05 **Runtime Analysis of Binary PSO**
Dirk Sudholt, Carsten Witt

Particle swarm optimization, runtime analysis

We investigate the runtime of the Binary Particle Swarm Optimization (PSO) algorithm introduced by Kennedy and Eberhart (1997). The Binary PSO maintains a global best solution and a swarm of particles. Each particle consists of a current position, an own best position and a velocity vector used in a probabilistic process to update the particle's position. We present lower bounds for swarms of polynomial size. To prove upper bounds, we transfer a fitness-level argument well-established for evolutionary algorithms (EAs) to PSO. This method is applied to estimate the expected runtime on the class of unimodal functions. A simple variant of the Binary PSO is considered in more detail. The 1-PSO only maintains one particle, hence own best and global best solutions coincide. Despite its simplicity, the 1-PSO is surprisingly efficient. A detailed analysis for the function OneMax shows that the 1-PSO is competitive to EAs.

11:05–11:30 **A New Quantum Behaved Particle Swarm Optimization**
Millie Pant, Radha Thangaraj, Ajith Abraham

Particle swarm optimization, Interpolation, Global optimization, Quantum behavior

This paper presents a variant of Quantum behaved Particle Swarm Optimization (QPSO) named Q-QPSO for solving global optimization problems. The Q-QPSO algorithm is based on the characteristics of QPSO, and uses interpolation based recombination operator for generating a new solution vector in the search space. The performance of Q-QPSO is compared with Basic Particle Swarm Optimization (BPSO), QPSO and two other variants of QPSO taken from literature on six standard unconstrained, scalable benchmark problems. The experimental results show that the proposed algorithm outperforms the other algorithms quite significantly.

11:30–11:55 **Particle Filtering with Particle Swarm Optimization in Systems with Multiplicative Noise**
A. D. Klamargias, K. E. Parsopoulos, Ph. D. Alevizos, M. N. Vrahatis

Sequential Monte Carlo Simulation, Particle Filter, Particle Swarm Optimization

We propose a Particle Filter model that incorporates Particle Swarm Optimization for predicting systems with multiplicative noise. The proposed model employs a conventional multiobjective optimization approach to weight the likelihood and prior of the filter in order to alleviate the particle impoverishment problem. The resulting scheme is tested on a well--known test problem with multiplicative noise. Results are promising, especially in cases of high system and measurement noise levels.

11:55–12:20 **Social Interaction in Particle Swarm Optimization, the Ranked FIPS, and Adaptive Multi-Swarms**
Johannes Jordan, Sabine Helwig, Rolf Wanka

Particle Swarm Optimization, Social Interaction, Adaptive Optimization, Subswarms, Performance Analysis

The interaction among particles is a vital aspect of Particle Swarm Optimization. As such, it has a strong influence on the swarm's success. In this study various approaches regarding the particles' communication behavior and their relationship are examined, as well as possibilities to combine the approaches. A new variant of the popular FIPS algorithm, the so-called Ranked FIPS, is introduced, which resolves specific shortcomings of the traditional FIPS. As all tested PSO variants feature distinct strengths and weaknesses, a new adaptive strategy is proposed which operates on dissimiliarly configured subswarms. The exchange between these subswarms is solely based on particle migration. The combination of the Ranked FIPS and other strategies within the so called Particle Swarm Optimizer with Migration achieves a very good, yet remarkably reliable performance over a wide range of recognized benchmark problems.

ALIFE-4: Artificial Life

Room: Lenox

Session Chair:

10:40–11:05 **Cooperative Network Construction Using Digital Germlines**
David B. Knoester, Philip K. McKinley, Charles Ofria

digital evolution, cooperative behavior, natural selection, multilevel selection, mutation, germline, biologically-inspired computing

This paper describes a study in the evolution of cooperative behavior, specifically the construction of communication networks, through digital evolution and multilevel selection. In digital evolution, a population of self-replicating computer programs exists in a user-defined computational environment and is subject to instruction-level mutations and natural selection. Multilevel selection links the survival of the individual to the survival of its group, thus encouraging cooperation. The results of experiments using the Avida digital evolution platform demonstrate that populations of digital organisms are capable of constructing communication networks, and that these networks can exhibit desired properties depending on the selective pressures used. We also show that the use of a digital germline can significantly improve evolvability of cooperation.

11:05–11:30 **On Hopeful Monsters, Neutral Networks and Junk Code in Evolving L-Systems**
Stefan Bornhofen, Claude Lattaud

virtual plants, L-systems, neutral networks, artificial evolution, artificial life

This paper investigates L-system evolution through experiments with a simulation platform of virtual plants. The conducted simulations vary the occurrence probability of terminal versus non-terminal symbols and study its impact on the evolutionary performance of the system. The results reveal a variant of the exploration-exploitation dilemma. A closer look at individual runs allows to discover a range of emergent evolutionary dynamics. In particular, the activation and improvement of previously dormant production rules leads to variation in the fixation rate of mutations. The corresponding fitness leaps suggest that L-system evolution derives much of its creative power from the mobilization of randomly drifting non-addressed rules. The observed patterns are related to the phenomena of positive and negative selection, neutral mutations and junk DNA in the natural genome.

11:30–11:55 **On the Evolution of Motility and Intelligent Tactic Response**
Laura M Grabowski, Wesley R Elsberry, Charles Ofria, Robert T Pennock

Digital evolution, chemotaxis, Avida, gradient following, experimental evolution

We present our first results concerning the de novo evolution of motility and tactic response in systems of digital organisms. Our model organism was E. coli and the behavior of interest was gradient following, since this represents simple decision-making. Our first experiments demonstrated the evolution of a tactic response, both when provided with a hand-coded system to remember previous gradient concentrations and without this crutch where the organisms must determine how to store previous values on their own. In our second set of experiments we investigated two different rotation strategies, random and systematic, and found no significant performance difference between the two strategies. These experiments served as a stepping-stone and proof-of-concept of the infrastructure needed for our future work on the evolution of simple intelligence.

THEORY-2:
Room: Roswell
Session Chair: Thomas Jansen (Technische Universität Dortmund)

10:40–11:05 **Focused No Free Lunch Theorems**
Darrell Whitley, Jonathan Rowe

No Free Lunch, Black Box Optimization

Proofs and empirical evidence are presented which show that a subset of algorithms can have identical performance over a subset of functions, even when the subset of functions is not closed under permutation. We refer to these as focused sets. In some cases focused sets correspond to the orbit of a permutation group; in other cases, the focused sets must be computed heuristically. In the smallest case, two algorithms can have identical performance over just two functions in a focused set. These results particularly exploit the case where search is limited to m steps, where m is significantly smaller than the size of the search space.

11:05–11:30 **A Tunable Model for Multi-Objective, Epistatic, Rugged, and Neutral Fitness Landscapes**
Thomas Weise, Stefan Niemczyk, Hendrik Skubch, Roland Reichle, Kurt Geihs

Genetic Algorithm, Fitness Landscape, Multi-Objective, Epistasis, Ruggedness, Neutrality, Model, Benchmark, Overfitting, Oversimplification, Deceptiveness

The fitness landscape of a problem is the relation between the solution candidates and their reproduction probability. In order to understand optimization problems, it is essential to also understand the features of fitness landscapes and their interaction. In this paper we introduce a model problem that allows us to investigate many characteristics of fitness landscapes. Specifically noise, affinity for overfitting, neutrality, epistasis, multi-objectivity, and ruggedness can be independently added, removed, and fine-tuned. With this model, we contribute a useful tool for assessing optimization algorithms and parameter settings.

11:30–11:55 **Simulated Annealing, its Parameter Settings and the Longest Common Subsequence Problem**
Dennis Weyland

Simulated Annealing, Run Time Analysis, Longest Common Subsequence Problem

Simulated Annealing is a probabilistic search heuristic for solving optimization problems and is used with great success on real life problems. In its standard form Simulated Annealing has two parameters, namely the initial temperature and the cooldown factor. In literature there are only rules of the thumb for choosing appropriate parameter values. This paper investigates the influence of different values for these two parameters on the optimization process from a theoretical point of view and presents some criteria for problem specific adjusting of these parameters. With these results the performance of the Simulated Annealing algorithm on solving the Longest Common Subsequence Problem is analysed using different values for the two parameters mentioned above. For all these parameter settings it is proved that even rather simple input instances of the Longest Common Subsequence Problem can neither be solved to optimality nor approximately up to an approximation factor arbitrarily close to 2 efficiently.

Late Breaking Papers-3
Room: Peachtree
Session Chair:

10:40–10:55 **Towards Memoryless Model Building**
David Iclanzan, D. Dumitrescu

Model based local-search, online model building, adaptive neighborhood structure

Probabilistic model building methods can render difficult problems feasible by identifying and exploiting dependencies. They build a probabilistic model from the statistical properties of multiple samples (population) scattered in the search space and generate offspring according to this model. The memory requirements of these methods grow along with the problem size as the population must be large enough to guarantee proper initial-supply, decision-making and accurate model-building. The paper presents a novel model based trajectory method, which samples only one point at the time and infers the problem structure online by means of Artificial Neural Network based machine learning technique. As case study we show how the proposed method can very efficiently address hard, non-separable building-block problems, specially designed to be solvable only by population based recombinative methods. The small memory requirement and fast convergence of the proposed method comes at the cost of a tradeoff: the complexity of an accurate model building is bounded by the exponential of the order of dependencies detected by the online learning.

10:55–11:10 **A Comparison Of Multiobjective Evolutionary Algorithms with Informed Initialization and Kuhn-Munkres Algorithm For The Sailor Assignment Problem**

Dipankar Dasgupta, German Hernandez, Deon Garrett, Pavan Kalyan Vejandla, Aishwarya Kaushal, Ramjee Yerneni, James Simien

multiobjective optimization, evolutionary algorithms

This paper examines the performance of two multiobjective evolutionary algorithms, NSGA-II and SPEA2, with informed initialization on large instances of United States Navy's Sailor Assignment Problem. The informed initialization includes in the initial population special solutions obtained by an extension of the Kuhn-Munkres algorithm. The Kuhn-Munkres algorithm, a classical algorithm that solves in $O(n^3)$ time instances of the single valued linear assignment problem, is extended here to render it applicable on single objective instances of the sailor assignment problem obtained using weight vectors to scalarize the natural multiobjective formulation. The Kuhn-Munkres extension is also used to provide a performance benchmark for comparison with the evolutionary algorithms.

11:10–11:25 **Incorporating Model Identifiability into Equation Discovery of ODE Systems**

Dirk J.W. De Pauw, Bernard De Baets

overfitting, model complexity, identifiability, equation discovery, genetic programming

Equation discovery is a machine learning technique that tries to automate the discovery of equations from measured data. In this contribution an equation discovery system based on genetic programming was developed in order to generate mechanistic models for systems described by ordinary differential equations. A problem often encountered with automatic model generation is that overly complex models are generated that "overfit" the measured data. This issue was addressed by incorporating a model identifiability measure (expressing which fraction of the model parameters can be given a unique value given the available data) into the fitness function of the individuals. Using noisy artificially generated data for a river water quality example case, it was shown that the developed system was able to generate model equations that fitted the data well and were also fully identifiable. Correct model equations were generated when starting from a model with minimum prior knowledge but also when starting from an overly complex model. As such, it was demonstrated that the developed equation discovery system is able to generate models with optimal complexity with regard to the available data.

11:25–11:40 **Using Feature-based Fitness Evaluation in Symbolic Regression with Added Noise**

Janine H Imada, Brian J Ross

genetic programming, noisy signals, symbolic regression

Symbolic regression is a popular genetic programming (GP) application. Typically, the fitness function for this task is based on a sum-of-errors, involving the values of the dependent variable directly calculated from the candidate expression. While this approach is extremely successful in many instances, its performance can deteriorate in the presence of noise. In this paper, a feature-based fitness function is considered, in which the fitness scores are determined by comparing the statistical features of the sequence of values, rather than the actual values themselves. The set of features used in the fitness evaluation are customized according to the target, and are drawn from a wide set of features capable of characterizing a variety of behaviours. Experiments examining the performance of the feature-based and standard fitness functions are carried out for non-oscillating and oscillating targets in a GP system which introduces noise during the evaluation of candidate expressions. Results show strength in the feature-based fitness function, especially for the oscillating target.

11:40–11:55 **Parameterizing Pair Approximations for Takeover Dynamics**

Joshua L. Payne, Margaret J. Eppstein

Interaction topologies, pair approximations, saturation dynamics, spatial structure, takeover time analysis

Pair approximations have often been used to predict equilibrium conditions in spatially-explicit epidemiological and ecological systems. In this work, we investigate whether this method can be used to approximate takeover dynamics in spatially structured evolutionary algorithms. Our results show that the pair approximation, as originally formulated, is insufficient for approximating pre-equibilibrium dynamics, since it does not properly account for the interaction between the size and shape of the local neighborhood and the population size. After parameterizing the pair approximation to account for these influences, we demonstrate that the resulting system of differential equations can serve as a general and rapid approximator for takeover dynamics on a variety of spatially-explicit regular interaction topologies with varying population sizes. Strengths, limitations, and potential applications of the pair approximation to evolutionary computation are discussed.

GA-7: Dynamic Optimization, Noise, Surrogate Models

Room: Georgia West

Session Chair: Khaled Rasheed (University of Georgia)

14:00–14:25 **A Self-Organized Criticality Mutation Operator for Dynamic Optimization Problems**

Carlos M. Fernandes, J. J. Merelo, Vitorino Ramos, Agostinho C. Rosa

Genetic Algorithms, Dynamic Optimization Problems, Self-Organized Criticality

This paper investigates a new method for Genetic Algorithms mutation rate control, based on the Sandpile Model: Sandpile Mutation. The Sandpile is a complex system operating at a critical state between chaos and order. This state is known as Self-Organized Criticality (SOC) and is characterized by displaying scale invariant behavior. In the precise case of the Sandpile Model, by randomly and continuously dropping sand grains on top of a two dimensional grid lattice, a power-law relationship between the frequency and size of sand avalanches is observed. Unlike previous off-line approaches, the Sandpile Mutation dynamics adapts during the run of the algorithm in a self-organized manner constrained by the fitness values progression. This way, the mutation intensity not only changes along the search process, but also depends on the convergence stage of the algorithm, thus increasing its adaptability to the problem context. The resulting system evolves a wide range of mutation rates during search, with large avalanches appearing occasionally. This particular behavior appears to be well suited for function optimization in dynamic environments, where large amounts of genetic novelty are regularly needed in order to track the moving extrema. Experimental results confirm these assumptions.

14:25–14:50 **Dual-population Genetic Algorithm for Nonstationary Optimization**

Taejin Park, Ri Choe, Kwang Ryel Ryu

Genetic algorithm, multi-population GA, dual-population GA, nonstationary optimization, dynamic optimization

In order to solve nonstationary optimization problems efficiently, evolutionary algorithms need sufficient diversity to adapt to envi-ronmental changes. The dual-population genetic algorithm (DPGA) is a novel evolutionary algorithm that uses an extra population called the reserve population to provide additional diversity to the main population through crossbreeding. Preliminary experimental results on various periods and degrees of environmental change have shown that the distance between the two populations of DPGA is one of the most important factors that affect its per-formance. However, it is very difficult to determine the best popu-lation distance without prior knowledge about the given problem. This paper proposes a new DPGA that uses two reserve popula-tions (DPGA2). The reserve populations are at different distances from the main population. The information inflow from the reserve populations is controlled by survival selection. Experimental results show that DPGA2 shows a better performance than other evolutionary algorithms for nonstationary optimization problems without relying on prior knowledge about the problem.

15:15–15:40 **ASAGA: An Adaptive Surrogate-Assisted Genetic Algorithm**

Liang Shi, Khaled Rasheed

Genetic algorithms, Surrogate-assisted evolution, Adaptive Meta-modeling, Fitness approximation

Genetic algorithms (GAs) used in complex optimization domains usually need to perform a large number of fitness function evaluations in order to get near-optimal solutions. In real world application domains such as the engineering design problems, such evaluations might be extremely expensive computationally. It is therefore common to estimate or approximate the fitness using certain methods. A popular method is to construct a so called surrogate or meta-model to approximate the original fitness function, which can simulate the behavior of the original fitness function but can be evaluated much faster. It is usually difficult to determine which approximate model should be used and/or what the frequency of usage should be. The answer also varies depending on the individual problem. To solve this problem, an adaptive fitness approximation GA (ASAGA) is presented. ASAGA adaptively chooses the appropriate model type; adaptively adjusts the model complexity and the frequency of model usage according to time spent and model accuracy. ASAGA also introduces a stochastic penalty function method to handle constraints. Experiments show that ASAGA outperforms non-adaptive surrogate-assisted GAs with statistical significance.

RWA-9 Planning
Room: Georgia East
Session Chair:

14:00–14:25 **3-D Path Planning for the Navigation of Unmanned Aerial Vehicles by Using Evolutionary Algorithms**
Isil Hasircioglu, Haluk Rahmi Topcuoglu, Murat Ermis

Unmanned Aerial Vehicles, Path Planning, Genetic Algorithms, B-Spline Curves

Military missions are turning to more complicated and advanced automation technology for maximum endurance and efficiency as well as the minimum vital risks. The path planners which generate collision-free and optimized paths are needed to give autonomous operation capability to the Unmanned Aerial Vehicles (UAVs). This paper presents an off-line path planner for UAVs. The path planner is based on Evolutionary Algorithms (EA), in order to calculate a curved path line with desired attributes in a 3-D terrain. The flight path is represented by parameterized B-Spline curves by considering four objectives: the shortest path to the destination, the feasible path without terrain collision, the path with the desired minimum and maximum distance to the terrain, and the path which provides UAV to maneuver with an angle greater than the minimum radius of curvature. The generated path is represented with the coordinates of its control points being the genes of the chromosome of the EA. The proposed method was tested in several 3-D terrains, which are generated with various terrain generator methods that differ with respect to levels of smoothness of the terrain.

14:25–14:50 **Computational Scenario-based Capability Planning**
Hussein A. Abbass, Axel Bender, Hai Huong Dam, Stephen Baker, James Whitacre, Ruhul Sarker

Genetic algorithms, capability planning, long term planning, uncertainty.

Scenarios are pen-pictures of plausible futures, used for strategic planning. The aim of this investigation is to expand the horizon of scenario-based planning through computational models that are able to aid the analyst in the planning process. The investigation builds upon the advances of Information and Communication Technology (ICT) to create a novel, flexible and customizable computational capability-based planning methodology that is practical and theoretically sound. We will show how evolutionary computation, in particular evolutionary multi-objective optimization, can play a central role both as an optimizer and as a source for innovation.

14:50–15:15 **Evolutionary Path Planner for UAVs in Realistic Environments**
Jesus Manuel de la Cruz, Eva Besada-Portas, Luis Torre-Cubillo, Bonifacio Andres-Toro, Jose Antonio Lopez-Orozco

Multiobjective Evolutionary Algorithms, path planning, UAVs

This paper presents a path planner for Unmanned Air Vehicles (UAVs) based on Evolutionary Algorithms (EA) that can be used in realistic risky scenarios. The path returned by the algorithm fulfills and optimizes multiple criteria which (1) are calculated based on properties of real UAVs, terrains, radars and missiles, and (2) are used to rank the solutions according to the priority levels and goals selected for each mission. Developed originally to work with only one UAV, the planner currently allows us to obtain the optimal path of several UAVs that are flying simultaneously. It works globally offline and locally online to recalculate a part of the path when an unexpected threat appears. Finally, the effectiveness of the solutions given by this planner has been successfully tested against a simulator that implements a complex model of the UAV and its environment.

ACO-4: Swarm Applications and Topics
Room: Atlanta A
Session Chair:

14:00–14:25 **Swarm Intelligence in e-learning: A Learning Object Sequencing Agent based on Competencies**
Luis de-Marcos, José-Javier Martínez, Jose-Antonio Gutierrez

e-Learning, Learning Object (LO), Learning Object Sequencing, Competency, Particle Swarm Optimization (PSO), Swarm Intelligence

In e-learning initiatives content creators are usually required to arrange a set of learning resources in order to present them in a comprehensive way to the learner. Course materials are usually divided into reusable chunks called Learning Objects (LOs) and the ordered set of LOs is called sequence, so the process is called LO sequencing. In this paper an intelligent agent that performs

the LO sequencing process is presented. Metadata and competencies are used to define relations between LOs so that the sequencing problem can be characterized as a Constraint Satisfaction Problem (CSP) and artificial intelligent techniques can be used to solve it. A Particle Swarm Optimization (PSO) agent is proposed, built, tuned and tested. Results show that the agent succeeds in solving the problem and that it handles reasonably combinatorial explosion inherent to this kind of problems.

14:25–14:50 **Denial of Service Detection and Analysis Using Idiotypic Networks Paradigm**
Marek Ostaszewski, Pascal Bouvry, Franciszek Seredynski

Idiotypic Networks, Denial of Service

In this paper we present a novel intrusion detection architecture based on Idiotypic Network Theory (INIDS), that aims at dealing with large scale network attacks featuring variable properties, like Denial of Service (DoS). The proposed architecture performs dynamic and adaptive clustering of the network traffic for taking fast and effective countermeasures against such high-volume attacks. INIDS is evaluated on the MIT'99 dataset and outperforms previous approaches for DoS detection applied to this set.

14:50–15:15 **A Formal Performance Modeling Framework for Bio-inspired Ad Hoc Routing Protocols**
Muhammad Saleem, Syed Ali Khayam, Muddassar Farooq

Swarm Intelligence, Telecommunications, Routing and Layout, Mathematical Models, Wireless Ad Hoc Networks

Bio-inspired ad hoc routing is an active area of research. The designers of these algorithms predominantly evaluate the performance of their protocols with the help of simulation studies. Such studies are mostly scenario and simulator specific and their results cannot be generalized to other scenarios and simulators. Therefore, we argue that mathematical tools should be utilized to develop a consistent, provable and compatible formal framework in order to provide an unbiased evaluation of Bio-inspired ad hoc routing protocols. Motivated by this requirement, in this paper, we develop a probabilistic performance evaluation framework that can be used to model the following key performance metrics of an ad hoc routing algorithm: (1) routing overhead, (2) route optimality, and (3) energy consumption. We utilize this framework to model a well known Bee-inspired routing protocol for ad hoc sensor networks, BeeSensor. We also show that the proposed framework is generic enough and can easily be adapted to even model a classical routing protocol, Ad Hoc on Demand Distance Vector (AODV). The modeled metrics of the two algorithms not only allow unbiased performance comparison but also provide interesting insights into the parameters governing the behavior of these routing protocols.

15:15–15:40 **Criticality Dispersion in Swarms to Optimize N-tuples**
M.A. Hannan Bin Azhar, Farzin Deravi, Keith Dimond

Swarm intelligence, Self-Organized criticality, Weightless neural network, Machine Learning, Optimization, Pattern Recognition and classification.

Among numerous pattern recognition methods the neural network approach has been the subject of much research due to its ability to learn from a given collection of representative examples. This paper concerns with the optimization of a weightless neural network, which decomposes a given pattern into several sets of n points, termed n-tuples. A population-based stochastic optimization technique, known as Particle Swarm Optimization (PSO), has been used to select an optimal set of connectivity patterns to improve the recognition performance of such n-tuple classifiers. The original PSO was refined by combining it with a bio-inspired technique called the Self-Organized Criticality (SOC) to add diversity in the population for finding better solutions. The hybrid algorithms were adapted for the n-tuple system and the performance was measured in selecting better connectivity patterns. The aim was to improve the discriminating power of the classifier in recognizing handwritten characters by exploiting the criticality dispersion in the swarm population. This paper presents the implementation of the hybrid model in greater detail with the effect of criticality dispersion in finding better solutions.

RWA-7 User Interaction Advances
Room: Atlanta B
Session Chair:

14:00–14:25 **EFIT-V - Interactive Evolutionary Strategy for the Construction of Photo-Realistic Facial Composites**
Ben George, Stuart J. Gibson, Matthew I.S. Maylin, Christopher J. Solomon

Interactive Evolutionary Algorithm, Appearance Models, Facial Composites, Facial Synthesis

Facial composite systems are used to create a likeness to a suspect in criminal investigations. Traditional, feature-based facial composite systems rely on the witness' ability to recall individual features, provide verbal descriptions and then select them

from stored libraries of labelled features - a task which witnesses often find difficult. The EFIT-V facial composite system is based on different principles, employing a holistic (whole face) approach to construction. The witness is shown a number of randomly generated faces and is asked to select the one that best resembles the target. A genetic algorithm is then used to breed a new generation of faces based upon the selected individual. This process is repeated until the user is satisfied with the composite generated. This paper describes the main components and methodology of EFIT-V and showcases the strengths of the system.

14:25–14:50 **Eye on the prize: Using Overt Visual Attention to Drive Fitness for Interactive Evolutionary Computation**
Tim Holmes, Johannes Zanker

Design Synthesis, Fitness Evaluation, Genetic Algorithm, Visual Perception, Attention, Interactive Evolutionary Computation, Eye-movements

Interactive Evolutionary Computation (IEC) has been applied to art and design problems where the fitness of an individual is at least partially subjective. Applications usually present a population from which the preferred individuals are selected before the usual evolutionary operations are performed to produce the next generation. Large population sizes and numbers of generations impose significant demands on the user. This paper proposes that selecting by means of eye movements could reduce user fatigue without sacrificing quality of fitness assessment. In the first experiment, an eye-tracker is used to capture fixations and confirm the reliability of such a measure of attention as a fitness driver for subjective evaluation such as aesthetic preference. In a second experiment, the robustness and efficiency of this technique is investigated for varying population sizes, presentation durations and levels of fitness sampling. The results and their consequences for future IEC applications are discussed.

14:50–15:15 **Genetic Algorithms and the abc Music Notation Language for Rock Music Composition**
Tomasz Michal Oliwa

Genetic algorithms, Art and music, Heuristics, Representations

In this paper a music composition system based on genetic algorithms (GAs) will be presented. It can create multi-instrumental, guitar-orientated rock music using objective measures for its fitness functions. The output of this system is a song in the MIDI format. Along with this system, a unique conversion procedure from numerical values to the abc language (and vice versa), which allows the combination of numerical optimization with the rich expressiveness of a music description language, will be shown. The described music composition system will be further compared to other composition systems.

15:15–15:40 **Using Coevolution to Understand and Validate Game Balance in Continuous Games**
Ryan Leigh, Justin Schonfeld, Sushil J. Louis

Games, Game Balance, Coevolution, Artificial Intelligence

We attack the problem of game balancing by using a coevolutionary algorithm to explore the space of possible game strategies and counter strategies. We define balanced games as games which have no single dominating strategy. Balanced games are more fun and provide a more interesting strategy space for players to explore. However, proving that a game is balanced mathematically may not be possible and industry commonly uses extensive and expensive human testing to balance games. We show how a coevolutionary algorithm can be used to test game balance and use the publicly available continuous state, capture-the-flag CaST game as our testbed. Our results show that we can use coevolution to highlight game imbalances in CaST and provide intuition towards balancing this game. This aids in eliminating dominating strategies, thus making the game more interesting as players must constantly adapt to opponent strategies.

Evolutionary Computation in Practice-6
Room: Atlanta D
Session Chair:

14:00–15:40 **Ask the Experts: Evolutionary Computation Questions from the Audience**
David Davis and Jörn Mehnen

Open panel discussion

EMO-5: Combinatorial Problems

Room: Buckhead

Session Chair: Carlos M Fonseca (University of Algarve)

14:00–14:25 **Graph Partitioning Through a Multi-Objective Evolutionary Algorithm: A Preliminary Study**

Dilip Datta, Jose Rui Figueira, Carlos M. Fonseca, Fernando Tavares-Pereira

Multi-objective optimization, evolutionary algorithms, partitioning problems.

The graph partitioning problem has numerous applications in various scientific fields. It usually involves the effective partitioning of a graph into a number of disjoint sub-graphs/ zones, and hence becomes a combinatorial optimization problem whose worst case complexity is NP-complete. The inadequacies of exact methods, like linear and integer programming approaches, to handle large-size instances of the combinatorial problems have motivated heuristic techniques to these problems. In the present work, a multi-objective evolutionary algorithm (MOEA), a kind of heuristic techniques, is developed for partitioning a graph under multiple objectives and constraints. The developed MOEA, which is a modified form of NSGA-II, is applied to four randomly generated graphs for partitioning them by optimizing three common objectives under five general constraints. The applications show that the MOEA is successful, in most of the cases, in achieving the expected results by partitioning a graph into a variable number of zones.

14:25–14:50 **Pareto Analysis for the Selection of Classifier Ensembles**

Eulanda M. Dos Santos, Robert Sabourin, Patrick Maupin

Classifier ensembles, ensemble selection, Pareto analysis, diversity measures

The overproduce-and-choose strategy involves the generation of an initial large pool of candidate classifiers and it is intended to test different candidate ensembles in order to select the best performing solution. The ensemble's error rate, ensemble size and diversity measures are the most frequent search criteria employed to guide this selection. By applying the error rate, we may accomplish the main objective in Pattern Recognition and Machine Learning, which is to find high-performance predictors. In terms of ensemble size, the hope is to increase the recognition rate while minimizing the number of classifiers in order to meet both the performance and low ensemble size requirements. Finally, ensembles can be more accurate than individual classifiers only when classifier members present diversity among themselves. In this paper we apply two Pareto front spread quality measures to analyze the relationship between the three main search criteria used in the overproduce-and-choose strategy. Experimental results conducted demonstrate that the combination of ensemble size and diversity does not produce conflicting multi-objective optimization problems. Moreover, we cannot decrease the generalization error rate by combining this pair of search criteria. However, when the error rate is combined with diversity or the ensemble size, we found that these measures are conflicting objective functions and that the performances of the solutions are much higher.

14:50–15:15 **Hybrid Genetic Algorithm for Dynamic Multi-objective Route Planning with Predicted Traffic in a Real-World Road Network**

Hitoshi Kanoh, Kenta Hara

multi-objective optimization, genetic algorithm, Dijkstra algorithm, hybrid, dynamic, planning, route, prediction, traffic, road network, real-world, transportation

Car navigation equipment in practical use has treated a route planning problem as a single-objective problem. In this paper, we formulate the problem as a dynamic multi-objective problem and show how it can be solved using a GA. There are three objective functions to optimize simultaneously in this problem: route length, travel time that changes rapidly with time, and ease of driving. The proposed method gives the Pareto-optimal set by using both the predicted traffic and a hybrid multi-objective GA (GA + Dijkstra algorithm) so that a driver can choose a favorite route after looking at feasible ones. We give the results of experiments comparing the proposed method with the Dijkstra algorithm and the single-objective GA in applications with a real road map and real traffic data in wide-area road network.

Late Breaking Papers-4

Room: Peachtree
Session Chair:

14:00–14:25 **Bond-Graphs + Genetic Programming: Analysis of an Automatically Synthesized Rotary Mechanical System**
Saheeb Ahmed Kayani, Muhammad Afzaal Malik

Bond-Graphs, Object Oriented Modeling, Genetic Programming, Unified/Automated Design, Topology Synthesis, Multi Energy Domain Dynamic or Mechatronic Systems, Rotary Mechanical Systems, Physical Design Realization, Dynamic Analysis

Initial results of an experiment devised to combine Bond-Graph modeling and simulation with genetic programming for automated design of a simple mechatronic system are reported in [1]. Two target eigen values are specified on complex plane and a Bond-Graph model is evolved through automated design scheme outlined in [1]. As a further development this research paper presents physical design realization based on the evolved Bond-Graph model. The physical design realization yields a second order open loop system. It is analyzed from a control systems stand point to determine system s dynamic characteristics. The dynamic analysis shows that damping ratio is 0.591 so we observe underdamped transient response typical of a system with complex conjugate poles.

14:25–14:50 **Evolutionary Design of Extractants For the Separation of Organic Compounds From Aqueous Streams By Liquid Extraction**
Juan Carlos Serrato, Luis A. Caicedo, Jonatan Gomez

Camd, adaptive genetic algorithm, extractants

Industry poses different separations problems for diverse compounds recovery. Separation stage is very important on the product cost, especially for the biotechnological products. Liquid-liquid extraction is a widely used separation operation; however it requires separation agents that must fulfill conditions such as low toxicity, high distribution coefficient and selectivity, among others. Therefore, different approaches have been developed to tackle this problem, being computer aided molecular design the most promising alternative. It is an optimization process looking for the best group combination to successfully perform some objective in a given process, including some physical, feasibility and process restrictions. To solve this problem we present a new genetic algorithm that does not show some limitations present in early works.

14:50–15:15 **Self-Managing Agents for Dynamic Scheduling in Manufacturing**
Ana Madureira, Filipe Santos, Ivo Pereira

Autonomic Computing, Multi-Agent Systems, Bio-Inspired Techniques, Dynamic Scheduling

The main purpose of this paper is to propose a Multi-Agent Autonomic and Bio-Inspired based framework with self-managing capabilities to solve complex scheduling problems using cooperative negotiation. Scheduling resolution requires the intervention of highly skilled human problem-solvers. This is a very hard and challenging domain because current systems are becoming more and more complex, distributed, interconnected and subject to rapidly changing. A natural Autonomic Computing (AC) evolution in relation to Current Computing is to provide systems with Self-Managing ability with a minimum human interference.

15:15–15:40 **Logarithmic Differential Evolution (LDE) for Optimization of Kinetic Parameters in Pyrolysis of Biomass**
Pratik N Sheth, B V Babu

Biomass; Pyrolysis; Kinetics; Parameter Estimation; Modeling; Simulation; Optimization; Evolutionary Algorithm; Initialization; Mutation; Differential Evolution; Logarithmic

Pyrolysis is the thermal decomposition of organic matter under inert atmospheric conditions, leading to the release of volatiles and formation of char. It is also a first step in the biomass gasification. Understanding of kinetic parameters is essential for the design of a suitable pyrolysis reactor. In the proposed kinetic model of this study, the kinetic scheme of biomass decomposition by two competing reactions giving gaseous volatiles and solid charcoal is used. Differential evolution is used to find the kinetic parameters by minimizing the square of the error between the reported experimental data of thermogravimetry of hazelnut shell and simulated model predicted values of residual weight fraction. Logarithmic DE, an improved version of simple DE, is proposed by incorporating logarithmic initialization and logarithmic mutation to take care of wide ranges of variable values. Logarithmic DE is found to yield better kinetic parameters in terms of objective function and gave better fit with experimental data.

GA-8: Linkage, Constrained Optimization and Memetic GAs

Room: Georgia West

Session Chair: Quang Huy Nguyen (Nanyang Technological University)

16:10–16:35 **Search Space Reduction Technique for Constrained Optimization with Tiny Feasible Space**
Abu S. S. M. Barkat Ullah, Ruhul Sarker, David Cornforth

Evolutionary algorithms, evolutionary agent systems, genetic algorithms, agent-based systems, nonlinear programming, constrained optimization, search space reduction

The hurdles in solving Constrained Optimization Problems (COP) arise from the challenge of searching a huge variable space in order to locate feasible points with acceptable solution quality. It becomes even more challenging when the feasible space is very tiny compare to the search space. Usually, the quality of the initial solutions influences the performance of the algorithm in solving such problems. In this paper, we discuss an Evolutionary Agent System (EAS) for solving COPs. In EAS, we treat each individual in the population as an agent. To enhance the performance of EAS for solving COPs with tiny feasible space, we propose a Search Space Reduction Technique (SSRT) as an initial step of our algorithm. SSRT directs the selected infeasible agents in the initial population to move towards the feasible space. The performance of the proposed algorithm is tested on a number of test problems and a real world case problem. The experimental results show that SSRT not only improves the solution quality but also speed up the processing time of the algorithm.

16:35–17:00 **Non-genetic Transmission of Memes by Diffusion**
Quang Huy Nguyen, Yew Soon Ong, Meng Hiot Lim

Cellular automata, Genetic algorithms, Optimization, Local search

In recent years, there has been an increase in research activities on Memetic Algorithm (MA). MA works with memes; a meme being defined as the basic unit of cultural transmission, or imitation . In this respect, a Memetic Algorithm essentially refers to an algorithm that mimics the mechanisms of cultural evolution . To date, there has been significant effort in bringing MA closer to the idea of cultural evolution. In this paper we assess MAs from the perspectives of Universal Darwinism and Memetics . Subsequently, we propose a Diffusion Memetic Algorithm where the memetic material is transmitted by means of non-genetic transfer. Numerical studies are presented based on some of the commonly used synthetic problems in continuous optimization.

GP-6: Representations

Room: Georgia East

Session Chair: Lee Spector (Hampshire College)

16:10–16:35 **Memory with memory: Soft assignment in Genetic Programming**
Nicholas Freitag McPhee, Riccardo Poli

Linear GP, Genetic Programming, soft assignment, memory with memory, symbolic regression

Based in part on observations about the incremental nature of most state changes in biological systems, we introduce the idea of Memory with Memory in Genetic Programming (GP), where we use "soft" assignments to registers instead of the "hard" assignments used in most computer science (including traditional GP). Instead of having the new value completely overwrite the old value of the register, these soft assignments combine the old and new values. We then report on extensive empirical tests (a total of 12, 800 runs) on symbolic regression problems where Memory with Memory GP almost always does as well as traditional GP, while significantly outperforming it in several cases. Memory with Memory GP also tends to be far more consistent, having much less variation in its best-of-run fitnesses than traditional GP. The data suggest that Memory with Memory GP works by successively refining an approximate solution to the target problem. This means it can continue to improve (if slowly) over time, but that it is less likely to get the sort of exact solution that one might find with traditional GP. The use of soft assignment also means that Memory with Memory GP is much less likely to have truly ineffective code, but the action of successive refinement of approximations means that the average program size is often larger than with traditional GP.

16:35–17:00 **Genetic Programming with Polymorphic Types and Higher-Order Functions**
Franck Binard, Amy Felty

genetic programming, lambda calculus, polymorphism, types

This article introduces our new approach to program representation for genetic programming (GP). We replace the usual s-expression representation scheme by a strongly-typed abstraction-based representation scheme. This allows us to represent many typical computational structures by abstractions rather than by functions defined in the GP system's terminal set. The

result is a generic GP system that is able to express programming structures such as recursion and data types without explicit definitions. We demonstrate the expressive power of this approach by evolving simple boolean programs without defining a set of terminals. We also evolve programs that exhibit recursive behavior without explicitly defining recursion specific syntax in the terminal set. In this article, we present our approach and experimental results.

17:00–17:25 **Advanced Techniques for the Creation and Propagation of Modules in Cartesian Genetic Programming**
Paul Kaufmann, Marco Platzner

Cartesian genetic programming (CGP), embedded cartesian genetic programming (ECGP), automatically defined functions (ADFs), module acquisition, crossover operator

The choice of an appropriate hardware representation model is key to successful evolution of digital circuits. One of the most popular models is cartesian genetic programming, which encodes an array of logic gates into a chromosome. While several smaller circuits have been successfully evolved on this model, it lacks scalability. A recent approach towards scalable hardware evolution is based on the automated creation of modules from primitive gates. In this paper, we present two novel approaches for module creation, an age-based and a cone-based technique. Further, we detail a cone-based crossover operator for use with cartesian genetic programming. We evaluate the different techniques and compare them with related work. The results show that age-based module creation is highly effective, while cone-based approaches are only beneficial for regularly structured, multiple output functions such as multipliers.

RWA-8 Security Applications
Room: Atlanta B
Session Chair:

16:10–16:35 **MLS Security Policy Evolution with Genetic Programming**
Yow Tzu Lim, Pau Chen Cheng, Pankaj Rohatgi, John Andrew Clark

Genetic Programming, Policy Inference, Security Policy, MLS

In the early days a policy was a set of simple rules with a clear intuitive motivation that could be formalised to good effect. However the world is becoming much more complex. Subtle risk decisions may often need to be made and people are not always adept at expressing rationale for what they do. In this paper we investigate how policies can be inferred automatically using Genetic Programming (GP) from examples of decisions made. This allows us to discover a policy that may not formally have been documented, or else extract an underlying set of requirements by interpreting user decisions to posed "what if" scenarios. Three proof of concept experiments on MLS Bell-LaPadula, Budgetised MLS and Fuzzy MLS policies have been carried out. The results show this approach is promising.

16:35–17:00 **Evolving Similarity Functions for Code Plagiarism Detection**
Vic Ciesielski, Nelson Wu, Seyed Tahaghoghi

Similarity function, Okapi BM25

Detecting whether computer program code is a student's original work or has been copied from another student or some other source is a major problem for many universities. Detection methods based on the information retrieval concepts of indexing and similarity matching scale well to large collections of files, but require appropriate similarity functions for good performance. We have used particle swarm optimization and genetic programming to evolve similarity functions that are suited to computer program code. Using a training set of plagiarised and non-plagiarised programs we have evolved better parameter values for the previously published Okapi BM25 similarity function. We have then used genetic programming to evolve completely new similarity functions that do not conform to any predetermined structure. We found that the evolved similarity functions outperformed the human developed Okapi BM25 function. We also found that a detection system using the evolved functions was more accurate than the the best code plagiarism detection system in use today, and scales much better to large collections of files. The evolutionary computing techniques have been extremely useful in finding similarity functions that advance the state of the art in code plagiarism detection.

17:00–17:25 **Multi-Resistant Radar Jamming Using Genetic Algorithms**
Hans Jonas Fossum Moen, Stein Kristoffersen

Jamming technique design, Digital RF Memory, pulse-Doppler radar, constant false alarm rate, genetic algorithm, multi-objective optimization, multi-resistant optimization

The next generation of advanced self-protection jammers is expected to deliver effective and energy efficient jamming against modern air tracking radars. However, optimizing such experimental jammers is a challenging task. In this paper the novelty and applicability of using genetic algorithms (GA) for developing advanced digital radio frequency memory jammer techniques

against radars employing the constant false alarm rate detection algorithm are demonstrated. It is shown how GA can handle the large and complex solution space of the problem, finding a Pareto front in the problem domain of jammer transmitting power versus detectability, producing new jamming techniques and fresh insight into the complex radar-jammer dynamics. As a main result, it is demonstrated how GA is capable of producing effective multi-resistant jamming techniques. This is an important jamming property when operating against uncertain radar detection algorithms in real world scenarios. Furthermore, single- and multi-resistant jamming techniques are shown to handle noisy environments, and the important issue of jamming robustness against varying target radar cross section is addressed. The energy efficiency of GA jamming techniques is investigated by comparing the efficiency of more conventional noise jamming techniques.

SBSE-2: SBSE Modeling and Resource Constraints

Room: Buckhead

Session Chair: Vahid Garousi (University of Calgary)

16:10–16:35 **Searching for Resource-Efficient Programs: Low-Power Pseudorandom Number Generators**

David R White, John Clark, Jeremy Jacob, Simon M Poulding

Search Based Software Engineering, Automatic Programming, Genetic Programming, Multi-Objective Optimisation, Non-functional Requirements

Non-functional properties of software, such as power consumption and memory usage, are important factors in designing software for resource-constrained platforms. This is an area where Search-Based Software Engineering has yet to be applied, and this paper investigates the potential of using Genetic Programming and Multi-Objective Optimisation as key tools in satisfying non-functional requirements. We outline the benefits of such an approach and give an example application of evolving pseudorandom number generators and performing power-functionality trade-offs.

16:35–17:00 **Avida-MDE: A Digital Evolution Approach to Generating Models of Adaptive Software Behavior**

Heather J. Goldsby, Betty H.C. Cheng

Digital evolution, model checking, model-driven engineering, autonomic computing

Increasingly, high-assurance applications rely on autonomic systems to respond to changes in their environment. The inherent uncertainty present in the environment of autonomic systems makes it difficult for developers to identify and model resilient autonomic behavior prior to deployment. In this paper, we propose Avida-MDE, a digital evolution approach to the generation of behavioral models (i.e., a set of interacting finite state machines) that capture autonomic system behavior that is potentially resilient to a variety of environmental conditions. We use an evolving population of digital organisms to generate behavioral models, where the organisms are subjected to natural selection and are rewarded for generating behavioral models that meet developer requirements. To illustrate this approach, we successfully applied it to the generation of behavioral models describing the navigation behavior of an autonomous robot.

17:00–17:25 **Finding Deadlocks in Large Concurrent Java Programs Using Genetic Algorithms**

Marco Ferreira, Enrique Alba, Francisco Chicano, Juan Gomez-Pulido

Genetic Algorithm, Memory Operator, Graph Search, Model Checking

Model checking is a fully automatic technique for checking concurrent software properties in which the states of a concurrent system are explored in an explicit or implicit way. However, the state explosion problem limits the size of the models that are possible to check. Genetic Algorithms (GAs) are metaheuristic techniques that have obtained good results in problems in which exhaustive techniques fail due to the size of the search space. Unlike exact techniques, metaheuristic techniques cannot be used to verify that a program satisfies a given property, but they can find errors on the software using a lower amount of resources than exact techniques. In this paper, we compare a GA against classical exact techniques and we propose a new operator for this problem, called memory operator, which allows the GA to explore even larger search spaces. We implemented our ideas in the Java Pathfinder (JPF) model checker to validate them and present our results. To the best of our knowledge, this is the first implementation of a Genetic Algorithm in this model checker.

Late Breaking Papers-5

Room: Peachtree

Session Chair:

16:10–16:25 **Threshold Selecting: Best Possible Probability Distribution for Crossover Selection in Genetic Algorithms**

Jörg Lässig, Karl Heinz Hoffmann, Mihaela Enachescu

Genetic Algorithms, Crossover Selection, Markov Process, Master Equation, Threshold Selecting

The paper considers the problem of selecting individuals in the current population in Genetic Algorithms for crossover to find a solution of high fitness of a given combinatorial optimization problem. Many different schemes have been considered in literature as possible selection strategies, such as Windowing, Exponential reduction, Linear transformation or normalization and Binary Tournament selection. It is shown that if one wishes to maximize any linear function of the final state probabilities, e.g. the fitness of the best individual of the final population of the algorithm, then the best probability distribution for selecting individuals in each generation is a rectangular distribution over the individuals sorted by their fitness values. This means uniform probabilities have to be assigned to a group of the best individuals of the population but probabilities equal to zero to individuals with fitness ranks higher than a fixed cutoff, which is equal to a certain rank in the sorted fitness vector. The considered strategy is called Threshold Selecting. The proof applies basic arguments of Markov chains and linear optimization and makes only a few assumptions on the underlying principles and hence applies to a large class of Genetic Algorithms.

16:25–16:40 **Using Quotient Graphs to Model Neutrality in Evolutionary Search**

Dominic Wilson, Devinder Kaur

Quotient sets, Degenerate Code, Fitness Distance Correlation, Neutral Evolution

We introduce quotient graphs for modeling neutrality in evolutionary search. We demonstrate that for a variety of evolutionary computing problems, search can be characterized by grouping genes with similar fitness and search behavior into quotient sets. These sets can potentially reduce the degrees of freedom needed for modeling evolutionary behavior without any loss of accuracy in such models. Quotients sets, which are also shown to be Markov models, aid in understanding the nature of search. We explain how to calculate Fitness Distance Correlation (FDC) through quotient graphs, and why different problems can have the same FDC but have different dynamics. Quotient models also allow visualization of correlated evolutionary drives.

16:40–16:55 **A Novel Methodology For Diversity Preservation In Evolutionary Algorithms**

Giovanni Squillero, Alberto Paolo Tonda

Evolutionary Algorithms, Diversity Preservation

In this paper we describe an improvement of an entropy-based diversity preservation approach for evolutionary algorithms. This approach exploits the information contained not only in the parts that compose an individual, but also in their position and relative order. We executed a set of preliminary experiments in order to test the new approach, using two different problems in which diversity preservation plays a major role in obtaining good solutions.

16:55–17:10 **Evolutionary Algorithm Considering Program Size: Efficient Program Evolution using GRAPE**

Shinichi Shirakawa, Tomoharu Nagao

Automatic Programming, Genetic Programming, Generation Alternation Model, Graph-based Genetic Programming, Evolutionary Algorithm, Genetic Algorithm

Today, a lot of Automatic Programming techniques have been proposed and applied various fields. Graph Structured Program Evolution (GRAPE) is one of the recent Automatic Programming techniques. GRAPE succeeds in generating the complex programs automatically. In this paper, a new generation alternation model for GRAPE, called Evolutionary Algorithm Considering Program Size (EACP), is proposed. EACP maintains the diversity of program size in the population by using particular fitness assignment and generation alternation. We apply EACP to three test problems, factorial, exponentiation and sorting a list. And we show the effectiveness of EACP and confirm evolution of maintaining the diversity of program size.

17:10–17:25 **Double-deck Elevator System using Genetic Network Programming with Genetic Operators based on Pheromone Information**
Lu Yu, Jin Zhou, Fengming Ye, Shingo Mabu, Kaoru Shimada, Kotaro Hirasawa, Sandor Markon

Elevator Group Supervisory Control System, Genetic Network Programming, ant colony optimization, genetic operator, hybrid algorithm

Genetic Network Programming (GNP), one of the extended evolutionary algorithms was proposed, whose gene is constructed by the directed graph. GNP is distinguished from other evolutionary techniques in terms of its compact structure and implicit memory function. GNP can perform a global searching, but it lacks of the exploitation ability. Since the behavior of GNP is characterized by the balance between exploitation and exploration in the search space, we proposed a hybrid algorithm in this paper that combines GNP with Ant Colony Optimization (ACO). The genetic operators are operated using the pheromone information in some special generations. We applied the proposed hybrid algorithm to a complicated real world problem, that is , Elevator Group Supervisory Control System (EGSCS). The simulation results showed the effectiveness of the proposed algorithm.

17:25–17:40 **Risk Prediction and Risk Factors Identification from Imbalanced Data with RPMBGA+**
Topon K Paul, Ken Ueno, Koichiro Iwata, Toshio Hayashi, Nobuyoshi Honda

Risk prediction, feature selection, classification, rare event, imbalanced data, genetic algorithm, fitness evaluation

In this paper, we propose a new method to predict the risk of an event very accurately from imbalanced data in which the number of instances of the majority class is very larger than that of the minority class and to identify the features that are relevant for the target risk factor. To solve the trade-off between the prediction rates of the majority and the minority classes, three input parameters are used, which supply the costs of misclassification of an instance from the majority and the minority classes or the sensitivity threshold of the minority class. To get relevant features and to utilize the prior information about the relationship of a feature with the target risk factor, a probabilistic model building genetic algorithm called RPMBGA+ is employed. By applying the proposed technique to the health checkup and lifestyle data of Toshiba Corporation, we have found that the proposed method improves the sensitivity of the minority class and selects a very small number of informative features.

2nd Annual Job Shop

Room: Atlanta C

Session Chair:

16:10–17:50 **For attendees looking for positions in academia or in industry, and for employers looking to hire**
No advance scheduling required, but job seekers and employers are encouraged to sign up at the Registration Desk.

Job seekers, bring your resume and publications and be prepared for brief 1-on-1 meetings with Employers. Employers, bring job descriptions and be prepared to make a quick announcement about your job(s) at the beginning of the Job Shop.

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- Programs to address the continuing education needs of computing professionals. A notable program is the Professional Knowledge Program, an online course on security. Please also see the Call for Proposals for new PKP modules.
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The Special Interest Group for Genetic and Evolutionary Computation, or SIGEVO, for short, is the parent organization of GECCO. The dues for SIGEVO are only $25/year for non-students, and $10/year for student members. Among the member benefits are a major discount for GECCO registration ($75 for SIGEVO or ACM members) and receipt of SIGEVO's brand new newsletter, SIGEVOlution! The first issue of SIGEvolutions, under the editorship of Pier Luca Lanzi, was issued in April, 2006. We hope you'll submit announcements and brief articles of interest to SIGEVO members to Pier Luca at lanzi@elet.polimi.it

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The **ACM Special Interest Group on Genetic and Evolutionary Computation** (SIGEVO) operates an annual Genetic and Evolutionary Computation Conference (GECCO) (combining the formerly held International Conference on Genetic Algorithms and Genetic Programming Conferences), supports and periodically operates other specialized conferences and events, provides support for student participation in the activities of the organization and educational activities, and promotes public information about the field of genetic and evolutionary computation.

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