EVOSTAR CONFERENCE HANDBOOK

EvoStar conferences held in Porto, Portugal
30 March – 1 April 2016

Overview Programme

Wednesday 30 March			
0845-0930	Registrations		
0930-0945	Conference opening		
0945-1045	Plenary invited talk: "*The Evolution of Beagle : confessions of a mongrel rule-breeder*" by Richard Forsyth		
1045-1110	Coffee break		
	room 1	room 2	room 3
1110-1300	EuroGP 1	EvoMusArt 1	EvoApplications 1
1300-1400	Lunch		
1400-1550	EuroGP 2	EvoMusArt 2	EvoApplications 2
1600-1700	Poster session 1 with coffee break		
1700-1850	EuroGP 3	EvoMusArt 3	EvoApplications 3
2000-2130	Conference reception		

Thursday 31 March			
	room 1	room 2	room 3
0930-1110	EvoApplications 4	EvoApplications 5	EvoApplications 6
1110-1130	Coffee break		
1130-1310	EvoApplications 7	EvoCOP 1	EvoApplications 8
1310-1415	Lunch		
1415-1555	EvoApplications 9	EvoCOP 2	EvoApplications 10
1555-1615	Coffee break		
1615-1745	EvoApplications 11	EvoCOP 3	EvoApplications 12
1930-2200	Conference dinner		

Friday 1 April			
0930-1030	Poster session 2 with coffee break		
1030-1130	Plenary invited talk: *Metaphors in metaheuristics - a symptom of a deeper ailment?* by Kenneth Sörensen		
	room 1	room 2	room 3
1130-1300	EvoApplications 13	EvoCOP 4	EvoApplications 14
1300-1330	Conference closing including best paper presentations		
1330-1415	Lunch		
1430-1700	Optional afternoon social trip : tour of Porto		

Acknowledgements

EvoStar gratefully acknowledges:

Invited speakers
Richard Forsyth and **Kenneth Sörensen**

The **Programme Chairs** and **Programme Committees** of all EvoStar events

local organisers **Ernesto Costa & Penousal Machado** (University of Coimbra)
together with help from João Correia, Ana Rodrigues, Filipe Assunção, João Cunha, Tiago Martins, Catarina Maçãs, Evgheni Polisciuc, António Leitão & Antonio Cruz

Pablo García Sánchez (University of Granada) for EvoStar Website and Publicity

Marc Schoenauer (INRIA Saclay - Île-de-France)
for continued assistance in providing MyReview conference management system

Edinburgh Napier University, UK
for EvoStar coordination and financial administration

EvoStar Handbook produced by **Jennifer Willies**, EvoStar Coordinator

Contents

EvoStar 2016 Organisers

EuroGP

19th European Conference on Genetic Programming

EuroGP programme chairs :
Malcolm Heywood, Dalhousie University, Canada
James McDermott, University College Dublin, Ireland

EuroGP publication chair :
Mauro Castelli, NOVA IMS, Universidade Nova de Lisboa, Portugal

EvoCOP

16th European Conference on Evolutionary Computation in Combinatorial Optimisation

EvoCOP programme chairs :
Francisco Chicano, University of Malaga, Spain
Bin Hu, Austrian Institute of Technology, Austria

EvoMUSART

5th International Conference on Evolutionary and Biologically Inspired Music, Sound, Art and Design

EvoMUSART programme chairs :
Colin Johnson, University of Kent, UK
Vic Ciesielski, RMIT University, Australia

EvoMUSART Publication chair :
João Correia, University of Coimbra, Portugal

EvoAPPLICATIONS

19th European Conference on the Applications of Evolutionary Computation

EvoApplications coordinator :
Giovanni Squillero, Politecnico di Torino, Italy ain

EvoAPPS publication chair :
Paolo Burelli, xxxxx

Track chairs :

EvoBAFIN : Natural Computing Methods in Business Analytics & Finance
Anthony Brabazon, University College Dublin, Ireland
Michael Kampouridis, University of Kent, UK

EvoBIO : Evolutionary Computation, Machine Learning and Data Mining in Computational Biology
Jaume Bacardit, Newcastle University, Newcastle, UK
Federico Divina, Universidad Pablo de Olavide, Sevilla, Spain
Ting Hu, Memorial University, St. John's, NL Canada

EvoCOMNET : Application of Nature-inspired Techniques for Communication Networks and other Parallel and Distributed Systems
Ivanoe De Falco, ICAR/CNR, Italy
Antonio Della Cioppa, University of Salerno, Italy
Ernesto Tarantino, ICAR/CNR, Italy

EvoStar 2016 Organisers

EvoCOMPLEX : Evolutionary Algorithms and Complex Systems
Carlos Cotta, Universidad de Málaga, Spain
Robert Schaefer, AGH University of Science and Technology, Poland

EvoENERGY : Evolutionary Algorithms in Energy Applications
Paul Kaufmann, University of Paderborn, Germany
Kyrre Glette, University of Oslo, Norway

EvoFIN : Natural Computing Methods in Finance and Economics
Alexandros Agapitos, University College Dublin, Ireland
Michael Kampouridis, University of Kent, UK

EvoGAMES : Bio-inspired Algorithms in Games
Paolo Burrelli, Aalborg University Copenhagen, Denmark
Antonio M. Mora Garcia, Universidad de Granada, Spain

EvoIASP : Evolutionary Computation in Image Analysis, Signal Processing and Pattern Recognition
Stefano Cagnoni, University of Parma, Italy
Mengjie Zhang, Victoria University of Wellington, New Zealand

EvoINDUSTRY : Evolutionary and Bio-Inspired Computational Techniques within Real-World Industrial and Commercial Environments
Kevin Sim, Edinburgh Napier University, UK
Neil Urquhart, Edinburgh Napier University, UK

EvoNUM : Bio-inspired algorithms for continuous parameter optimization
Anna I Esparcia-Alcázar, Universitat Politècnica de València, Spain

EvoPAR : Parallel Architectures and Distributed Infrastructures
Francisco Fernandez de Vega, University of Extremadura, Spain
J. Ignacio Hidalgo, Universidad Complutense de Madrid, Spain

EvoRISK : Computational Intelligence for Risk Management, Security and Defense Applications
Anna I Esparcia-Alcázar, Universitat Politècnica de València, Spain

EvoROBOT : Evolutionary Computation in Robotics
Evert Haasdijk, VU University Amsterdam, The Netherlands
A.E. Eiben, VU University Amsterdam, The Netherlands

EvoSTOC : Evolutionary Algorithms and Meta-heuristics in Stochastic and Dynamic Environments
Trung Thanh Nguyen, Liverpool John Moores University, UK
Michalis Mavrovouniotis, De Montfort University, UK

EvoStar 2016 publicity chair
Pablo García Sánchez, University of Granada, Spain

EvoStar 2016 local chairs
Penousal Machado, University of Coimbra, Portugal,
Ernesto Costa, University of Coimbra, Portuga

EvoStar coordinator
Jennifer Willies, Edinburgh Napier University, UK

Welcome to Porto

On behalf of all the EvoStar 2016 organisers, we are pleased to see you in Porto for the four co-located EvoStar conferences of EuroGP, EvoCOP, EvoMUSART and EvoAPPLICATIONS. We are presenting a total of 28 conference sessions with 126 papers presented over two and a half days. EvoStar is now in its 19th year and it arose out of workshops originally developed by EvoNet, the Network of Excellence in Evolutionary Computing, established by the European Commission. These events represent a continuity of research collaboration stretching back over 20 years.

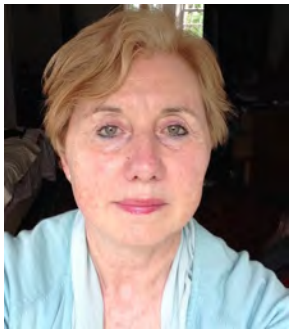
Again this year we have an exciting program with many high-quality contributions from the diverse fields within bio-inspired computation. All accepted papers will present a talk in a series of long and short presentations and all papers have been encouraged to present a poster in one of the two poster sessions (see p 16). The EvoStar events provide excellent opportunities to meet friends and establish new collaborative relationships within comfortable social settings. We are very pleased to include two inspiring invited talks from Richard Forsyth and Kenneth Sörensen (see p 10).

This year's EvoStar is held at the **Seminário de Vilar near** the town centre. Porto has been a UNESCO-recognised World Heritage Site for 20 years. It has a lot of historic character, beautiful buildings, interesting port cellars, and fabulous views of the Duoro, The conference reception will be held on Wednesday evening and the conference dinner will be held in the Ferreira port cellar, (more info on p 83-84)

Porto has a lot to offer so have a look at www.evostar.org/2016/location_about_porto.php for some suggestions for visiting this city. For those staying on Friday afternoon, we have organised a tour of some Porto highlights, (details are on p 86)

If you want more information or need any help, do not hesitate to ask at the conference desk or any of the local organisers. We wish you an enjoyable stay in Porto.

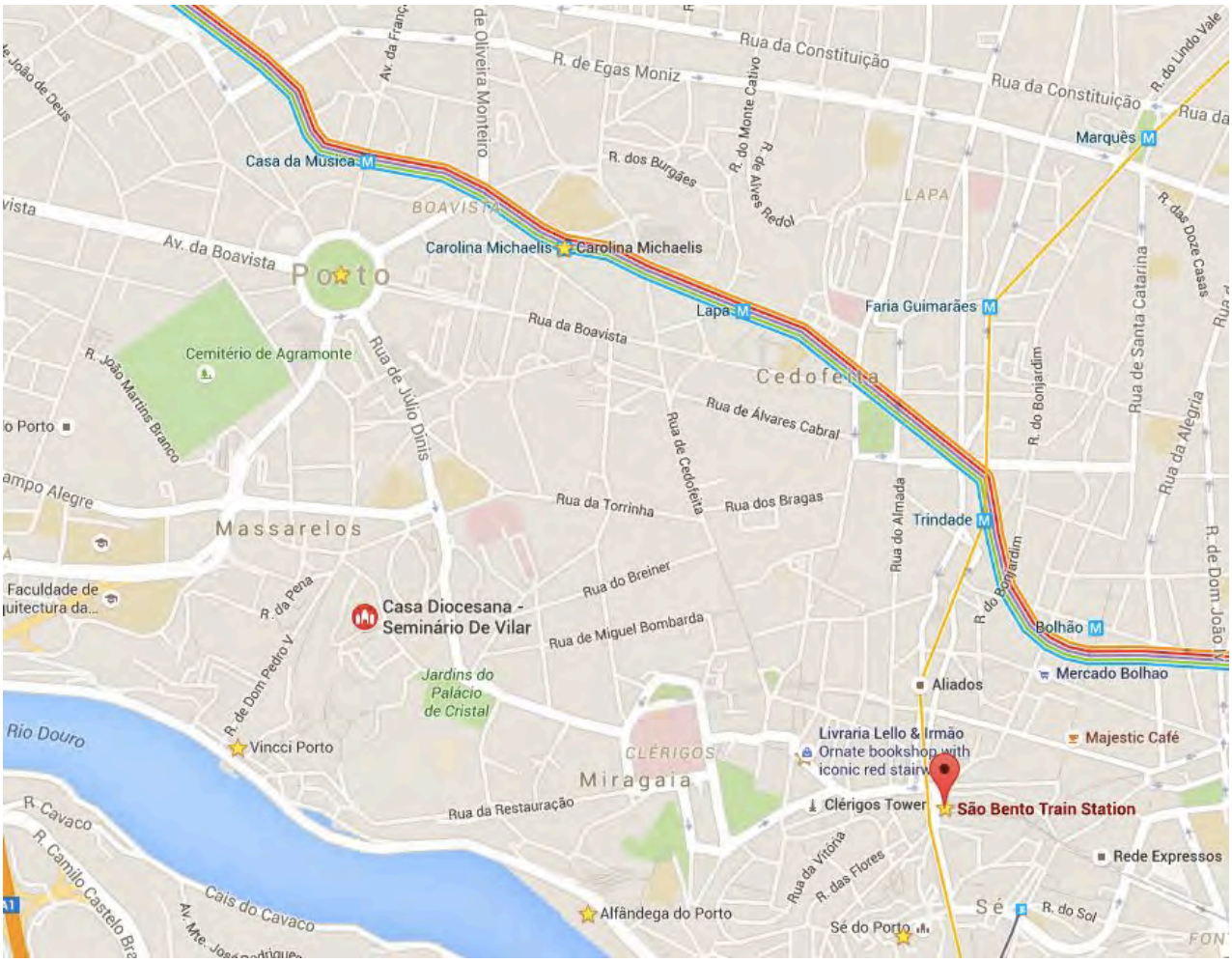
Local Organisers : Ernesto Costa and Penousal Machado



EvoStar Coordinator : Jennifer Willies

Getting around Porto

The conference venue is the Seminário de Vilar on Rua Arcediago Van Zeller 50, Porto 4050-621. The closest Metro stations are *Carolina Michaelis* and *Casa da Música* and the nearest railway station is *São Bento* station. Trains to and from Lisbon use the *Campanhã* station, to the east of the centre



Use Metro Line E (the Violet line) for airport connections, and the frequency of trains is approximately every 20-30 minutes from 0600-0100 and the journey from airport to the city centre takes about 25 minutes.

A single ticket costs €2.45 and there are also options for a 24 hour or 72 hour card for unlimited trips valid on the Porto transport network. This is done on a re-chargeable Andante ticket (keep your ticket to recharge for other journeys). Payment can be made in cash (notes/coins) and credit/debit cards. See http://metrodoporto.pt for more information including a metro map.

REMEMBER TO VALIDATE YOUR TICKET in the yellow machines before starting your journey, to avoid a hefty fine!

Invited speakers

Opening Talk on Wednesday, 30 March at 0945

Richard Forsyth

"The Evolution of Beagle : confessions of a mongrel rule-breeder "

This talk falls into three main parts (as recommended by Aristotle). First, a look back at the heady days of the 1980s when evolutionary computing had an appealing air of raffish unorthodoxy at a time of peak Prolog. This will include a biased perspective on the genealogy of Genetic Programming, summarized in a simple spreadsheet as a staircase of synthetic serendipity, which I intend to use to explore the issue of what exactly are the defining features of GP, and who decides. Then I plan to discuss some of the design choices that arose in reviving and revising BEAGLE, in the light of experience with earlier versions. Some of these choices were guided by experimental trials, whose results will be reported. This reporting will include coverage of a couple of apparently neat ideas that don't seem to work. Finally, I will look ahead to the evolution (sorry, hard to resist sometimes) of the field. This provides an opportunity to indulge in some crystal-ball-gazing at indistinct impressions of the cybernetworked dystopia awaiting our grandchildren if the big-data fanatics ever get their acts together -- while still leaving time for questions from the audience.

Richard Forsyth describes himself as a relic from the medieval period of evolutionary computing. In 1981, inspired by even earlier pioneers like Oliver Selfridge and Gordon Pask, he published an account of what was arguably the first working example of tree-structured program code optimized by evolutionary methods. Nowadays it would probably be called Genetic Programming. At the time he called it a Darwinian rule-learner trained by "naturalistic selection". The term didn't catch on. In 1985 he started selling a PC version of the BEAGLE rule-finder system (Biological Evolutionary Algorithm Generating Logical Expressions). He feels his fortunate lack of business acumen spared him from the fate of becoming a software billionaire. In consequence, he has spent most of the last 30 years in the lower echelons of Britain's "higher" education system. His peregrinations have taken him on a tour through a motley assortment of faculties, including Arts, Medicine, Science and Social Sciences. Released from the academic hamster-wheel, he has recently revived & revised BEAGLE, with a few novel twists that will be described in his talk. This activity has caused BEAGLE to give birth to a rather mischievous pup called RUNSTER (Regression Using Naturalistic Selection To Evolve Rules). Both these systems will soon be made freely available to all & sundry on Richard's website, www.richardsandesforsyth.net

Invited speakers

Closing Talk on Friday, 1 April at 10:30

Kenneth Sörensen

"Metaphors in metaheuristics - a symptom of a deeper ailment?"

Consensus is forming in (a large part of) the metaheuristics community that there is a problem with the current flood of "novel" metaphor-based methods. In the paper "Metaheuristics - the metaphor exposed", I have investigated why the field of heuristic optimization is especially vulnerable to this kind of bad science. In this talk, I further investigate this issue and arrive at the conclusion that the entire field of heuristic optimization is in need of an update of its standards.

Kenneth Sörensen (Antwerp, Belgium, 1974) holds a PhD from the University of Antwerp, obtained in 2003. Currently, he is a Research Professor of the Faculty of Applied Economics of the University of Antwerp. Within this Faculty, he founded the ANT/OR research group, that focuses on applications of operations research. Kenneth Sörensen has published a large number of articles in international refereed journals, and has presented his work at numerous scientic conferences. His main research interests are the application of advanced (metaheuristic) optimization methods and the development and study of optimization methods.

Kenneth Sörensen is the founder and current coordinator of the EURO working group EU/ME – the metaheuristics community, the largest online platform for researchers in metaheuristics worldwide. He is also associate editor of the Journal of Heuristics, International Transactions in Operational Research, and 4OR.
http://antor.ua.ac.be/kenneth.sorensen

Best paper nominations

Best paper prizes are presented during the EvoStar closing ceremony on Friday, 1 April at 13:00

EuroGP candidates

Evolutionary Approximation of Edge Detection Circuits
Petr Dvoracek, Lukas Sekanina

Surrogate Fitness via Factorization of Interaction Matrix
Paweł Liskowski, Krzysztof Krawiec

Scheduling in Heterogeneous Networks using Grammar-based Genetic Programming
David Lynch, Michael Fenton, Stepan Kucera, Holger Claussen, Michael O'Neill

On the Analysis of Simple Genetic Programming for Evolving Boolean Functions
Andrea Mambrini, Pietro S. Oliveto

EvoCOP candidates

Hyperplane Elimination for Quickly Enumerating Local Optima,
Brian W. Goldman, William F. Punch

Particle Swarm Optimisation with Sequence-Like Indirect Representation for Web Service Composition
Alexandre Sawczuk da Silva, Yi Mei, Hui Ma, Mengjie Zhang

Deconstructing the Big Valley Search Space Hypothesis,
Gabriela Ochoa, Nadarajen Veerapen

EvoMUSART candidates

Augmenting Live Coding with Evolved Patterns
Simon Hickinbotham and Susan Stepney

Computer-Aided Musical Orchestration Using an Artificial Immune System
José Abreu, Marcelo Caetano and Rui Penha

MetaCompose: A Compositional Evolutionary Music Composer
Marco Scirea, Julian Togelius, Peter Eklund and Sebastian Risi

Evolving Atomic Aesthetics and Dynamics
Edward Davies, Phillip Tew, David Glowacki, Jim Smith and Thomas Mitchell

Best paper nominations

EvoAPP candidates

Automating biomedical data science through tree-based pipeline optimization **(EvoBIO)**
Randal Olson, Ryan Urbanowicz, Peter Andrews, Nicole Lavender, La Creis Kidd, Jason Moore

An (MI)LP-based Metaheuristic for 3-Architecture Connected Facility Location in Urban Access Network Design **(EvoCOMNET)**
Fabio D'Andreagiovanni, Fabian Mett, Jonad Pulaj

Comparison of Multi-objective Evolutionary Optimization in Smart Building Scenarios **(EvoENERGY)**
Marlon Braun, Thomas Dengiz, Ingo Mauser, Hartmut Schmeck

Orthogonally Evolved AI to Improve Difficulty Adjustment in Video Games **(EvoGAMES)**
Arend Hintze, Randal Olson, Joel Lehman

Speaker Verification on Unbalanced Data with Genetic Programming **(EvoIASP)**
Roisin Loughran, Alexandros Agapitos, Ahmed Kattan, Anthony Brabazon, Michael O'Neill

Implementing Parallel Differential Evolution on Spark **(EvoPAR)**
Diego Teijeiro, Xoan C. Pardo, Patricia Gonzalez, Julio R. Banga, Ramon Doallo

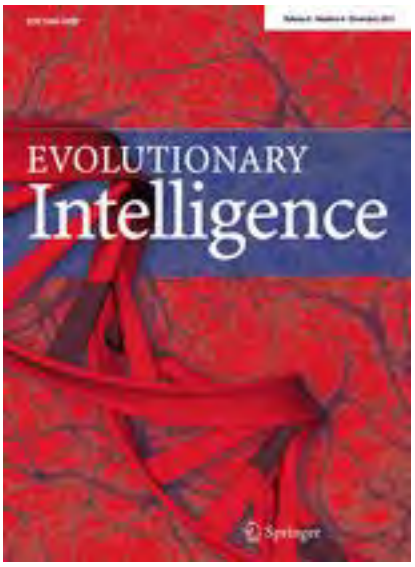
Direct Memory Schemes for Population-based Incremental Learning in Cyclically Changing Environments **(EvoSTOC)**
Michalis Mavrovouniotis, Shengxiang Yang

Sponsored Awards & Publications

Best **EvoROBOT** paper award

Frontiers in Robotics and AI has sponsored the EvoROBOT best paper award. The winner receives a full waiver of the publication fee for submission of an extended version of the work presented at EvoStar this year, with the final decision to publish the extended version made in conjunction with the Frontiers policies of originality and review.

EvoIASP : special issue on "*Evolutionary Image Analysis, Signal Processing and Pattern Recognition*" in Evolutionary Intelligence (Springer)



This year authors of the best papers accepted by the EvoIASP PC will be invited to submit an extended version of their paper, with the positive reviews forwarded to the journal reviewers, to an upcoming special issue of Springer's "Evolutionary Intelligence" (http://link.springer.com/journal/12065) on "Evolutionary Image Analysis, Signal Processing and Pattern Recognition".

EvoCOMNET best papers

A selection of the best papers, accepted for the EvoCOMNET track, suitably revised and extended, will be eligible for fast-track publication in Applied Soft Computing journal by Elsevier thanks to the technical sponsorship offered by the World Federation on Soft Computing.

Posterboard info

Poster boards are 1.25m width X 1.75m height and you can choose any display format within these dimensions

Two nearby printers are available if you prefer to print your poster onsite and details and approximate costs for colour printing on 180gr paper are shown below. Expect to wait about an hour for printing but you can send your PDF in advance.

www.qualquerideia.com : located approx 1km from the venue

R. Campo Alegre, 261, 4150-178 Porto
Colour A0: 21.12€
Colour A1: 10.56€

Can be sent by WeTransfer or Dropbox to:
qualquerideia@qualquerideia.com
Be sure to send in PDF format in the correct size!

www.grafipronto.pt : located approx 1.3km from the venue

Shopping Cidade do Porto, R. de Gonçalo Sampaio 350, 4150-365, Porto
Colour A0: 19€
Colour A1: 13.5€

Can be sent by WeTransfer to:
cidadedoporto@grafipronto.pt
Be sure to send in PDF format in the correct size!

Blu-Tac or similar sticky adhesive tack can be used on the poster boards (but not pins or staples). Fixing materials for the posters will be given out at the conference venue.

Storage facilities for poster tubes will be available at the conference office, remember to label your's clearly.

EvoStar poster session I

Wednesday 30 March 1600 - 1700

"Turingalila" Visual Music on the theme of Morphogenesis, Terry Trickett

A Decentralized PSO with Decoder for Scheduling Distributed Electricity Generation, Jorg Bremer, Sebastian Lehnhoff

A Distributed Intrusion Detection Framework based on Evolved Specialized Ensembles of Classifiers, Gianluigi Folino, Francesco Sergio Pisani, Pietro Sabatino

A Genetic Programming Approach for the Traffic Signal Control Problem with Epigenetic Modifications, Esteban Ricalde, Wolfgang Banzhaf

A Genetic Programming-based Imputation Method for Classification with Missing Data, Cao Truong Tran, Mengjie Zhang, Peter Andreae

A Hybrid Constructive Mat-heuristic Algorithm for the Heterogeneous Vehicle Routing Problem with Simultaneous Pickup and Delivery, Baris Kececi, Fulya Altiparmak, Imdat Kara

A Memory-Based NSGA-II Algorithm for Dynamic Multi-Objective Optimization Problems, Shaaban Sahmoud, Haluk Topcuoglu

A Multi-objective Genetic Programming Biomarker Detection Approach in Mass Spectrometry Data, Soha Ahmed, Mengjie Zhang, Lifeng Peng, Bing Xue

A spatially-structured PCG method for content diversity in a Physics-based simulation game, Raul Lara-Cabrera, Alejandro Gutierrez-Alcoba, Antonio Jose' Fernandez-Leiva

A Wrapper Feature Selection Approach to Classification with Missing Data, Cao Truong Tran, Mengjie Zhang, Peter Andreae, Bing Xue

Addressing high dimensional multi-objective optimization problems by coevolutionary islands with overlapping search spaces, Pablo Garcia-Sanchez, Julio Ortega, Jesús Gonzalez, Pedro A. Castillo, Juan J. Merelo

An Evolutionary Approach to the Full Optimization of the Traveling Thief Problem, Nuno Lourenço, Francisco B. Pereira, Ernesto Costa

Application of Evolutionary Algorithms for the Optimization of Genetic Regulatory Networks, Elise Rosati, Morgan Madec, Abir Rezgui, Quentin Colman, Nicolas Toussaint, Christophe Lallement, Pierre Collet

Benchmarking languages for evolutionary algorithms, JJ Merelo, Pedro Castillo, Israel Blancas, Gustavo Romero, Pablo Garcia-Sánchez, Antonio Fernandez-Ares, Víctor Rivas, Mario Garcia-Valdez

Bicliques in Graphs with Correlated Edges: From Artificial to Biological Networks, Aaron Kershenbaum, Alicia Cutillo, Christian Darabos, Murray Keitha, Schiaffino Robert, Jason H. Moore

Compilable phenotypes: Accelerating the evaluation of individuals in Grammatical Evolution, J. Manuel Colmenar, J. Ignacio Hidalgo, Juan Lanchares, Oscar Garnica, Jose-L. Risco-Martín, Ivan Contreras, Almudena Sanchez, J. Manuel Velasco

Construct, Merge, Solve & Adapt: Application to the Repetition-Free Longest Common Subsequence Problem, Christian Blum, Maria J. Blesa

Dangerousness Metric for Gene Regulated Car Driving, Sylvain Cussat-Blanc, Jean Disset, Stephane Sanchez

Design and Evaluation of an Extended Learning Classifier-based StarCraft Micro AI, Stefan Rudolph, Sebastian von Mammen, Johannes Jungbluth, Jorg Hahner

Discovering potential clinical profiles of Multiple Sclerosis from clinical and pathological free text data with Constraint Non-negative Matrix Factorization, Jacopo Acquarelli, Elena Marchiori, Monica Bianchini

Efficient Hill Climber for Multi-Objective Pseudo-Boolean Optimization, Francisco Chicano, Darrell Whitley, Renato Tinós

Electrical Load Pattern Shape Clustering using Ant Colony Optimization, Fernando Lezama, Ansel Y. Rodriguez, Enrique Munoz de Cote

Enhanced Multi-objective Population-Based Incremental Learning with Applications in Risk Treaty Optimization, Omar Andres Carmona Cortes, Andrew Rau-Chaplin

EvoStar poster session I

Wednesday 30 March 1600 - 1700

Evaluating hyperheuristics and local search operators for periodic routing problems, Yujie Chen, Philip Mourdjis, Fiona Polack, Peter Cowling, Stephen Remde

Evolutionary Algorithms for Finding Short Addition Chains: Going the Distance, Stjepan Picek, Carlos A. Coello Coello, Domagoj Jakobovic, Nele Mentens

Evolutionary Multi-objective Optimization for Portfolios in Emerging Markets: Contrasting Higher Moments and Median Models, Mai Ibrahim, Mohammed El-Beltagy, Motaz Khorshid

Evolving Chess-like Games Using Relative Algorithm Performance Profiles, Jakub Kowalski, Marek Szykula

Evolving classification models for prediction of patient recruitment in multicentre clinical trials using grammatical evolution, Gilyana Borlikova, Michael Phillips, Louis Smith, Michael O'Neill

Evolving Coverage Optimisation Functions for Heterogeneous Networks using Grammatical Genetic Programming, Michael Fenton, David Lynch, Stepan Kucera, Holger Claussen, Michael O'Neill

Evolving L-systems with Musical Notes, Ana Rodrigues, Ernesto Costa, Amílcar Cardoso, Penousal Machado and Tiago Cruz

Evolving Smoothing Kernels for Global Optimization, Paul Manns, Kay Hamacher

Exploring the Visual Styles of Arcade Game Assets, Antonios Liapis

Genetic Programming based Hyper-heuristics for Dynamic Job Shop Scheduling: Cooperative Coevolutionary Approaches, John Park, Yi Mei, Su Nguyen, Gang Chen, Mengjie Zhang

Genetic Programming for Region Detection, Feature Extraction, Feature Construction and Classification in Image Data, Andrew Lensen, Harith Al-Sahaf, Mengjie Zhang, Bing Xue

Genetic Programming with Memory for Financial Trading, Alexandros Agapitos, Anthony Brabazon, Michael O'Neill

Geometric Semantic Genetic Programming is Overkill, Tomasz P. Pawlak

GPU Accelerated Molecular Docking Simulation with Genetic Algorithms, Serkan Altuntas, Zeki Bozkus, Basilio B. Fraguela

Grammar Design for Derivation Tree Based Genetic Programming Systems, Stefan Forstenlechner, Miguel Nicolau, David Fagan, Michael O'Neill

Hybrid biclustering algorithms for data mining, Patryk Orzechowski, Krzysztof Boryczko

Hybrid Control for a Real Swarm Robotics System in an Intruder Detection Task, Miguel Duarte, Jorge Gomes, Vasco Costa, Sancho Moura Oliveira, Anders Lyhne Christensen

Hybrid Dynamic Resampling Algorithms for Evolutionary Multi-objective Optimization of Invariant-Noise Problems, Florian Siegmund, Amos H.C. Ng, Kalyanmoy Deb

Improving Fitness Functions in Genetic Programming for Classification on Unbalanced Credit Card Data, Van Loi Cao, Nhien-An Le-Khac, Michael O'Neill, Miguel Nicolau, James McDermott

Influence Maximization in Social Networks with Genetic Algorithms, Doina Bucur, Giovanni Iacca

Iterative Brush Path Extraction Algorithm for Aiding Flock Brush Simulation of Stroke-based Painterly Rendering, Tieta Putri and Ramakrishnan Mukundan

Joint Topology Optimization, Power Control and Spectrum Allocation for Intra-Vehicular Multi-hop Sensor Networks using Dandelion-encoded Heuristics, Javier Del Ser, Miren Nekane Bilbao, Cristina Perfecto, Gonzalez-Pardo, Sergio Campos-Cordobes

Limits to Learning in Reinforcement Learning Hyper-heuristics, Fawaz Alanazi, Per Kristian Lehre

Local Fitness Meta-Models with Nearest Neighbor Regression, Oliver Kramer

Measuring Diversity of Socio-cognitively Inspired ACO Search, Ewelina Swiderska, Jakub Lasisz, Aleksander Byrski,Tom Lenaerts, Dana Samson, Bipin Indurkhya, Ann Nowe, Marek Kisiel-Dorohinicki

Michal Wiglasz, Michaela Drahosova

Modelling Evolvability in Genetic Programming, Benjamin Fowler, Wolfgang Banzhaf

EvoStar poster session I

Wednesday 30 March 1600 - 1700

Modifying Colourings between Time-steps to Tackle Changes in Dynamic Random Graphs, Bradley Hardy, Rhyd Lewis, Jonathan Thompson

Mutual Information Estimation for Filter Based Feature Selection Using Particle Swarm Optimization, Bach Hoai Nguyen, Bing Xue, Peter Andreae

On the Closest Averaged Hausdorff Archive for a Circularly Convex Pareto Front, Gunter Rudolph, Oliver Schutze, Heike Trautmann

Particle Swarm Optimization for Multi-Objective Web Service Location Allocation, Boxiong Tan, Yi Mei, Hui Ma, Mengjie Zhang

Plastic Fitness Predictors Coevolved with Cartesian Programs

Plecto: A Low-level Interactive Genetic Algorithm for the Evolution of Audio, Steffan Ianigro and Oliver Bown

Portfolio Optimization, a Decision-Support Methodology for Small Budgets, Igor Deplano, Giovanni Squillero, Alberto Tonda

Search-Based SQL Injection Attacks Testing using Genetic Programming, Benjamin Aziz, Mohamed Bader, Cerana Hippolyte

Solving the Quadratic Assignment Problem with Cooperative Parallel Extremal Optimization, Danny Munera, Daniel Diaz, Salvador Abreu

The Emergence of Cooperation in Public Goods Games on Randomly Growing Dynamic Networks, Steve Miller, Joshua Knowles

The story of their lives: Massive procedural generation of heroes' journeys using evolved agent-based models and logical reasoning, Ruben H. Garcia-Ortega, Pablo Garcia-Sanchez, Juan J. Merelo, Aranzazu San-Gines, Angel Fernandez-Cabezas

There can be only one: Evolving RTS Bots via joust selection, Antonio Fernandez Ares, Pablo Garcia-Sanchez, Antonio Miguel Mora Garcia, Pedro A. Castillo, Juan J. Merelo

Towards Automated Strategies in Satisfiability Modulo Theory, Nicolás Gálvez Ramírez, Youssef Hamadi, Eric Monfroy, Frédéric Saubion

UAV Fleet Mobility Model with Multiple Pheromones for Tracking Moving Observation Targets, Christophe Atten, Loubna Channouf, Gregoire Danoy, Pascal Bouvry

Using Isovists to Evolve Terrains with Gameplay Elements, Andrew William Pech, Chiou-Peng Lam, Philip Hingston, Martin Masek

Validating the Grid Diversity Operator: an Infusion Technique for Diversity Maintenance in Population-based Optimisation Algorithms, Ahmed Salah, Emma Hart, Kevin Sim

EvoStar poster session II

Friday 1 April 0930 - 1030

A Comparison Between Representations for Evolving Images, Alessandro Re, Mauro Castelli, Leonardo Vanneschi

A Heuristic Crossover Enhanced Evolutionary Algorithm for Clustering Wireless Sensor Network, Muyiwa Olakanmi Oladimeji, Mikdam Turkey, Sandra Dudley

A Hybrid Discrete Artificial Bee Colony Algorithm for the Multicast Routing Problem, Yannis Marinakis, Magdalene Marinaki, Athanasios Migdalas

A hybrid genetic algorithm for the interaction of electricity retailers with demand response, Maria Joao Alves, Carlos Henggeler Antunes, Pedro Carrasqueira

A Property Preserving Method for Extending a Single-objective Problem Instance to Multiple Objectives with Specific Correlations, Ruby L. V. Moritz, Enrico Reich, Matthias Bernt, Martin Middendorf

A Variable Local Search based Memetic Algorithm for the Load Balancing Problem in Cloud Computing, Nasser Sabar, Andy Song, Mengjie Zhang

An (MI)LP-based Primal Heuristic for 3-Architecture Connected Facility Location in Urban Access Network Design, Fabio D'Andreagiovanni, Fabian Mett, Jonad Pulaj

An Evolutionary Composer for Real-Time Background Music, Roberto De Prisco, Delfina Malandrino, Gianluca Zaccagnino, Rocco Zaccagnino

Animating Typescript Using Aesthetically Evolved Images, Ashley Mills

Augmenting Live Coding with Evolved Patterns, Simon Hickinbotham and Susan Stepney

Automating biomedical data science through tree-based pipeline optimization, Randal Olson, Ryan Urbanowicz, Peter Andrews, Nicole Lavender, La Creis Kidd, Jason Moore

Bare-Bone Particle Swarm Optimisation for Simultaneously Discretising and Selecting Features For High-Dimensional Classification, Binh Tran, Mengjie Zhang, Bing Xue

Benchmarking dynamic three-dimensional bin packing problems using discrete-event simulation, Ran Wang, Trung Thanh Nguyen, Shayan Kavakeb, Zaili Yang, Changhe Li

Binary Tomography Reconstruction by Particle Aggregation, Mohammad Majid al-Rifaie, Tim Blackwell

Can Evolutionary Algorithms Beat Dynamic Programming for Hybrid Car Control? Tobias Rodemann, Ken Nishikawa

Challenging Anti-virus through Evolutionary Malware Obfuscation, Marco Gaudesi, Andrea Marcelli, Ernesto Sanchez, Giovanni Squillero, Alberto Tonda

Comparison of Multi-objective Evolutionary Optimization in Smart Building Scenarios, Marlon Braun, Thomas Dengiz, Ingo Mauser, Hartmut Schmeck

Computer-Aided Musical Orchestration Using an Artificial Immune System, José Abreu, Marcelo Caetano and Rui Penha

Constrained Level Generation through Grammar-Based Evolutionary Algorithms, Jose M. Font, Roberto Izquierdo, Daniel Manrique, Julian Togelius

Correlation Between Human Aesthetic Judgement and Spatial Complexity Measure, Mohammad Ali Javaheri Javid, Tim Blackwell, Robert Zimmer, Mohammad Majid al-Rifaie

Deconstructing the Big Valley Search Space Hypothesis, Gabriela Ochoa, Nadarajen Veerapen

Determining the Difficulty of Landscapes by PageRank Centrality in Local Optima Networks, Sebastian Herrmann

Direct Memory Schemes for Population-based Incremental Learning in Cyclically Changing Environments, Michalis Mavrovouniotis, Shengxiang Yang

ECJ+HADOOP: An easy way to deploy massive runs of evolutionary algorithm, Francisco Chavez, Francisco Fernandez, Cesar Benavides-Alvarez, Daniel Lanza, Juan Villegas, Leonardo Trujillo, Gustavo Olague, Graciela Roman

EvoStar poster session II

Friday 1 April 0930 - 1030

Environment-Model Based Testing with Differential Evolution in an Industrial Setting, Annamaria Szenkovits, Noemi Gasko, Erwan Jahier

Evolutionary Approximation of Edge Detection Circuits, Petr Dvoracek, Lukas Sekanina

Evolving Atomic Aesthetics and Dynamics, Edward Davies, Phillip Tew, David Glowacki, Jim Smith and Thomas Mitchell

Experimental Evaluation of Two Approaches to Optimal Recombination for Permutation Problems, Anton V. Eremeev, Julia V. Kovalenko

Fitness and Novelty in Evolutionary Art, Adriano Vinhas, Filipe Assunção, João Correia, Penousal Machado, Aniko Ekárt

Genetic Programming Algorithms for Dynamic Environments, Joao Macedo, Ernesto Costa, Lino Marques

Grammatical Music Composition with Dissimilarity Driven Hill Climbing, Róisín Loughran, James McDermott, Michael O'Neill

Hyperplane Elimination for Quickly Enumerating Local Optima, Brian W. Goldman, William F. Punch

Implementing Parallel Differential Evolution on Spark, Diego Teijeiro, Xoan C. Pardo, Patricia Gonzalez, Julio R. Banga, Ramon Doallo

Iterative Cartesian Genetic Programming: Creating general algorithms for solving Travelling Salesman Problems, Patricia Ryser-Welch, Julian F. Miller, Jerry Swan, Martin A. Trefzer

Leveraging Online Racing and Population Cloning in Evolutionary Multirobot Systems, Fernando Silva, Luis Correia, Anders Lyhne Christensen

MetaCompose: A Compositional Evolutionary Music Composer, Marco Scirea, Julian Togelius, Peter Eklund and Sebastian Risi

Multi-Agent Behavior-Based Policy Transfer

Multiwinner Voting in Genetic Algorithms for Solving Ill-Posed Global Optimization Problems, Piotr Faliszewski, Jakub Sawicki, Robert Schaefer, Maciej Smolka

NSGA-II based Auto-Calibration of Automatic Number Plate Recognition Camera for Vehicle Speed Measurement, Patryk Filipiak, Bartlomiej Golenko, Cezary Dolega

On Combinatorial Optimisation in Analysis of Protein-Protein Interaction and Protein Folding Networks, David Chalupa

On the Analysis of Simple Genetic Programming for Evolving Boolean Functions, Andrea Mambrini, Pietro S. Oliveto

On the Impact of Class Imbalance in GP Streaming Classification with Label Budgets, Sara Khanchi, Malcolm I. Heywood, Nur Zincir-Heywood

On-line Evolution of Foraging Behaviour in a Population of Real Robots, Jacqueline Heinerman, Alessandro Zonta, Evert Haasdijk, A.E.Eiben

One-class Classification for Anomaly Detection with Kernel Density Estimation and Genetic Programming, Van Loi Cao, Miguel Nicolau, James McDermott

Online Evolution for Multi-Action Adversarial Games, Niels Justesen, Tobias Mahlmann, Julian Togelius

Optimization of Operation and Control Strategies for Battery Energy Storage Systems by Evolutionary Algorithms, Jan Muller, Matthias Marz, Ingo Mauser, Hartmut Schmeck

Orthogonally Evolved AI to Improve Difficulty Adjustment in Video Games, Arend Hintze, Randal Olson, Joel Lehman

Particle Swarm Optimisation with Sequence-Like Indirect Representation for Web Service Composition, Alexandre Sawczuk da Silva, Yi Mei, Hui Ma, Mengjie Zhang

Patterns for Constructing Mutation Operators: Limiting the Search Space in a Software Engineering Application, Thomas Kühne, Heiko Hamann, Svetlana Arifulina, Gregor Engels

EvoStar poster session II

Friday 1 April 0930 - 1030

Population Based Ant Colony Optimization for Reconstructing ECG Signals, Yih-Chun Cheng, Tom Hartmann, Pei-Yun Tsai, Martin Middendorf

Reducing Efficiency of Connectivity-Splitting Attack on Newscast via Limited Gossip, Jakub Muszynski, Sebastien Varrette, Pascal Bouvry

Sabre Didi, Geoff Nitschke,

Scheduling in Heterogeneous Networks using Grammar-based Genetic Programming, David Lynch, Michael Fenton, Stepan Kucera, Holger Claussen, Michael O'Neill

Semantic Geometric Initialization, Tomasz P. Pawlak, Krzysztof Krawiec

Sim-EDA: A Multipopulation Estimation of Distribution Algorithm Based on Problem Similarity, Krzysztof Michalak

Simheuristics for the Multiobjective Nondeterministic Firefighter Problem in a Time-Constrained Setting, Krzysztof Michalak, Joshua D. Knowles

Speaker Verification on Unbalanced Data with Genetic Programming, Roisin Loughran, Alexandros Agapitos, Ahmed Kattan, Anthony Brabazon, Michael O'Neill

Stigmergy-Based Scheduling of Flexible Loads, Fredy Rios, Lukas Konig, Hartmut Schmeck

Surrogate Fitness via Factorization of Interaction Matrix, Paweł Liskowski, Krzysztof Krawiec

Towards Adaptive Evolutionary Architecture, Sebastian Hölt Bak, Nina Rask, Sebastian Risi

Towards intelligent biological control: Controlling Boolean networks with Boolean networks, Nadia S. Taou, David W. Corne, Michael A. Lones

Workforce Scheduling in Inbound Customer Call Centres With a Case Study, Goran Molnar, Domagoj Jakobovic, Matija Pavelic

EuroGP conference programme

Wednesday 30 March, room 1

1110-1300

EuroGP 1 : Models of Evolution

chairs : Malcolm Heywood & James McDermott

Genetic Programming based Hyper-heuristics for Dynamic Job Shop Scheduling: Cooperative Coevolutionary Approaches
John Park, Yi Mei, Su Nguyen, Gang Chen, Mengjie Zhang

A Genetic Programming Approach for the Traffic Signal Control Problem with Epigenetic Modifications
Esteban Ricalde, Wolfgang Banzhaf

Plastic Fitness Predictors Coevolved with Cartesian Programs
Michal Wiglasz, Michaela Drahosova

Search-Based SQL Injection Attacks Testing using Genetic Programming
Benjamin Aziz, Mohamed Bader, Cerana Hippolyte

Towards Automated Strategies in Satisfiability Modulo Theory
Nicolás Gálvez Ramírez, Youssef Hamadi, Eric Monfroy, Frédéric Saubion

Patterns for Constructing Mutation Operators: Limiting the Search Space in a Software Engineering Application
Thomas Kühne, Heiko Hamann, Svetlana Arifulina, Gregor Engels

Iterative Cartesian Genetic Programming: Creating general algorithms for solving Travelling Salesman Problems
Patricia Ryser-Welch, Julian F. Miller, Jerry Swan, Martin A. Trefzer

1300-1400 **Lunch**

1400-1550

EuroGP 2 : Classification

chair : Jerry Swan

One-class Classification for Anomaly Detection with Kernel Density Estimation and Genetic Programming
Van Loi Cao, Miguel Nicolau, James McDermott

On the Impact of Class Imbalance in GP Streaming Classification with Label Budgets
Sara Khanchi, Malcolm I. Heywood, Nur Zincir-Heywood

Genetic Programming for Region Detection, Feature Extraction, Feature Construction and Classification in Image Data
Andrew Lensen, Harith Al-Sahaf, Mengjie Zhang, Bing Xue

A Genetic Programming-based Imputation Method for Classification with Missing Data
Cao Truong Tran, Mengjie Zhang, Peter Andreae

Modelling Evolvability in Genetic Programming
Benjamin Fowler, Wolfgang Banzhaf

Grammar Design for Derivation Tree Based Genetic Programming Systems
Stefan Forstenlechner, Miguel Nicolau, David Fagan, Michael O'Neill

Geometric Semantic Genetic Programming is Overkill
Tomasz P. Pawlak

Semantic Geometric Initialization
Tomasz P. Pawlak, Krzysztof Krawiec

EuroGP conference programme

Wednesday 30 March, room 1	
1600-1700	**Poster session 1 with coffee break**
1700-1850	**EuroGP 3 : Best Papers** **chair : Mengjie Zhang** ***Evolutionary Approximation of Edge Detection Circuits*** **Petr Dvoracek, Lukas Sekanina** ***Surrogate Fitness via Factorization of Interaction Matrix*** **Paweł Liskowski, Krzysztof Krawiec** ***Scheduling in Heterogeneous Networks using Grammar-based Genetic Programming*** **David Lynch, Michael Fenton, Stepan Kucera, Holger Claussen, Michael O'Neill** ***On the Analysis of Simple Genetic Programming for Evolving Boolean Functions*** **Andrea Mambrini, Pietro S. Oliveto**

EuroGP session 1 : Models of Evolution

Wednesday 30 March 1110-1300

Room 1

session chairs : Malcolm Heywood & James McDermott

Genetic Programming based Hyper-heuristics for Dynamic Job Shop Scheduling: Cooperative Coevolutionary Approaches

John Park, Yi Mei, Su Nguyen, Gang Chen, Mengjie Zhang

Job shop scheduling (JSS) problems are optimisation problems that have been studied extensively due to their computational complexity and application in manufacturing systems. This paper focuses on a dynamic JSS problem to minimise the total weighted tardiness. In dynamic JSS, jobs' attributes are only revealed after they arrive at the shop floor. Dispatching rule heuristics are prominent approaches to dynamic JSS problems, and Genetic Programming based Hyper-heuristic (GP-HH) approaches have been proposed to automatically generate effective dispatching rules for dynamic JSS problems. Research on static JSS problems shows that high quality ensembles of dispatching rules can be evolved by a GP-HH that uses cooperative coevolution. Therefore, we compare two coevolutionary GP approaches to evolve ensembles of dispatching rules for dynamic JSS problem. First, we adapt the Multilevel Genetic Programming (MLGP) approach, which has never been applied to JSS problems. Second, we extend an existing approach for static JSS problem, called Ensemble Genetic Programming for Job Shop Scheduling (EGP-JSS), by adding “less-myopic” terminals that take job and machine attributes outside of the scope of the attributes commonly used in the literature. The results show that MLGP for JSS evolves ensembles that are significantly better than single “less-myopic” rules evolved using GP with only little difference in computation time. In addition, the rules evolved using EGP-JSS perform better than the MLGP-JSS rules, but MLGP-JSS evolves rules significantly faster than EGP-JSS.

A Genetic Programming Approach for the Traffic Signal Control Problem with Epigenetic Modifications

Esteban Ricalde, Wolfgang Banzhaf

This paper presents a proof-of-concept for an Epigenetics-based modification of Genetic Programming (GP). The modification is tested with a traffic signal control problem under dynamic traffic conditions. We describe the new algorithm and show first results. Experiments reveal that GP benefits from properties such as phenotype differentiation, memory consolidation within generations and environmentally-induced change in behavior provided by the epigenetic mechanism. The method can be extended to other dynamic environments.

Plastic Fitness Predictors Coevolved with Cartesian Programs

Michal Wiglasz, Michaela Drahosova

Coevolution of fitness predictors, which are a small sample of all training data for a particular task, was successfully used to reduce the computational cost of the design performed by cartesian genetic programming. However, it is necessary to specify the most advantageous number of fitness cases in predictors, which differs from task to task. This paper introduces a new type of directly encoded fitness predictors inspired by the principles of phenotypic plasticity. The size of the coevolved fitness predictor is adapted in response to the learning phase that the program evolution goes through. It is shown in 5 symbolic regression tasks that the proposed algorithm is able to adapt the number of fitness cases in predictors in response to the solved task and the program evolution flow.

EuroGP session 1 : Models of Evolution

Wednesday 30 March 1110-1300

Room 1

Short presentations: *Applications*

Search-Based SQL Injection Attacks Testing using Genetic Programming

Benjamin Aziz, Mohamed Bader, Cerana Hippolyte

Software testing is a key phase of many development methodologies as it provides a natural opportunity for integrating security early in the software development lifecycle. However despite the known importance of software testing, this phase is often overlooked as it is quite difficult and labour-intensive to obtain test datasets to effectively test an application. This lack of adequate automatic software testing renders software applications vulnerable to malicious attacks after they are deployed as detected software vulnerabilities start having an impact during the production phase. Among such attacks are SQL injection attacks. Exploitation of SQL injection vulnerabilities by malicious programs could result in severe consequences such as breaches of confidentiality and false authentication. It is therefore important that an application is adequately tested with a high volume of test data to ensure that it can withstand such attacks before it is deployed into the production phase. We present a search-based software testing technique to detect SQL injection vulnerabilities in software applications. This approach uses genetic programming as a means of generating our test datasets, which are then used to test applications for SQL injection-based vulnerabilities.

Towards Automated Strategies in Satisfiability Modulo Theory

Nicolás Gálvez Ramírez, Youssef Hamadi, Eric Monfroy, Frédéric Saubion

SMT solvers include many heuristic components in order to ease the theorem proving process for different logics and problems. Handling these heuristics is a non-trivial task requiring specific knowledge of many theories that even a SMT solver developer may be unaware of. This is the first barrier to break in order to allow end-users to control heuristics aspects of any SMT solver and to successfully build a strategy for their own purposes. We present a first attempt for generating an automatic selection of heuristics in order to improve SMT solver efficiency and to allow end-users to take better advantage of solvers when unknown problems are faced. Evidence of improvement is shown and the basis for future works with evolutionary and/or learning-based algorithms are raised.

Patterns for Constructing Mutation Operators: Limiting the Search Space in a Software Engineering Application

Thomas Kühne, Heiko Hamann, Svetlana Arifulina, Gregor Engels

We apply methods of genetic programming to a general problem from software engineering, namely example-based generation of specifications. In particular, we focus on model transformation by example. The definition and implementation of model transformations is a task frequently carried out by domain experts, hence, a (semi-)automatic approach is desirable. This application is challenging because the underlying search space has rich semantics, is high-dimensional, and unstructured. Hence, a computationally brute-force approach would be unscalable and potentially infeasible. To address that problem, we develop a sophisticated approach of designing complex mutation operators. We define “patterns” for constructing mutation operators and report a successful case study. Furthermore, the code of the evolved model transformation is required to have high maintainability and extensibility, that is, the code should be easily readable by domain experts. We report an evaluation of this approach in a software engineering case study.

Cont

EuroGP session 1 : Models of Evolution

Wednesday 30 March 1110-1300

Room 1

Short presentations: *Applications (cont)*

Iterative Cartesian Genetic Programming: Creating general algorithms for solving Travelling Salesman Problems

Patricia Ryser-Welch, Julian F. Miller, Jerry Swan, Martin A. Trefzer

Evolutionary algorithms have been widely used to optimise or design search algorithms, however, very few have considered evolving iterative algorithms. In this paper, we introduce a novel extension to Cartesian Genetic Programming that allows it to encode iterative algorithms. We apply this technique to the Traveling Salesman Problem to produce human-readable solvers which can be then be independently implemented. Our experimental results demonstrate that the evolved solvers scale well to much larger TSP instances than those used for training.

EuroGP session 2 : Classification

Wednesday 30 March 1400-1550

Room 1

session chair : Jerry Swan

One-class Classification for Anomaly Detection with Kernel Density Estimation and Genetic Programming

Van Loi Cao, Miguel Nicolau, James McDermott

A novel approach is proposed for fast anomaly detection by one-class classification. Standard kernel density estimation is first used to obtain an estimate of the input probability density function, based on the one-class input data. This can be used for anomaly detection: query points are classed as anomalies if their density is below some threshold. The disadvantage is that kernel density estimation is lazy, that is the bulk of the computation is performed at query time. For large datasets it can be slow. Therefore it is proposed to approximate the density function using genetic programming symbolic regression, before imposing the threshold. The runtime of the resulting genetic programming trees does not depend on the size of the training data. The method is tested on datasets including in the domain of network security. Results show that the genetic programming approximation is generally very good, and hence classification accuracy approaches or equals that when using kernel density estimation to carry out one-class classification directly. Results are also generally superior to another standard approach, one-class support vector machines.

On the Impact of Class Imbalance in GP Streaming Classification with Label Budgets

Sara Khanchi, Malcolm I. Heywood, Nur Zincir-Heywood

Streaming data scenarios introduce a set of requirements that do not exist under supervised learning paradigms typically employed for classification. Specific examples include, anytime operation, non-stationary processes, and limited label budgets. From the perspective of class imbalance, this implies that it is not even possible to guarantee that all classes are present in the samples of data used to construct a model. Moreover, when decisions are made regarding what subset of data to sample, no label information is available. Only after sampling is label information provided. This represents a more challenging task than encountered under non-streaming (offline) scenarios because the training partition contains label information. In this work, we investigate the utility of different protocols for sampling from the stream under the above constraints. Adopting a uniform sampling protocol was previously shown to be reasonably effective under both evolutionary and non-evolutionary streaming classifiers. In this work, we introduce a scheme for using the current “champion” classifier to bias the sampling of training instances during the course of the stream. The resulting streaming framework for genetic programming is more effective at sampling minor classes and therefore reacting to changes in the underlying process responsible for generating the data stream.

Genetic Programming for Region Detection, Feature Extraction, Feature Construction and Classification in Image Data

Andrew Lensen, Harith Al-Sahaf, Mengjie Zhang, Bing Xue

Image analysis is a key area in the computer vision domain that has many applications. Genetic Programming (GP) has been successfully applied to this area extensively, with promising results. High-level features extracted from methods such as Speeded Up Robust Features (SURF) and Histogram of Oriented Gradients (HoG) are commonly used for object detection with machine learning techniques. However, GP techniques are not often used with these methods, despite being applied extensively to image analysis problems. Combining the training process of GP with the powerful features extracted by SURF or HoG has the potential to improve the performance by generating high-level, domain-tailored features. This paper proposes a new GP method that

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Room 1

cont
automatically detects different regions of an image, extracts HoG features from those regions, and simultaneously evolves a classifier for image classification. By extending an existing GP region selection approach to incorporate the HoG algorithm, we present a novel way of using high-level features with GP for image classification. The ability of GP to explore a large search space in an efficient manner allows all stages of the new method to be optimised simultaneously, unlike in existing approaches. The new approach is applied across a range of datasets, with promising results when compared to a variety of well-known machine learning techniques. Some high-performing GP individuals are analysed to give insight into how GP can effectively be used with high-level features for image classification.

A Genetic Programming-based Imputation Method for Classification with Missing Data

Cao Truong Tran, Mengjie Zhang, Peter Andreae

Many industrial and real-world datasets suffer from an unavoidable problem of missing values. The ability to deal with missing values is an essential requirement for classification because inadequate treatment of missing values may lead to large errors on classification. The problem of missing data has been addressed extensively in the statistics literature, and also, but to a lesser extent in the classification literature. One of the most popular approaches to deal with missing data is to use imputation methods to fill missing values with plausible values. Some powerful imputation methods such as regression-based imputations in MICE are often suitable for batch imputation tasks. However, they are often expensive to impute missing values for every single incomplete instance in the unseen set for classification. This paper proposes a genetic programming-based imputation (GPI) method for classification with missing data that uses genetic programming as a regression method to impute missing values. The experiments on six benchmark datasets and five popular classifiers compare GPI with five other popular and advanced regression-based imputation methods in MICE on two measures: classification accuracy and computation time. The results showed that, in most cases, GPI achieves classification accuracy at least as good as the other imputation methods, and sometimes significantly better. However, using GPI to impute missing values for every single incomplete instance is dramatically faster than the other imputation methods.

Short presentations: *Foundations*

Modelling Evolvability in Genetic Programming

Benjamin Fowler, Wolfgang Banzhaf

We develop a tree-based genetic programming system capable of modelling evolvability during evolution through machine learning algorithms, and exploiting those models to increase the efficiency and final fitness. Existing methods of determining evolvability require too much computational time to be effective in any practical sense. By being able to model evolvability instead, computational time may be reduced. This will be done first by demonstrating the effectiveness of modelling these properties *a priori*, before expanding the system to show its effectiveness as evolution occurs.

EuroGP session 2 : Classification

Wednesday 30 March 1400-1550

Room 1

Grammar Design for Derivation Tree Based Genetic Programming Systems

Stefan Forstenlechner, Miguel Nicolau, David Fagan, Michael O'Neill

Grammar-based genetic programming systems have gained interest in recent decades and are widely used nowadays. Although researchers normally present the grammar used to solve a certain problem, they seldom write about processes used to construct the grammar. This paper sheds some light on how to design a grammar that not only covers the search space, but also supports the search process in finding good solutions. The focus lies on context free grammar guided systems using derivation tree crossover and mutation, in contrast to linearised grammar based systems. Several grammars are presented encompassing the search space of sorting networks and show concepts which apply to general grammar design. An analysis of the search operators on different grammar is undertaken and performance examined on the sorting network problem. The results show that the overall structure for derivation trees created by the grammar has little effect on the performance, but still affects the genetic material changed by search operators.

Geometric Semantic Genetic Programming is Overkill

Tomasz P. Pawlak

Recently, a new notion of Geometric Semantic Genetic Programming emerged in the field of automatic program induction from examples. Given that the induction problem is stated by means of function learning and a fitness function is a metric, GSGP uses geometry of solution space to search for the optimal program. We demonstrate that a program constructed by GSGP is indeed a linear combination of random parts. We also show that this type of program can be constructed in a predetermined time by much simpler algorithm and with guarantee of solving the induction problem optimally. We experimentally compare the proposed algorithm to GSGP on a set of symbolic regression, Boolean function synthesis and classifier induction problems. The proposed algorithm is superior to GSGP in terms of training-set fitness, size of produced programs and computational cost, and generalizes on test-set similarly to GSGP.

Semantic Geometric Initialization

Tomasz P. Pawlak, Krzysztof Krawiec

A common approach in Geometric Semantic Genetic Programming (GSGP) is to seed initial populations using conventional, semantic-unaware methods like Ramped Half-and-Half. We formally demonstrate that this may limit GSGP's ability to find a program with the sought semantics. To overcome this issue, we determine the desired properties of geometric-aware semantic initialization and implement them in Semantic Geometric Initialization (SGI) algorithm, which we instantiate for symbolic regression and Boolean function synthesis problems. Properties of SGI and its impact on GSGP search are verified experimentally on nine symbolic regression and nine Boolean function synthesis benchmarks. When assessed experimentally, SGI leads to superior performance of GSGP search: better best-of-run fitness and higher probability of finding the optimal program.

EuroGP session 3 : Best Papers

Wednesday 30 March 1700-1850

Room 1

session chair : Mengjie Zhang

Evolutionary Approximation of Edge Detection Circuits

Petr Dvoracek, Lukas Sekanina

Approximate computing exploits the fact that many applications are inherently error resilient which means that some errors in their outputs can safely be exchanged for improving other parameters such as energy consumption or operation frequency. A new method based on evolutionary computing is proposed in this paper which enables to approximate edge detection circuits. Rather than evolving approximate edge detectors from scratch, key components of existing edge detector are replaced by their approximate versions obtained using Cartesian genetic programming (CGP). Various approximate edge detectors are then composed and their quality is evaluated using a database of images. The paper reports interesting edge detectors showing a good tradeoff between the quality of edge detection and implementation cost.

Surrogate Fitness via Factorization of Interaction Matrix

Paweł Liskowski, Krzysztof Krawiec

We propose SFIMX, a method that reduces the number of required interactions between programs and tests in genetic programming. SFIMX performs factorization of the matrix of the outcomes of interactions between the programs in a working population and the tests. Crucially, that factorization is applied to matrix that is only partially filled with interaction outcomes, i.e., sparse. The reconstructed approximate interaction matrix is then used to calculate the fitness of programs. In empirical comparison to several reference methods in categorical domains, SFIMX attains higher success rate of synthesizing correct programs within a given computational budget

Scheduling in Heterogeneous Networks using Grammar-based Genetic Programming

David Lynch, Michael Fenton, Stepan Kucera, Holger Claussen, Michael O'Neill

Effective scheduling in Heterogeneous Networks is key to realising the benefits from enhanced Inter-Cell Interference Coordination. In this paper we address the problem using Grammar-based Genetic Programming. Our solution executes on a millisecond timescale so it can track with changing network conditions. Furthermore, the system is trained using only those measurement statistics that are attainable in real networks. Finally, the solution generalises well with respect to dynamic traffic and variable cell placement. Superior results are achieved relative to a benchmark scheme from the literature, illustrating an opportunity for the further use of Genetic Programming in software-defined autonomic wireless communications networks.

On the Analysis of Simple Genetic Programming for Evolving Boolean Functions

Andrea Mambrini, Pietro S. Oliveto

This work presents a first step towards a systematic time and space complexity analysis of genetic programming (GP) for evolving functions with desired input/output behaviour. Two simple GP algorithms, called (1+1) GP and (1+1) GP*, equipped with minimal function (F) and terminal (L) sets are considered for evolving two standard classes of Boolean functions. It is rigorously proved that both algorithms are efficient for the easy problem of evolving conjunctions of Boolean variables with the minimal sets. However, if an extra function (i.e. NOT) is added to F, then the algorithms require at least exponential time to evolve the conjunction of n variables. On the other hand, it is proved that both algorithms fail at evolving the difficult parity function in polynomial time with probability at least exponentially close to 1. Concerning generalisation, it is shown how the quality of the evolved conjunctions depends on the size of the training set s while the evolved exclusive disjunctions generalize equally badly independent of s.

notes

EvoMUSART conference programme

Wednesday 30 March, room 2

1110-1300

EvoMusArt 1 : Evolutionary Art

chair: Colin Johnson

Exploring the Visual Styles of Arcade Game Assets
Antonios Liapis

"Turingalila" Visual Music on the theme of Morphogenesis
Terry Trickett

Iterative Brush Path Extraction Algorithm for Aiding Flock Brush Simulation of Stroke-based Painterly Rendering
Tieta Putri, Ramakrishnan Mukundan

Fitness and Novelty in Evolutionary Art
Adriano Vinhas, Filipe Assunção, João Correia, Penousal Machado, Aniko Ekárt

Animating Typescript Using Aesthetically Evolved Images
Ashley Mills

1300-1400 — **Lunch**

1400-1550

EvoMusArt 2 : Mostly Evolutionary Music

chair: Vic Ciesielski

Augmenting Live Coding with Evolved Patterns
Simon Hickinbotham, Susan Stepney

Computer-Aided Musical Orchestration Using an Artificial Immune System
José Abreu, Marcelo Caetano, Rui Penha

MetaCompose: A Compositional Evolutionary Music Composer
Marco Scirea, Julian Togelius, Peter Eklund, Sebastian Risi

Evolving Atomic Aesthetics and Dynamics
Edward Davies, Phillip Tew, David Glowacki, Jim Smith, Thomas Mitchell

Evolving L-systems with Musical Notes
Ana Rodrigues, Ernesto Costa, Amílcar Cardoso, Penousal Machado, Tiago Cruz

EvoMUSART conference programme

Wednesday 30 March, room 2

1600-1700	**Poster session 1 with coffee break**
1700-1850	**EvoMusArt 3 : Style and Aesthetics** **chair: João Nuno** ***Grammatical Music Composition with Dissimilarity Driven Hill Climbing*** **Róisín Loughran, James McDermott, Michael O'Neill** ***A Comparison Between Representations for Evolving Images*** **Alessandro Re, Mauro Castelli, Leonardo Vanneschi** ***An Evolutionary Composer for Real-Time Background Music*** **Roberto De Prisco, Delfina Malandrino, Gianluca Zaccagnino, Rocco Zaccagnino** ***Correlation Between Human Aesthetic Judgement and Spatial Complexity Measure*** **Mohammad Ali Javaheri Javid, Tim Blackwell, Robert Zimmer, Mohammad Majid al-Rifaie** ***Towards Adaptive Evolutionary Architecture*** **Sebastian Hölt Bak, Nina Rask, Sebastian Risi** ***Plecto: A Low-level Interactive Genetic Algorithmfor the Evolution of Audio*** **Steffan Ianigro, Oliver Bown**

EvoMUSART session 1 : Evolutionary Art

Wednesday 30 March 1110-1300

Room 2

session chair : Colin Johnson

Exploring the Visual Styles of Arcade Game Assets

Antonios Liapis

This paper describes a method for evolving assets for video games based on their visuals properties. Focusing on assets for a space shooter game, a genotype consisting of turtle commands is transformed into a spaceship image composed of human-authored sprite components. Due to constraints on the final spaceships' plausibility, the paper investigates two-population constrained optimization and constrained novelty search methods. A sample of visual styles is tested, each a combination of visual metrics which primarily evaluate balance and shape complexity. Experiments with constrained optimization of a visual style demonstrate that a visually consistent set of spaceships can be generated, while experiments with constrained novelty search demonstrate that several distinct visual styles can be discovered by exploring along select, or all, visual dimensions.

"Turingalila" Visual Music on the theme of Morphogenesis

Terry Trickett

Alan Turing's paper 'The Chemical basis of Morphogenesis', written in 1952, is a masterpiece of mathematical modelling which defines how self-regulated pattern formation occurs in the developing animal embryo. Its most revolutionary feature is the concept of 'morphogens' that are responsible for producing an almost limitless array of animal and fish markings. Turingalila, a piece of Visual Music, takes morphogenesis as its theme. The diversity of forms evident in my projected images are based on just two Turing Patterns which are 'perturbed' to reveal processes of self-organisation reminiscent of those found in nature. A live performance of Turingalila forms the focal point of my oral presentation. It is prefaced by an examination of how artistic potential has been unleashed by Turing's biological insights and concludes with comments on how Turing's ideas are exerting an ever increasing impact in today's world.

Iterative Brush Path Extraction Algorithm for Aiding Flock Brush Simulation of Stroke-based Painterly Rendering

Tieta Putri and Ramakrishnan Mukundan

Painterly algorithms form an important part of non-photorealistic rendering (NPR) techniques where the primary aim is to incorporate expressive and stylistic qualities in the output. Extraction, representation and analysis of brush stroke parameters are essential for mapping artistic styles in stroke based rendering (SBR) applications. In this paper, we present a novel iterative method for extracting brush stroke regions and paths for aiding a particle swarm based SBR process. The algorithm and its implementation aspects are discussed in detail. Experimental results are presented showing the painterly rendering of input images and the extracted brush paths.

EvoMUSART session 1 : Evolutionary Art

Wednesday 30 March 1110-1300

Room 2

Fitness and Novelty in Evolutionary Art

Adriano Vinhas, Filipe Assunção, João Correia, Penousal Machado, Aniko Ekárt

In this paper the effects of introducing novelty search in evolutionary art are explored. Our algorithm combines fitness and novelty metrics to frame image evolution as a multi-objective optimisation problem, promoting the creation of images that are both suitable and diverse. The method is illustrated by using two evolutionary art engines for the evolution of figurative objects and context free design grammars. The results demonstrate the ability of the algorithm to obtain a larger set of fit images compared to traditional fitness-based evolution, regardless of the engine used.

Short presentation:

Animating Typescript Using Aesthetically Evolved Images

Ashley Mills

The genotypic functions from apriori aesthetically evolved images are mutated progressively and their phenotypes sequenced temporally to produce animated versions. The animated versions are mapped onto typeface and combined spatially to produce animated typescript. The output is then discussed with reference to computer aided design and machine learning.

EvoMUSART session 2 : Mostly Evolutionary Music

Wednesday 30 March 1400-1550

Room 2

session chair : Vic Ciesielski

Augmenting Live Coding with Evolved Patterns

*Simon Hickinbotham and Susan Stepney (**Best Paper Candidate**)*

We present a new system for integrating evolvutionary processes with live coding. The system is built upon an existing platform called Extramuros, which facilitates network-based collaboration on live coding performances. Our evolutionary approach uses the Tidal live coding language within this platform. The system uses a grammar to parse code patterns and create random mutations that conform to the grammar, thus guaranteeing that the resulting pattern has the correct syntax. With these mutations available, we provide a facility to integrate them during a live performance. To achieve this, we added controls to the Extramuros web client that allows coders to select patterns for submission to the Tidal interpreter. The fitness of the pattern is updated implicitly by the way the coder uses the patterns. In this way, appropriate patterns are continuously generated and selected for throughout a performance. We present examples of performances, and discuss the utility of this approach in live coding music.

Computer-Aided Musical Orchestration Using an Artificial Immune System

*José Abreu, Marcelo Caetano and Rui Penha (**Best Paper Candidate**)*

The aim of computer-aided musical orchestration is to find a combination of musical instrument sounds that approximates a target sound. The difficulty arises from the complexity of timbre perception and the combinatorial explosion of all possible instrument mixtures. The estimation of perceptual similarities between sounds requires a model capable of capturing the multidimensional perception of timbre, among other perceptual qualities of sounds. In this work, we use an artificial immune system (AIS) called opt-aiNet to search for combinations of musical instrument sounds that minimize the distance to a target sound encoded in a fitness function. Opt-aiNet is capable of finding multiple solutions in parallel while preserving diversity, proposing alternative orchestrations for the same target sound that are different among themselves. We performed a listening test to evaluate the subjective similarity and diversity of the orchestrations.

MetaCompose: A Compositional Evolutionary Music Composer

*Marco Scirea, Julian Togelius, Peter Eklund and Sebastian Risi (**Best Paper Candidate**)*

This paper describes a compositional, extensible framework for music composition and a user study to systematically evaluate its core components. These components include a graph traversal-based chord sequence generator, a search-based melody generator and a pattern-based accompaniment generator. An important contribution of this paper is the melody generator which uses a novel evolutionary technique combining FI-2POP and multi-objective optimization. A participant-based evaluation overwhelmingly confirms that all current components of the framework combine effectively to create harmonious, pleasant and interesting compositions.

EvoMUSART session 2 : Mostly Evolutionary Music

Wednesday 30 March 1400-1550

Room 2

Evolving Atomic Aesthetics and Dynamics

*Edward Davies, Phillip Tew, David Glowacki, Jim Smith and Thomas Mitchell (**Best Paper Candidate**)*

The depiction of atoms and molecules in scientific literature owes as much to the creative imagination of scientists as it does to scientific theory and experimentation. danceroom Spectroscopy (dS) is an interactive art/science project that explores this aesthetic dimension of scientific imagery, presenting a rigorous atomic simulation as an immersive and interactive installation. This paper introduces new methods based on interactive evolutionary computation which allow users - both individually and collaboratively - to explore the design space of dS and construct aesthetically engaging visual states. Pilot studies are presented in which the feasibility of this evolutionary approach is discussed and compared with the standard interface to the dS system. Still images of the resulting visual states are also included.

Short presentation:

Evolving L-systems with Musical Notes

Ana Rodrigues, Ernesto Costa, Amílcar Cardoso, Penousal Machado and Tiago Cruz

Over the years researchers have been interested in devising computational approaches for music and image generation. Some of the approaches rely on generative rewriting systems like L-systems. More recently, some authors questioned the interplay of music and images, that is, how we can use one type to drive the other. In this paper we present a new method for the algorithmic generations of images that are the result of a visual interpretation of an L-system. The main novelty of our approach is based on the fact that the L-system itself is the result of an evolutionary process guided by musical elements. Musical notes are decomposed into elements -- pitch, duration and volume in the current implementation -- and each of them is mapped into corresponding parameters of the L-system -- currently line length, width, color and turning angle. We describe the architecture of our system, based on a multi-agent simulation environment, and show the results of some experiments that provide support to our approach.

EvoMUSART session 3 : Style & Aesthetics

Wednesday 30 March 1700-1850

Room 2

session chair : João Nuno

Grammatical Music Composition with Dissimilarity Driven Hill Climbing

Róisín Loughran, James McDermott, Michael O'Neill

An algorithmic compositional system that uses hill climbing to create short melodies is presented. A context free grammar maps each section of the resultant individual to a musical segment resulting in a series of MIDI notes described by pitch and duration. The dissimilarity between each pair of segments is measured using a metric based on the pitch contour of the segments. Using a GUI, the user decides how many segments to include and how they are to be distanced from each other. The system performs a hill-climbing search using several mutation operators to create a population of segments the desired distances from each other. A number of melodies composed by the system are presented that demonstrate the algorithm's ability to match the desired targets and the versatility created by the inclusion of the designed grammar.

A Comparison Between Representations for Evolving Images

Alessandro Re, Mauro Castelli and Leonardo Vanneschi

Evolving images using genetic programming is a complex task and the representation of the solutions has an important impact on the performance of the system. In this paper, we present two novel representations for evolving images with genetic programming. Both these representations are based on the idea of recursively partitioning the space of an image. This idea distinguishes these representations from the ones that are currently most used in the literature. The first representation that we introduce partitions the space using rectangles, while the second one partitions using triangles. These two representations are compared to one of the most well known and frequently used expression-based representations, on five different test cases. The presented results clearly indicate the appropriateness of the proposed representations for evolving images. Also, we give experimental evidence of the fact that the proposed representations have a higher locality compared to the compared expression-based representation.

An Evolutionary Composer for Real-Time Background Music

Roberto De Prisco, Delfina Malandrino, Gianluca Zaccagnino, Rocco Zaccagnino

Systems for real-time composition of background music respond to changes of the environment by generating music that matches the current state of the environment and/or of the user. In this paper we propose one such a system that we call EvoBackMusic. EvoBackMusic is a multi-agent system that exploits a feed-forward neural network and a multi-objective genetic algorithm to produce background music. The neural network is trained to learn the preferences of the user and such preferences are exploited by the genetic algorithm to compose the music. The composition process takes into account a set of controllers that describe several aspects of the environment, like the dynamism of both the user and the context, other physical characteristics, and the emotional state of the user. Previous system mainly focus on the emotional aspect. EvoBackMusic has been implemented in Java using Encog and JFugue, and it can be integrated in real and virtual environments. We have performed several tests to evaluate the system and we report the results of such tests. The tests aimed at analyzing the users' perception about the quality of the produced music compositions.

EvoMUSART session 3 : Style & Aesthetics

Wednesday 30 March 1700-1850

Room 2

Short presentations:

Correlation Between Human Aesthetic Judgement and Spatial Complexity Measure
Mohammad Ali Javaheri Javid, Tim Blackwell, Robert Zimmer, Mohammad Majid al-Rifaie
The quantitative evaluation of order and complexity conforming with human intuitive perception has been at the core of computational notions of aesthetics. Informational theories of aesthetics have taken advantage of entropy in measuring order and complexity of stimuli in relation to their aesthetic value. However entropy fails to discriminate structurally different patterns in a 2D plane. This paper investigates a computational measure of complexity, which is then compared to a results from a previous experimental study on human aesthetic perception in the visual domain. The model is based on the information gain from specifying the spacial distribution of pixels and their uniformity and non-uniformity in an image. The results of the experiments demonstrate the presence of correlations between a spatial complexity measure and the way in which humans are believed to aesthetically appreciate asymmetry. However the experiments failed to provide a significant correlation between the measure and aesthetic judgements of symmetrical images.

Towards Adaptive Evolutionary Architecture
Sebastian Hölt Bak, Nina Rask, Sebastian Risi
This paper presents first results from an interdisciplinary project, in which the fields of architecture, philosophy and artificial life are combined to explore possible futures of architecture. Through an interactive evolutionary installation, called \emph{EvoCurtain}, we investigate aspects of how living in the future could occur, if built spaces could evolve and adapt alongside inhabitants. As such, present study explores the interdisciplinary possibilities in utilizing computational power to co-create with users and generate designs based on human input. We argue that this could lead to the development of designs tailored to the individual preferences of inhabitants, changing the roles of architects and designers entirely. \emph{Architecture-as-it-could-be} is a philosophical approach conducted through artistic methods to anticipate the technological futures of human-centered development within architecture.

Plecto: A Low-level Interactive Genetic Algorithm for the Evolution of Audio
Steffan Ianigro and Oliver Bown
The creative potential of Genetic Algorithms (GAs) has been explored by many musicians who attempt to harness the unbound possibilities for creative search evident in nature. Within this paper, we investigate the possibility of using Continuous Time Recurrent Neural Networks (CTRNNs) as an evolvable low-level audio synthesis structure, affording users access to a vast creative search space of audio possibilities. Specifically, we explore some initial GA designs through the development of Plecto (see www.plecto.io), a creative tool that evolves CTRNNs for the discovery of audio. We have found that the evolution of CTRNNs offers some interesting prospects for audio exploration and present some design considerations for the implementation of such a system.

EvoCOP conference programme

Thursday 31 March, room 2

1130-1310	**EvoCOP 1 : Real World Applications** **chair : Francisco Chicano** ***Particle Swarm Optimization for Multi-Objective Web Service Location Allocation*** **Boxiong Tan, Yi Mei, Hui Ma, Mengjie Zhang** ***Evaluating hyperheuristics and local search operators for periodic routing problems*** **Yujie Chen, Philip Mourdjis, Fiona Polack, Peter Cowling, Stephen Remde** ***A Hybrid Constructive Mat-heuristic Algorithm for the Heterogeneous Vehicle Routing Problem with Simultaneous Pickup and Delivery*** **Baris Kececi, Fulya Altiparmak, Imdat Kara** ***Modifying Colourings between Time-steps to Tackle Changes in Dynamic Random Graphs*** **Bradley Hardy, Rhyd Lewis, Jonathan Thompson** ***An Evolutionary Approach to the Full Optimization of the Traveling Thief Problem*** ***Nuno Lourenço, Francisco B. Pereira,* Ernesto Costa**
1310-1415	**Lunch**
1415-1555	**EvoCOP 2 : Theoretical Studies** **chair: Gabriela Ochoa** ***Determining the Difficulty of Landscapes by PageRank Centrality in Local Optima Networks*** **Sebastian Herrmann** ***A Property Preserving Method for Extending a Single-objective Problem Instance to Multiple Objectives with Specific Correlations*** **Ruby L. V. Moritz, Enrico Reich, Matthias Bernt, Martin Middendorf** ***Efficient Hill Climber for Multi-Objective Pseudo-Boolean Optimization*** **Francisco Chicano, Darrell Whitley, Renato Tinós** ***Evolutionary Algorithms for Finding Short Addition Chains: Going the Distance*** **Stjepan Picek, Carlos A. Coello Coello, Domagoj Jakobovic, Nele Mentens** ***Limits to Learning in Reinforcement Learning Hyper-heuristics*** **Fawaz Alanazi, Per Kristian Lehre**
1555-1615	**Coffee break**

EvoCOP conference programme

Thursday 31 March, room 2

1615-1745

EvoCOP 3 : Methodologies

chair: Christian Blum

Experimental Evaluation of Two Approaches to Optimal Recombination for Permutation Problems
Anton V. Eremeev, Julia V. Kovalenko

Sim-EDA: A Multipopulation Estimation of Distribution Algorithm Based on Problem Similarity
Krzysztof Michalak

Solving the Quadratic Assignment Problem with Cooperative Parallel Extremal Optimization
Danny Munera, Daniel Diaz, Salvador Abreu

Construct, Merge, Solve & Adapt: Application to the Repetition-Free Longest Common Subsequence Problem
Christian Blum, Maria J. Blesa

Friday 1 April, room 2

1130-1300

EvoCOP 4 : Best Paper Candidates

Chair : Bin Hu

Hyperplane Elimination for Quickly Enumerating Local Optima
Brian W. Goldman, William F. Punch

Particle Swarm Optimisation with Sequence-Like Indirect Representation for Web Service Composition
Alexandre Sawczuk da Silva, Yi Mei, Hui Ma, Mengjie Zhang

Deconstructing the Big Valley Search Space Hypothesis
Gabriela Ochoa, Nadarajen Veerapen

EvoCOP session 1 : Real World Applications

Thursday 31 March 1130-1310

Room 2

session chair : Francisco Chicano

Particle Swarm Optimization for Multi-Objective Web Service Location Allocation

Boxiong Tan, Yi Mei, Hui Ma, Mengjie Zhang

Automated Web service composition, which refers to the creation of a complex application from pre-existing building blocks (Web services), has been an active research topic in the past years. The advantage of having an automated composition system is that it allows users to create new applications simply by providing the required parameters, instead of having to manually assemble the services. Existing approaches to automated composition rely on planning techniques or evolutionary computing (EC) to modify and optimise composition solutions directly in their tree/graph form, a complex process that requires several constraints to be considered before each alteration. To improve the search efficiency and simplify the checking of constraints, this work proposes an indirect Particle Swarm Optimisation (PSO)-based approach. The key idea of the indirect approach is to optimise a service queue which is then decoded into a composition solution by using a planning algorithm. This approach is compared to a previously proposed graph-based direct representation method, and experiment results show that the indirect representation can lead to a greater (or equivalent) quality while requiring a lower execution time. The analysis conducted shows that this is due to the design of the algorithms used for building and evaluating the fitness of solutions.

Evaluating hyperheuristics and local search operators for periodic routing problems

Yujie Chen, Philip Mourdjis, Fiona Polack, Peter Cowling, Stephen Remde

Meta-heuristics and hybrid heuristic approaches have been successfully applied to Periodic Vehicle Routing Problems (PVRPs). However, to be competitive, these methods require careful design of specific search strategies for each problem. By contrast, hyperheuristics use the performance of low level heuristics to automatically select and tailor search strategies. Hyperheuristics have been successfully applied to problem domains such as timetabling and production scheduling. In this study, we present a comprehensive analysis of hyperheuristic approaches to solving PVRPs. The performance of hyperheuristics is compared to published performance of state-of-the-art meta-heuristics.

A Hybrid Constructive Mat-heuristic Algorithm for the Heterogeneous Vehicle Routing Problem with Simultaneous Pickup and Delivery

Baris Kececi, Fulya Altiparmak, Imdat Kara

In this paper, a variant of Vehicle Routing Problem, called Heterogeneous Vehicle Routing Problem with Simultaneous Pick-up and Delivery (HVRPSPD), is considered. The HVRPSPD can be defined as determining the routes and vehicle types on each route in such a way that the pickup and delivery demands of each customer must be performed with same vehicle, while minimizing the total cost. We propose a mathematical model for the problem and some valid inequalities for the model. Since the HVRPSPD is an NP-hard problem, the proposed mathematical model can be used to find the optimal solution for the small-size problems. Therefore we propose a hybrid mat-heuristic approach based on the formulation and Local Search to solve medium and large-size HVRPSPDs. A series of experiments is performed to evaluate the performance of proposed algorithm. Computational results show that hybrid mat-heuristic is computationally efficient to find good quality of initial solutions.

EvoCOP session 1 : Real World Applications

Thursday 31 March 1130-1310

Room 2

Modifying Colourings between Time-steps to Tackle Changes in Dynamic Random Graphs

Bradley Hardy, Rhyd Lewis, Jonathan Thompson

Many real world operational research problems can be formulated as graph colouring problems. Algorithms for this problem usually operate under the assumption that the size and constraints of a problem are fixed, allowing us to model the problem using a static graph. For many problems however, this is not the case and it would be more appropriate to model such problems using dynamic graphs. In this paper we will explore whether feasible colourings for one graph at time-step *t* can be modified into a colouring for a similar graph at time-step *t+1* in some beneficial manner.

An Evolutionary Approach to the Full Optimization of the Traveling Thief Problem

Nuno Lourenço, Francisco B. Pereira, Ernesto Costa

Real-World problems usually consist of several different small sub-problems interacting with each other. These interactions promote a relation of interdependence, where the quality of a solution to one sub-problem influences the quality of another partial solution. The Traveling Thief Problem (TTP) is a recent benchmark that results from the combination of the Traveling Salesman Problem (TSP) and the Knapsack Problem (KP). Thus far, existing approaches solve the TTP by fixing one of the components, usually the TSP, and then tackling the KP. We follow in a different direction and propose an Evolutionary Algorithm that addresses both sub-problems at the same time. Experimental results show that solving the TTP as whole creates conditions for discovering solutions with enhanced quality, and that fixing one of the components might compromise the overall results.

EvoCOP session 2: Theoretical Studies

Thursday 31 March 1415-1555

Room 2

session chair : Gabriela Ochoa

Determining the Difficulty of Landscapes by PageRank Centrality in Local Optima Networks

Sebastian Herrmann

The contribution of this study is twofold: First, we show that we can predict the performance of Iterated Local Search (ILS) in different landscapes with the help of Local Optima Networks (LONs) with escape edges. As a predictor, we use the PageRank Centrality of the global optimum. Escape edges can be extracted with lower effort than the edges used in a previous study. Second, we show that the PageRank vector of a LON can be used to predict the solution quality (average fitness) that can be achieved by ILS in different landscapes.

A Property Preserving Method for Extending a Single-objective Problem Instance to Multiple Objectives with Specific Correlations

Ruby L. V. Moritz, Enrico Reich, Matthias Bernt, Martin Middendorf

A method is proposed to generate multi-objective optimization problem instances from a corresponding single-objective instance. The user of the method can specify the correlations between the generated the objectives. Different from existing instance generation methods the new method allows to keep certain properties of the original single-objective instance. In particular, we consider optimization problems where the objective is defined by a matrix, e.g., a distance matrix for the Traveling Salesperson problem (TSP) or a flow matrix for the Quadratic Assignment problem. It is shown that the method creates new distance matrices with specific correlations between each other and also have the same average distance and variance of distances as the distance matrix of the original instance. This property is important, e.g., when the influence of correlations between the objectives on the behavior of metaheuristics for the multi-objective TSP are investigated. Some properties of the new method are shown theoretically. In an empirical analysis the new method is compared with instance generation methods from the literature.

Efficient Hill Climber for Multi-Objective Pseudo-Boolean Optimization

Francisco Chicano, Darrell Whitley, Renato Tinós

Local search algorithms and iterated local search algorithms are a basic technique. Local search can be a stand-alone search method, but it can also be hybridized with evolutionary algorithms. Recently, it has been shown that it is possible to identify improving moves in Hamming neighborhoods for k-bounded pseudo-Boolean optimization problems in constant time. This means that local search does not need to enumerate neighborhoods to find improving moves. It also means that evolutionary algorithms do not need to use random mutation as a operator, except perhaps as a way to escape local optima. In this paper, we show how improving moves can be identified in constant time for multiobjective problems that are expressed as k-bounded pseudo-Boolean functions. In particular, multiobjective forms of NK Landscapes and Mk Landscapes are considered.

EvoCOP session 2: Theoretical Studies

Thursday 31 March 1415-1555

Room 2

Evolutionary Algorithms for Finding Short Addition Chains: Going the Distance

Stjepan Picek, Carlos A. Coello Coello, Domagoj Jakobovic, Nele Mentens

The problem of finding the shortest addition chain for a given exponent is of great relevance in cryptography, but is also very difficult to solve since it is an NP-hard problem. In this paper, we propose a genetic algorithm with a novel representation of solutions and new crossover and mutation operators to minimize the length of the addition chains corresponding to a given exponent. We also develop a repair strategy that significantly enhances the performance of our approach. The results are compared with respect to those generated by other metaheuristics for instances of moderate size, but we also investigate values up to $2^{127} - 3$. For those instances, we were unable to find any results produced by other metaheuristics for comparison, and three additional strategies were adopted in this case to serve as benchmarks. Our results indicate that the proposed approach is a very promising alternative to deal with this problem.

Limits to Learning in Reinforcement Learning Hyper-heuristics

Fawaz Alanazi, Per Kristian Lehre

Learning mechanisms in selection hyper-heuristics are used to identify the most appropriate subset of heuristics when solving a given problem. Several experimental studies have used additive reinforcement learning mechanisms, however, these are inconclusive with regard to the performance of selection hyper-heuristics with these learning mechanisms. This paper points out limitations to learning with additive reinforcement learning mechanisms. Our theoretical results show that if the probability of improving the candidate solution in each point of the search process is less than 1/2 which is a mild assumption, then additive reinforcement learning mechanisms perform asymptotically similar to the simple random mechanism which chooses heuristics uniformly at random. In addition, frequently used adaptation schemes can affect the memory of reinforcement learning mechanisms negatively. We also conducted experiments on two well-known combinatorial optimisation problems, bin-packing and flow-shop, and the obtained results confirm the theoretical findings. This study suggests that alternatives to the additive updates in reinforcement learning mechanisms should be considered.

EvoCOP session 3 : Methodologies

Thursday 31 March 1615-1745

Room 2

session chair : Christian Blum

Experimental Evaluation of Two Approaches to Optimal Recombination for Permutation Problems

Anton V. Eremeev, Julia V. Kovalenko

We consider two approaches to formulation and solving of optimal recombination problems arising as supplementary problems in genetic algorithms for the Asymmetric Travelling Salesman Problem and the Makespan Minimization Problem on a Single Machine. All four optimal recombination problems under consideration are NP-hard but relatively fast exponential-time algorithms are known for solving them. The experimental evaluation carried out in this paper shows that the two approaches to optimal recombination are competitive with each other.

Sim-EDA: A Multipopulation Estimation of Distribution Algorithm Based on Problem Similarity

Krzysztof Michalak

In this paper a new estimation of distribution algorithm Sim-EDA is presented. This algorithm combines a multipopulation approach with distribution modelling. The proposed approach is to tackle several similar instances of the same optimization problem at once. Each subpopulation is assigned to a different instance and a migration mechanism is used for transferring information between the subpopulations. The migration process can be performed using one of the proposed strategies: two based on similarity between problem instances and one which migrates specimens between subpopulations with uniform probability. Similarity of problem instances is expressed numerically and the value of the similarity function is used for determining how likely a specimen is to migrate between two populations. The Sim-EDA algorithm is a general framework which can be used with various EDAs. The presented algorithm has been tested on several instances of the Max-Cut and TSP problems using three different migration strategies and without migration. The results obtained in the experiments confirm, that the performance of the algorithm is improved when information is transferred between subpopulations assigned to similar instances of the problem. The migration strategy which transfers specimens between the most similar problem instances consistently produces better results than the algorithm without migration.

EvoCOP session 3 : Methodologies

Thursday 31 March 1615-1745

Room 2

Solving the Quadratic Assignment Problem with Cooperative Parallel Extremal Optimization

Danny Munera, Daniel Diaz, Salvador Abreu

Several real-life applications can be stated in terms of the Quadratic Assignment Problem. Finding an optimal assignment is computationally very difficult, for many useful instances. We address this problem using a local search technique, based on Extremal Optimization and present experimental evidence that this approach is competitive. Moreover, cooperative parallel versions of our solver improve performance so much that large and hard instances can be solved quickly.

Construct, Merge, Solve & Adapt: Application to the Repetition-Free Longest Common Subsequence Problem

Christian Blum, Maria J. Blesa

In this paper we present the application of a recently proposed, general, algorithm for combinatorial optimization to the repetition-free longest common subsequence problem. The applied algorithm, which is labelled CONSTRUCT, MERGE, SOLVE & ADAPT, generates sub-instances based on merging the solution components found in randomly constructed solutions. These sub-instances are subsequently solved by means of an exact solver. Moreover, the considered sub-instances are dynamically changing due to adding new solution components at each iteration, and removing existing solution components on the basis of indicators about their usefulness. The results of applying this algorithm to the repetition-free longest common subsequence problem show that the algorithm generally outperforms competing approaches from the literature. Moreover, they show that the algorithm is competitive with CPLEX for small and medium size problem instances, whereas it outperforms CPLEX for larger problem instances.

EvoCOP session 4: Best Paper Candidates

Friday 1 April 1130-1300

Room 2

session chair : Bin Hu

Hyperplane Elimination for Quickly Enumerating Local Optima

Brian W. Goldman, William F. Punch

Examining the properties of local optima is a common method for understanding combinatorial-problem landscapes. Unfortunately, exhaustive algorithms for finding local optima are limited to very small problem sizes. We propose a method for exploiting problem structure to skip hyperplanes that cannot contain local optima, allowing runtime to scale with the number of local optima instead of with the landscape size. We prove optimality for linear functions and Concatenated Traps, and we provide empirical evidence of optimality on NKq Landscapes and Ising Spin Glasses. We further refine this method to find solutions that cannot be improved by flipping *r* or fewer bits, which counterintuitively can reduce total runtime. While previous methods were limited to landscapes with at most 2^{34} binary strings, hyperplane elimination can enumerate the same problems with 2^{77} binary strings, and find all 4-bit local optima of problems with 2^{200} binary strings.

Particle Swarm Optimisation with Sequence-Like Indirect Representation for Web Service Composition

Alexandre Sawczuk da Silva, Yi Mei, Hui Ma, Mengjie Zhang

Automated Web service composition, which refers to the creation of a complex application from pre-existing building blocks (Web services), has been an active research topic in the past years. The advantage of having an automated composition system is that it allows users to create new applications simply by providing the required parameters, instead of having to manually assemble the services. Existing approaches to automated composition rely on planning techniques or evolutionary computing (EC) to modify and optimise composition solutions directly in their tree/graph form, a complex process that requires several constraints to be considered before each alteration. To improve the search efficiency and simplify the checking of constraints, this work proposes an indirect Particle Swarm Optimisation (PSO)-based approach. The key idea of the indirect approach is to optimise a service queue which is then decoded into a composition solution by using a planning algorithm. This approach is compared to a previously proposed graph-based direct representation method, and experiment results show that the indirect representation can lead to a greater (or equivalent) quality while requiring a lower execution time. The analysis conducted shows that this is due to the design of the algorithms used for building and evaluating the fitness of solutions.

Deconstructing the Big Valley Search Space Hypothesis

Gabriela Ochoa, Nadarajen Veerapen

The big valley hypothesis suggests that, in combinatorial optimisation, local optima of good quality are clustered and surround the global optimum. We show here that the idea of a single valley does not always hold. Instead the big valley seems to de-construct into several valleys, also called ‘funnels’ in theoretical chemistry. We use the local optima networks model and propose an effective procedure for extracting the network data. We conduct a detailed study on four selected TSP instances of moderate size and observe that the big valley decomposes into a number of sub-valleys of different sizes and fitness distributions. Sometimes the global optimum is located in the largest valley, which suggests an easy to search landscape, but this is not generally the case. The global optimum might be located in a small valley, which offers a clear and visual explanation of the increased search difficulty in these cases. Our study opens up new possibilities for analysing and visualising combinatorial landscapes as complex networks.

EvoAPPLICATIONS conference programme

Wednesday 30 March

1110-1300 room 3

EvoApps 1 : Real world applications
chair : Giovani Squillero

Evolving classification models for prediction of patient recruitment in multicentre clinical trials using grammatical evolution
Gilyana Borlikova, Michael Phillips, Louis Smith, Michael O'Neill

Evolving Coverage Optimisation Functions for Heterogeneous Networks using Grammatical Genetic Programming
Michael Fenton, David Lynch, Stepan Kucera, Holger Claussen, Michael O'Neill

A Variable Local Search based Memetic Algorithm for the Load Balancing Problem in Cloud Computing
Nasser Sabar, Andy Song, Mengjie Zhang

Challenging Anti-virus through Evolutionary Malware Obfuscation
Marco Gaudesi, Andrea Marcelli, Ernesto Sanchez, Giovanni Squillero, Alberto Tonda

Simheuristics for the Multiobjective Nondeterministic Firefighter Problem in a Time-Constrained Setting
Krzysztof Michalak, Joshua D. Knowles

1400-1550 room 3

EvoApps 2 : Image Analysis & Signal Processing
chairs : Stefano Cagnoi & Mengjie Zhang

Binary Tomography Reconstruction by Particle Aggregation
Mohammad Majid al-Rifaie, Tim Blackwell

Population Based Ant Colony Optimization for Reconstructing ECG Signals
Yih-Chun Cheng, Tom Hartmann, Pei-Yun Tsai, Martin Middendorf

Speaker Verification on Unbalanced Data with Genetic Programming
Roisin Loughran, Alexandros Agapitos, Ahmed Kattan, Anthony Brabazon, Michael O'Neill

Bare-Bone Particle Swarm Optimisation for Simultaneously Discretising and Selecting Features For High-Dimensional Classification
Binh Tran, Mengjie Zhang, Bing Xue

NSGA-II based Auto-Calibration of Automatic Number Plate Recognition Camera for Vehicle Speed Measurement
Patryk Filipiak, Bartlomiej Golenko, Cezary Dolega

1600-1700 — **Poster session 1 with coffee break**

1700-1850 room 3

EvoApps 3 : Evolutionary algorithms and meta-heuristics in stochastic and dynamic environments
chairs : Trung Thanh Nguyen & Michalis Mavrovouniotis

Direct Memory Schemes for Population-based Incremental Learning in Cyclically Changing Environments
Michalis Mavrovouniotis, Shengxiang Yang

Benchmarking dynamic three-dimensional bin packing problems using discrete-event simulation
Ran Wang, Trung Thanh Nguyen, Shayan Kavakeb, Zaili Yang, Changhe Li

Genetic Programming Algorithms for Dynamic Environments
Joao Macedo, Ernesto Costa, Lino Marques

A Memory-Based NSGA-II Algorithm for Dynamic Multi-Objective Optimization Problems
Shaaban Sahmoud, Haluk Topcuoglu

Hybrid Dynamic Resampling Algorithms for Evolutionary Multi-objective Optimization of Invariant-Noise Problems
Florian Siegmund, Amos H.C. Ng, Kalyanmoy Deb

EvoAPPLICATIONS conference programme

Thursday 31 March

0930-1110 room 1

EvoApps 4 : Bio-inspired algorithms applied to networks

chairs : Ivanoe De Falco & Antonio Della Cioppa

Joint Topology Optimization, Power Control and Spectrum Allocation for Intra-Vehicular Multi-hop Sensor Networks using Dandelion-encoded Heuristics
Javier Del Ser, Miren Nekane Bilbao, Cristina Perfecto, Gonzalez-Pardo, Sergio Campos-Cordobes

A Hybrid Discrete Artificial Bee Colony Algorithm for the Multicast Routing Problem
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An (MI)LP-based Primal Heuristic for 3-Architecture Connected Facility Location in Urban Access Network Design
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A Heuristic Crossover Enhanced Evolutionary Algorithm for Clustering Wireless Sensor Network
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Reducing Efficiency of Connectivity-Splitting Attack on Newscast via Limited Gossip
Jakub Muszynski, Sebastien Varrette, Pascal Bouvry

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EvoApps 5 : Evolutionary algorithms in games

chair : Antonio Mora

Orthogonally Evolved AI to Improve Difficulty Adjustment in Video Games
Arend Hintze, Randal Olson, Joel Lehman

There can be only one: Evolving RTS Bots via joust selection
Antonio Fernandez Ares, Pablo Garcia-Sanchez, Antonio Miguel Mora Garcia, Pedro A. Castillo, Juan J. Merelo

Evolving Chess-like Games Using Relative Algorithm Performance Profiles
Jakub Kowalski, Marek Szykula

Online Evolution for Multi-Action Adversarial Games
Niels Justesen, Tobias Mahlmann, Julian Togelius

The story of their lives: Massive procedural generation of heroes' journeys using evolved agent-based models and logical reasoning
Ruben H. Garcia-Ortega, Pablo Garcia-Sanchez, Juan J. Merelo, Aranzazu San-Gines, Angel Fernandez-Cabezas

0930-1110 room 3

EvoApps 6 : Parallel and multi-agents systems

chairs : Ignacio Hidalgo & Francisco Fernandez de Vega

Implementing Parallel Differential Evolution on Spark
Diego Teijeiro, Xoan C. Pardo, Patricia Gonzalez, Julio R. Banga, Ramon Doallo

ECJ+HADOOP: An easy way to deploy massive runs of evolutionary algorithm
Francisco Chavez, Francisco Fernandez, Cesar Benavides-Alvarez, Daniel Lanza, Juan Villegas, Leonardo Trujillo, Gustavo Olague, Graciela Roman

Addressing high dimensional multi-objective optimization problems by coevolutionary islands with overlapping search spaces
Pablo Garcia-Sanchez, Julio Ortega, Jesús Gonzalez, Pedro A. Castillo, Juan J. Merelo

Leveraging Online Racing and Population Cloning in Evolutionary Multirobot Systems
Fernando Silva, Luis Correia, Anders Lyhne Christensen

Multi-Agent Behavior-Based Policy Transfer
Sabre Didi, Geoff Nitschke

EvoAPPLICATIONS conference programme

Thursday 31 March

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EvoApps 7 : Bio-inspired algorithms and complex systems

chair : Carlos Cotta

Towards intelligent biological control: Controlling Boolean networks with Boolean networks
Nadia S. Taou, David W. Corne, Michael A. Lones

The Emergence of Cooperation in Public Goods Games on Randomly Growing Dynamic Networks
Steve Miller, Joshua Knowles

Influence Maximization in Social Networks with Genetic Algorithms
Doina Bucur, Giovanni Iacca

Measuring Diversity of Socio-cognitively Inspired ACO Search
Ewelina Swiderska, Jakub Lasisz, Aleksander Byrski,Tom Lenaerts, Dana Samson, Bipin Indurkhya, Ann Nowe, Marek Kisiel-Dorohinicki

Multiwinner Voting in Genetic Algorithms for Solving Ill-Posed Global Optimization Problems
Piotr Faliszewski, Jakub Sawicki, Robert Schaefer, Maciej Smolka

1130-1310 room 3

EvoApps 8 : Bio-inspired algorithms in energy applications

chairs : Neil Urquhart & Kevin Sim

Stigmergy-Based Scheduling of Flexible Loads
Fredy Rios, Lukas Konig, Hartmut Schmeck

A hybrid genetic algorithm for the interaction of electricity retailers with demand response
Maria Joao Alves, Carlos Henggeler Antunes, Pedro Carrasqueira

Comparison of Multi-objective Evolutionary Optimization in Smart Building Scenarios
Marlon Braun, Thomas Dengiz, Ingo Mauser, Hartmut Schmeck

Electrical Load Pattern Shape Clustering using Ant Colony Optimization
Fernando Lezama, Ansel Y. Rodriguez, Enrique Munoz de Cote

A Decentralized PSO with Decoder for Scheduling Distributed Electricity Generation
Jorg Bremer, Sebastian Lehnhoff

1415-1555 room 1

EvoApps 9 : Natural computing methods in finance

chairs : Anthony Brabazon & Michael Kampouridis

Portfolio Optimization, a Decision-Support Methodology for Small Budgets
Igor Deplano, Giovanni Squillero, Alberto Tonda

Improving Fitness Functions in Genetic Programming for Classification on Unbalanced Credit Card Data
Van Loi Cao, Nhien-An Le-Khac, Michael O'Neill, Miguel Nicolau, James McDermott

Enhanced Multi-objective Population-Based Incremental Learning with Applications in Risk Treaty Optimization
Omar Andres Carmona Cortes, Andrew Rau-Chaplin

Evolutionary Multi-objective Optimization for Portfolios in Emerging Markets: Contrasting Higher Moments and Median Models
Mai Ibrahim, Mohammed El-Beltagy, Motaz Khorshid

Genetic Programming with Memory for Financial Trading
Alexandros Agapitos, Anthony Brabazon, Michael O'Neill

EvoAPPLICATIONS conference programme

Thursday 31 March

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EvoApplications 10 : Evolutionary algorithms in industrial and simulated environments

chairs : Kevin Sim & Neil Urquhart

Constrained Level Generation through Grammar-Based Evolutionary Algorithms
Jose M. Font, Roberto Izquierdo, Daniel Manrique, Julian Togelius

Can Evolutionary Algorithms Beat Dynamic Programming for Hybrid
Tobias Rodemann, Ken Nishikawa

Environment-Model Based Testing with Differential Evolution in an Industrial Setting
Annamaria Szenkovits, Noemi Gasko, Erwan Jahier

Workforce Scheduling in Inbound Customer Call Centres With a Case Study
Goran Molnar, Domagoj Jakobovic, Matija Pavelic

Optimization of Operation and Control Strategies for Battery Energy Storage Systems by Evolutionary Algorithms
Jan Muller, Matthias Marz, Ingo Mauser, Hartmut Schmeck

1615-1745 room 1

EvoApps 11 : Biological applications

chair : Federico Divina

On Combinatorial Optimisation in Analysis of Protein-Protein Interaction and Protein Folding Networks
David Chalupa

Automating biomedical data science through tree-based pipeline optimization
Randal Olson, Ryan Urbanowicz, Peter Andrews, Nicole Lavender, La Creis Kidd, Jason Moore

Bicliques in Graphs with Correlated Edges: From Artificial to Biological Networks
Aaron Kershenbaum, Alicia Cutillo, Christian Darabos, Murray Keitha, Schiaffino Robert, Jason H. Moore

A Multi-objective Genetic Programming Biomarker Detection Approach in Mass Spectrometry Data
Soha Ahmed, Mengjie Zhang, Lifeng Peng, Bing Xue

1615-1745 room 3

EvoApps 12 : Interactive Presentations I

chair : Antonio Mora

Dangerousness Metric for Gene Regulated Car Driving
Sylvain Cussat-Blanc, Jean Disset, Stephane Sanchez

Using Isovists to Evolve Terrains with Gameplay Elements
Andrew William Pech, Chiou-Peng Lam, Philip Hingston, Martin Masek

A spatially-structured PCG method for content diversity in a Physics-based simulation game
Raul Lara, Alejandro Gutierrez, Antonio Jose' Fernandez

Design and Evaluation of an Extended Learning Classifier-based StarCraft Micro AI
Stefan Rudolph, Sebastian von Mammen, Johannes Jungbluth, Jorg Hahner

Benchmarking languages for evolutionary algorithms
JJ Merelo, Pedro Castillo, Israel Blancas, Gustavo Romero, Pablo Garcia, Antonio Fernandezs, Víctor Rivas, Mario Garcia

On the Closest Averaged Hausdorff Archive for a Circularly Convex Pareto Front
Gunter Rudolph, Oliver Schutze, Heike Trautmann

Evolving Smoothing Kernels for Global Optimization
Paul Manns, Kay Hamacher

On-line Evolution of Foraging Behaviour in a Population of Real Robots
Jacqueline Heinerman, Alessandro Zonta, Evert Haasdijk, A.E.Eiben

EvoAPPLICATIONS conference programme

Friday 1 April

1130-1300 room 1

EvoApps 13 : Pattern recognition & numerical optimisation
chair : Anna I Esparcia-Alcázar

Mutual Information Estimation for Filter Based Feature Selection Using Particle Swarm Optimization
Bach Hoai Nguyen, Bing Xue, Peter Andreae

A Wrapper Feature Selection Approach to Classification with Missing Data
Cao Truong Tran, Mengjie Zhang, Peter Andreae, Bing Xue

Local Fitness Meta-Models with Nearest Neighbor Regression
Oliver Kramer

Validating the Grid Diversity Operator: an Infusion Technique for Diversity Maintenance in Population-based Optimisation Algorithms
Ahmed Salah, Emma Hart, Kevin Sim

1130-1300 room 3

EvoApps 14 : Interactive Presentations II
chair : Evert Haasdijk

Hybrid biclustering algorithms for data mining
Patryk Orzechowski, Krzysztof Boryczko

Discovering potential clinical profiles of Multiple Sclerosis from clinical and pathological free text data with Constraint Non-negative Matrix Factorization
Jacopo Acquarelli, Elena Marchiori, Monica Bianchini

Application of Evolutionary Algorithms for the Optimization of Genetic Regulatory Networks
Elise Rosati, Morgan Madec, Abir Rezgui, Quentin Colman, Nicolas Toussaint, Christophe Lallement, Pierre Collet

A Distributed Intrusion Detection Framework based on Evolved Specialized Ensembles of Classifiers
Gianluigi Folino, Francesco Sergio Pisani, Pietro Sabatino

UAV Fleet Mobility Model with Multiple Pheromones for Tracking Moving Observation Targets
Christophe Atten, Loubna Channouf, Gregoire Danoy, Pascal Bouvry

Compilable phenotypes: Accelerating the evaluation of individuals in Grammatical Evolution
J. Manuel Colmenar, J. Ignacio Hidalgo, Juan Lanchares, Oscar Garnica, Jose-L. Risco-Martín, Ivan Contreras, Almudena Sanchez, J. Manuel Velasco

GPU Accelerated Molecular Docking Simulation with Genetic Algorithms
Serkan Altuntas, Zeki Bozkus, Basilio B. Fraguela

Hybrid Control for a Real Swarm Robotics System in an Intruder Detection Task
Miguel Duarte, Jorge Gomes, Vasco Costa, Sancho Moura Oliveira, Anders Lyhne Christensen

EvoAPP session 1 : Real world applications

Wednesday 30 March 1110-1300

Room 3

chair : Giovanni Squillero

Evolving classification models for prediction of patient recruitment in multicentre clinical trials using grammatical evolution

Gilyana Borlikova, Michael Phillips, Louis Smith, Michael O'Neill

Successful and timely completion of prospective clinical trials depends on patient recruitment as patients are critical to delivery of the prospective trial data. There exists a pressing need to develop better tools/techniques to optimise patient recruitment in multicentre clinical trials. In this study Grammatical Evolution (GE) is used to evolve classification models to predict future patient enrolment performance of investigators/site to be selected for the conduct of the trial. Prediction accuracy of the evolved models is compared with results of a range of machine learning algorithms widely used for classification. The results suggest that GE is able to successfully induce classification models and analysis of these models can help in our understanding of the factors providing advanced indication of a trial sites' future performance.

Evolving Coverage Optimisation Functions for Heterogeneous Networks using Grammatical Genetic Programming

Michael Fenton, David Lynch, Stepan Kucera, Holger Claussen, Michael O'Neill

Heterogeneous Cellular Networks are multi-tiered cellular networks comprised of Macro Cells and Small Cells in which all cells occupy the same bandwidth. User Equipments greedily attach to whichever cell provides the best signal strength. While Macro Cells are invariant, the power and selection bias for each small cell can be increased or decreased (subject to pre-defined limits) such that more or fewer UEs attach to that cell. Setting optimal power and selection bias levels for small cells is key for good network performance. The application of Genetic Programming techniques has been proven to produce good results in the control of Heterogenous Networks. Expanding on previous works, this paper uses grammatical GP to evolve distributed control functions for Small Cells in order to vary their power and bias settings. The objective of these control functions is to evolve control functions that maximise a proportional fair utility of UE throughputs.

A Variable Local Search based Memetic Algorithm for the Load Balancing Problem in Cloud Computing

Nasser Sabar, Andy Song, Mengjie Zhang

Load balancing (LB) is an important and challenging optimisation problem in cloud computing. LB involves assigning a set of services into a set of machines for which the goal is to optimise machine usages. This study presents a memetic algorithm (MA) for the LB problem. MA is a hybrid method that combines the strength of population based evolutionary algorithms with local search. However the effectiveness of MA mainly depends on the local search method chosen for MA. This is because local search methods perform differently for different instances and under different stages of search. In addition, invoking local search at every generation can be computationally expensive and compromise the exploration capacity of search. To address these issues, this study proposes a variable local search based MA in the context of LB problem. The proposed MA uses multiple local search mechanisms. Each one navigates a different area in search space using a different search mechanism which can leads to a different search path with distinct local optima. This will not only help the search to avoid being trap in a local optima point,

cont

but can also effectively deal with various landscape search charateristics and dynamic changes of the problem. In addition, a diversity indicator is adoped to control the local search processes to encourage solution diversity. Our MA method is evaluated on instances of the Google machine reassignment problem proposed for the ROADEF/EURO 2012 challenge. Compared with the state of the art methods, our method achieved the best performance on most of instances, showing the effectiveness of variable local search based MA for the Load Balancing problem.

Challenging Anti-virus through Evolutionary Malware Obfuscation

Marco Gaudesi, Andrea Marcelli, Ernesto Sanchez, Giovanni Squillero, Alberto Tonda

The use of anti-virus software has become something of an act of faith. A recent study showed that more than 80% of all personal computers have anti-virus software installed. However, the protection mechanisms in place are far less effective than users would expect. Malware analysis is a classical example of cat-and-mouse game: as new anti-virus techniques are developed, malware authors respond with new ones to thwart analysis. Every day, anti-virus companies analyze thousands of malware that has been collected through honeypots, hence they restrict the research to only already existing viruses. This article describes a novel method for malware obfuscation based an evolutionary opcode generator and a special ad-hoc packer. The results can be used by the security industry to test the ability of their system to react to malware mutations.

Simheuristics for the Multiobjective Nondeterministic Firefighter Problem in a Time-Constrained Setting

Krzysztof Michalak, Joshua D. Knowles

The firefighter problem (FFP) is a combinatorial problem requiring the allocation of `firefighters' to nodes in a graph in order to protect the nodes from fire (or other threat) spreading along the edges. In the original formulation the problem is deterministic: fire spreads from burning nodes to adjacent, unprotected nodes with certainty. In this paper a nondeterministic version of the FFP is introduced where fire spreads to unprotected nodes with a probability P_{sp} (lower than~1) per time step. To account for the stochastic nature of the problem the simheuristic approach is used in which a metaheuristic algorithm uses simulation to evaluate candidate solutions. Also, it is assumed that the optimization has to be performed in a limited amount of time available for computations in each time step. In this paper online and offline optimization using a multipopulation evolutionary algorithm is performed and the results are compared to various heuristics that determine how to place firefighters. Given the time-constrained nature of the problem we also investigate for how long to simulate the spread of fire when evaluating solutions produced by an evolutionary algorithm. Results generally indicate that the evolutionary algorithm proposed is effective for $P_{sp} \geq 0.7$, whereas for lower probabilities the heuristics are competitive suggesting that more work on hybrids is warranted.

EvoAPP session 2 : Image Analysis and Signal Processing

Wednesday 30 March 1400-1550

Room 3

chairs : Stefano Cagnoni & Mengjie Zhang

Binary Tomography Reconstruction by Particle Aggregation

Mohammad Majid al-Rifaie, Tim Blackwell

This paper presents a novel reconstruction algorithm for binary tomography based on the movement of particles. Particle Aggregate Reconstruction Technique (PART) supposes that pixel values are particles, and that the particles can diffuse through the image, sticking together in regions of uniform pixel value known as aggregates. The algorithm is tested on four phantoms of varying sizes and numbers of forward projections and compared to a random search algorithm and to SART, a standard algebraic reconstruction method. PART, in this small study, is shown to be capable of zero error reconstruction and compares favourably with SART and random search.

Population Based Ant Colony Optimization for Reconstructing ECG Signals

Yih-Chun Cheng, Tom Hartmann, Pei-Yun Tsai, Martin Middendorf

A population based ant optimization algorithm (PACO) for reconstructing electrocardiogram (ECG) signals is proposed in this paper. In particular, the PACO algorithm is used to find a subset of nonzero positions of a sparse wavelet domain ECG signal vector which is used for the reconstruction of a signal. The proposed PACO algorithm uses a time window for xing certain decisions of the ants during the run of the algorithm. The optimization behaviour of the PACO is compared with two random search heuristics and several algorithms from the literature for ECG signal reconstruction. Experimental results are presented for ECG signals from the MIT-BIT Arrhythmia database. The results show that the proposed PACO reconstructs ECG signals very successfully.

Speaker Verification on Unbalanced Data with Genetic Programming

Roisin Loughran, Alexandros Agapitos, Ahmed Kattan, Anthony Brabazon, Michael O'Neill ***(best paper candidate)***

Automatic Speaker Verification (ASV) is a highly unbalanced binary classification problem, in which any given speaker must be verified against everyone else. We apply Genetic programming (GP) to this problem with the aim of both prediction and inference. We examine the generalisation of evolved programs using a variety of fitness functions and data sampling techniques found in the literature. A significant difference between train and test performance, which can indicate overfitting, is found in the evolutionary runs of all to-be-verified speakers. Nevertheless, in all speakers, the best test performance attained is always superior than just merely predicting the majority class. We examine which features are used in good-generalising individuals. The findings can inform future applications of GP or other machine learning techniques to ASV about the suitability of feature-extraction techniques.

EvoAPP session 2 : Image Analysis and Signal Processing

Wednesday 30 March 1400-1550

Room 3

Bare-Bone Particle Swarm Optimisation for Simultaneously Discretising and Selecting Features For High-Dimensional Classification

Binh Tran, Mengjie Zhang, Bing Xue

Feature selection and discretisation have shown their effectiveness for data preprocessing especially for high-dimensional data with many irrelevant features. While feature selection selects only relevant features, feature discretisation finds a discrete representation of data that contains enough information but ignoring some minor fluctuation. These techniques are usually applied in two stages, discretisation and then selection since many feature selection methods work only on discrete features. Most commonly used discretisation methods are univariate in which each feature is discretised independently; therefore, the feature selection stage may not work efficiently since information showing feature interaction may be destroyed in the discretisation process. In this study, we propose a new method called PSO-DFS using bare-bone particle swarm optimisation (BBPSO) for discretisation and feature selection in a single stage. The results on ten high-dimensional datasets show that PSO-DFS obtains a substantial dimensionality reduction for all datasets. The classification performance is significantly improved or at least maintained on nine out of ten datasets by using the transformed ``small'' data by PSO-DFS. Compared to applying the two-stage approach which uses PSO for feature selection on the discretised data, PSO-DFS achieves better performance on six datasets, and similar performance on three datasets with a much smaller number of features selected.

NSGA-II based Auto-Calibration of Automatic Number Plate Recognition Camera for Vehicle Speed Measurement

Patryk Filipiak, Bartlomiej Golenko, Cezary Dolega

This paper introduces an auto-calibration mechanism for an Automatic Number Plate Recognition camera dedicated to a vehicle speed measurement. A calibration task is formulated as a multi-objective optimization problem and solved with Non-dominated Sorting Genetic Algorithm. For simplicity a uniform motion profile of a majority of vehicles is assumed. The proposed speed estimation method is based on tracing licence plates quadrangles recognized on video frames. The results are compared with concurrent measurements performed with piezoelectric sensors.

EvoAPP session 3 : Evolutionary algorithms and meta-heuristics in stochastic and dynamic environments

Wednesday 30 March 1700-1850

Room 3

chairs : Trung Thanh Nguyen & Michalis Mavrovouniotis

Direct Memory Schemes for Population-based Incremental Learning in Cyclically Changing Environments *(best paper candidate)*

Michalis Mavrovouniotis, Shengxiang Yang

The population-based incremental learning (PBIL) algorithm is a combination of evolutionary optimization and competitive learning. The integration of PBIL with associative memory schemes has been successfully applied to solve dynamic optimization problems (DOPs). The best sample together with its probability vector are stored and reused to generate the samples when an environmental change occurs. It is straight forward that these methods are suitable for dynamic environments that are guaranteed to reappear, known as cyclic DOPs. In this paper, direct memory schemes are integrated to the PBIL where only the sample is stored and reused directly to the current samples. Based on a series of cyclic dynamic test problems, experiments are conducted to compare PBILs with the two types of memory schemes. The experimental results show that one specific direct memory scheme, where memory-based immigrants are generated, always improves the performance of PBIL. Finally, the memory-based immigrant PBIL is compared with other peer algorithms and shows promising performance.

Benchmarking dynamic three-dimensional bin packing problems using discrete-event simulation

Ran Wang, Trung Thanh Nguyen, Shayan Kavakeb, Zaili Yang, Changhe Li

In this paper a framework is developed to generate benchmark problems for dynamic three-dimensional (3D) bin packing problems (BPPs). This framework is able to generate benchmark problems for different variants of BPPs by taking into account potential uncertainty in real-world BPPs, which are uncertainties in dimensions, costs, weights of upcoming items. This paper has three main contributions. First, a benchmark generator framework is developed for the first time using an open source discrete-event simulation platform. This framework generates benchmark problems for BPPs by reproducing uncertainty in real-world BPPs. Second, this framework can be integrated with any dynamic BPP algorithm so that the optimisation algorithm can be run alongside the simulation to solve dynamic BPPs. Third, various performance measures from the literature are included in the framework to evaluate the optimisation algorithms from different perspectives. Thanks to the 3D visualisation feature of this framework, the optimisation results can also be observed visually. Finally, empirical experiments on a real-world BPP are conducted to verify these contributions.

Genetic Programming Algorithms for Dynamic Environments

Joao Macedo, Ernesto Costa, Lino Marques

Evolutionary algorithms are a family of stochastic search heuristics that include Genetic Algorithms (GA) and Genetic Programming (GP). Both GAs and GPs have been successful in many applications, mainly with static scenarios. However, many real world applications involve dynamic environments (DE). Many work has been made to adapt GAs to DEs, but only a few efforts in adapting GPs for this kind of environments. In this paper we present novel GP algorithms for dynamic environments and study their performance using three dynamic benchmark problems, from the areas of Symbolic Regression, Classification and Path Planning. Furthermore, we apply the best algorithm we found in the navigation of an Erratic Robot through a dynamic Santa Fe Ant Trail and compare its performance to the standard GP algorithm. The results, statistically validated, are very promising.

EvoAPP session 3 : Evolutionary algorithms and meta-heuristics in stochastic and dynamic environments

Wednesday 30 March 1700-1850

Room 3

A Memory-Based NSGA-II Algorithm for Dynamic Multi-Objective Optimization Problems

Shaaban Sahmoud, Haluk Topcuoglu

Dynamic multi-objective optimization problems (DMOPs) have been rapidly attracting the interest of the research community. Although static multi-objective evolutionary algorithms have been adapted for solving the DMOPs in the literature, some of those extensions may have high running time and may be inefficient for the given set of test cases. In this paper, we present a new hybrid strategy by integrating the memory concept with the NSGA-II algorithm, called the MNSGA-II algorithm. The proposed algorithm utilizes an explicit memory to store a number of non-dominated solutions using a new memory updating technique. The stored solutions are reused in later stages to reinitialize part of the population when an environment change occurs. The performance of the MNSGA-II algorithm is validated using three test functions from a framework proposed in a recent study. The results show that performance of the MNSGA-II algorithm is competitive with the other state-of-the-art algorithms in terms of tracking the true Pareto front and maintaining the diversity.

Hybrid Dynamic Resampling Algorithms for Evolutionary Multi-objective Optimization of Invariant-Noise Problems

Florian Siegmund, Amos H.C. Ng, Kalyanmoy Deb

In Simulation-based Evolutionary Multi-objective Optimization (EMO) the available time for optimization usually is limited. Since many real-world optimization problems are stochastic models, the optimization algorithm has to employ a noise compensation technique for the objective values. This article analyzes Dynamic Resampling algorithms for handling the objective noise. Dynamic Resampling improves the objective value accuracy by spending more time to evaluate the solutions multiple times, which tightens the optimization time limit even more. This circumstance can be used to design Dynamic Resampling algorithms with a better sampling allocation strategy that uses the time limit. In our previous work, we investigated Time-based Hybrid Resampling algorithms for Preference-based EMO. In this article, we extend our studies to general EMO which aims to find a converged and diverse set of alternative solutions along the whole Pareto-front of the problem. We focus on problems with an invariant noise level, i.e. a flat noise landscape.

EvoAPP session 4 : Bio-inspired algorithms applied to networks

Thursday 31 March 0930 -1110

Room 1

chairs : Ivanoe De Falco & Antonio Della Cioppa

Joint Topology Optimization, Power Control and Spectrum Allocation for Intra-Vehicular Multi-hop Sensor Networks using Dandelion-encoded Heuristics

Javier Del Ser, Miren Nekane Bilbao, Cristina Perfecto, Gonzalez-Pardo, Sergio Campos-Cordobes

In the last years the interest in multi-hop communications has gained momentum within the research community due to the challenging characteristics of the intra-vehicular radio environment and the stringent robustness imposed on critical sensors within the vehicle. As opposed to point-to-point network topologies, multi-hop networking allows for an enhanced communication reliability at the cost of an additional processing overhead. In this context this manuscript poses a novel bi-objective optimization problem aimed at jointly minimizing 1) the average Bit Error Rate (BER) of sensing nodes under a majority fusion rule at the central data collection unit; and 2) the mean delay experienced by packets forwarded by such nodes due to multi-hop networking, frequency channel switching time multiplexing at intermediate nodes. The formulated paradigm is shown to be computationally tractable via a combination of evolutionary meta-heuristic algorithms and Dandelion codes, the latter capable of representing tree-like structures like those modeling the multi-hop routing approach. Simulations are carried out for realistic values of intra-vehicular radio channels and co-channel interference due to nearby IEEE 802.11 signals. The obtained results are promising and pave the way towards assessing the practical performance of the proposed scheme in real setups.

A Hybrid Discrete Artificial Bee Colony Algorithm for the Multicast Routing Problem

Yannis Marinakis, Magdalene Marinaki, Athanasios Migdalas

In this paper, a new algorithm is proposed for the solution of the Multicast Routing Problem. The algorithm is based on the Artificial Bee Colony approach hybridized with Variable Neighborhood Search. The quality of the algorithm is evaluated with experiments conducted on suitably modified benchmark instances of the Euclidean Traveling Salesman Problem from the TSP library. The results of the algorithm are compared to results obtained by several versions of the Particle Swarm Optimization algorithm. The comparisons indicated the effectiveness of the new approach.

An (MI)LP-based Primal Heuristic for 3-Architecture Connected Facility Location in Urban Access Network Design ***(best paper candidate)***

Fabio D'Andreagiovanni, Fabian Mett, Jonad Pulaj

We investigate the 3-architecture Connected Facility Location Problem arising in the design of urban telecommunication access networks integrating wired and wireless technologies. We propose an original optimization model for the problem that includes additional variables and constraints to take into account wireless signal coverage represented through signal-to-interference ratios. Since the problem can prove very challenging even for modern state-of-the art optimization solvers, we propose to solve it by an original primal heuristic that combines a probabilistic fixing procedure, guided by peculiar Linear Programming relaxations, with an exact MIP heuristic, based on a very large neighborhood search. Computational experiments on a set of realistic instances show that our heuristic can find solutions associated with much lower optimality gaps than a state-of-the-art solver.

EvoAPP session 4 : Bio-inspired algorithms applied to networks

Thursday 31 March 0930 -1110

Room 1

A Heuristic Crossover Enhanced Evolutionary Algorithm for Clustering Wireless Sensor Network

Muyiwa Olakanmi Oladimeji, Mikdam Turkey, Sandra Dudley

In this paper, a Heuristic-Crossover Enhanced Evolutionary Algorithm for Cluster Head Selection is proposed. The algorithm uses a novel heuristic crossover operator to combine two different solutions in order to achieve a high quality solution that distributes the energy load evenly among the sensor nodes and enhances the distribution of cluster head nodes in a network. Additionally, we propose the Stochastic Selection of Inactive Nodes, a mechanism inspired by the Boltzmann Selection process in genetic algorithms. This mechanism stochastically considers coverage effect in the selection of nodes that are required to go into sleep mode in order to conserve energy of sensor nodes. The proposed selection of inactive node mechanisms and cluster head selections protocol are performed sequentially at every round and are part of the main algorithm proposed, namely the Heuristic Algorithm for Clustering Hierarchy (HACH). The main goal of HACH is to extend network lifetime of wireless sensor networks by reducing and balancing the energy consumption among sensor nodes during communication processes. Our protocol shows improved performance compared with state-of-the-art protocols like LEACH, TCAC and SEECH in terms of improved network lifetime for wireless sensor networks deployments.

Reducing Efficiency of Connectivity-Splitting Attack on Newscast via Limited Gossip

Jakub Muszynski, Sebastien Varrette, Pascal Bouvry

Newscast is a Peer-to-Peer, nature-inspired gossip-based data exchange protocol used for information dissemination and membership management in large-scale, agent-based distributed systems. The model follows a probabilistic scheme able to keep a self-organised, small-world equilibrium featuring a complex, spatially structured and dynamically changing environment. Newscast gained popularity since the early 2000s thanks to its inherent resilience to node volatility as the protocol exhibits strong self-healing properties. However, the original design proved to be surprisingly fragile in a byzantine environment subjected to cheating faults. Indeed, a set of recent studies emphasized the hard-wired vulnerabilities of the protocol, leading to an efficient implementation of a malicious client, where a few naive cheaters are able to break the network connectivity in a very short time. Extending these previous works, we propose in this paper a modification of the seminal protocol with embedded counter-measures, improving the resilience of the scheme against malicious acts without significantly affecting the original Newscast's properties nor its inherent performance. Concrete experiments were performed to support these claims, using a framework implementing all the solutions discussed in this work.

EvoAPP session 5 : Evolutionary algorithms in games

Thursday 31 March 0930-1110

Room 2

chair : Antonio Mora

Orthogonally Evolved AI to Improve Difficulty Adjustment in Video Games

Arend Hintze, Randal Olson, Joel Lehman ***(best paper candidate)***

Computer games are most engaging when their difficulty is well matched to the player's ability, thereby providing an experience in which the player is neither overwhelmed nor bored. In games where the player interacts with computer-controlled opponents, the difficulty of the game can be adjusted not only by changing the distribution of opponents or game resources, but also through modifying the skill of the opponents. Applying evolutionary algorithms to evolve the artificial intelligence that controls opponent agents is one established method for adjusting opponent difficulty. Less-evolved agents (i.e.\ agents subject to fewer generations of evolution) make for easier opponents, while highly-evolved agents are more challenging to overcome. In this publication we test a new approach for difficulty adjustment in games: orthogonally evolved AI, where the player receives support from collaborating agents that are co-evolved with opponent agents (where collaborators and opponents have orthogonal incentives). The advantage is that game difficulty can be adjusted more granularly by manipulating two independent axes: by having more or less adept collaborators, and by having more or less adept opponents. Furthermore, human interaction can modulate (and be informed by) the performance and behavior of collaborating agents. In this way, orthogonally evolved AI both facilitates smoother difficulty adjustment and enables new game experiences.

There can be only one: Evolving RTS Bots via joust selection

Antonio Fernandez Ares, Pablo Garcia-Sanchez, Antonio Miguel Mora Garcia, Pedro A. Castillo, Juan J. Merelo

This paper proposes an evolutionary algorithm for evolving game bots that eschews an explicit fitness function using instead a match between individuals called {\em joust} and implemented as a selection mechanism where only the winner survives. This algorithm has been designed as an optimization approach to generate the behavioural engine of bots for the RTS game Planet Wars using Genetic Programming and has two objectives: first, to deal with the noisy nature of the fitness function and second, to obtain more general bots than those evolved using a specific opponent. In addition, avoiding the explicit evaluation step reduce the number of combats to perform during the evolution and thus, the algorithm time consumption is decreased. Results show that the approach performs converges, is less sensitive to noise than other methods and it yields very competitive bots in the comparison against other bots available in the literature.

Evolving Chess-like Games Using Relative Algorithm Performance Profiles

Jakub Kowalski, Marek Szykula

We deal with the problem of automatic generation of complete rules of an arbitrary game. This requires a generic and accurate evaluating function that is used to score games. Recently, the idea that game quality can be measured using differences in performance of various game-playing algorithms of different strengths has been proposed; this is called Relative Algorithm Performance Profiles. We formalize this method into a generally application algorithm estimating game quality, according to some set of model games with properties that we want to reproduce. We applied our method to evolve chess-like boardgames. The results show that we can obtain playable and balanced games of high quality.

EvoAPP session 5 : Evolutionary algorithms in games

Thursday 31 March 0930-1110

Room 2

Online Evolution for Multi-Action Adversarial Games

Niels Justesen, Tobias Mahlmann, Julian Togelius

We present Online Evolution, a novel method for playing turn-based multi-action adversarial games. Such games, which include most strategy games, have extremely high branching factors due to each turn having multiple actions. In Online Evolution, an evolutionary algorithm is used to evolve the combination of atomic actions that make up a single move, with a state evaluation function used for fitness. We implement Online Evolution for the turn-based multi-action game Hero Academy and compare it with a standard Monte Carlo Tree Search implementation as well as two types of greedy algorithms. Online Evolution is shown to outperform these methods by a large margin. This shows that evolutionary planning on the level of a single move can be very effective for this sort of problems.

The story of their lives: Massive procedural generation of heroes' journeys using evolved agent-based models and logical reasoning

Ruben H. Garcia-Ortega, Pablo Garcia-Sanchez, Juan J. Merelo, Aranzazu San-Gines, Angel Fernandez-Cabezas

The procedural generation of massive subplots and backstories in secondary characters that inhabit Open World videogames usually lead to stereotyped characters that act as a mere backdrop for the virtual world; however, many game designers claim that the stories can be very relevant for the player's experience. For this reason we are looking for a methodology that improves the variability of the characters' personality while enhancing the quality of their backstories following artistic or literary guidelines. In previous works, we used multi agent systems in order to obtain stochastic, but regulated, inter-relations that became backstories; later, we have used genetic algorithms to promote the appearance of high level behaviors inside them. Our current work continues the previous research line and propose a three layered system (Evolutionary computation - Agent-Based Model - Logical Reasoner) that is applied to the promotion of the monomyth, commonly known as the hero's journey, a social pattern that constantly appears in literature, films, and videogames. As far as we know, there is no previous attempt to model the monomyth as a logical theory, and no attempt to use the sub-solutions for narrating purposes. Moreover, this paper shows for the first time this multi-paradigm three-layered methodology to generate massive backstories. Different metrics have been tested in the experimental phase, from those that sum all the monomyth-related tropes to those that promote distribution of archetypes in the characters. Results confirm that the system can make the monomyth emerge and that the metric has to take into account facilitator predicates in order to guide the evolutionary process.

EvoAPP session 6 : Parallel and multi-agents systems

Thursday 31 March 0930-1110

Room 3

chairs : Ignacio Hidalgo & Francisco Fernandez de Vega

Implementing Parallel Differential Evolution on Spark ***(best paper candidate)***
Diego Teijeiro, Xoan C. Pardo, Patricia Gonzalez, Julio R. Banga, Ramon Doallo
Metaheuristics are gaining increased attention as an efficient way of solving hard global optimization problems. Differential Evolution (DE) is one of the most popular algorithms in that class. However, its application to realistic problems results in excessive computation times. Therefore, several parallel DE schemes have been proposed, most of them focused on traditional parallel programming interfaces and infrastructures. However, with the emergence of Cloud Computing, new programming models, like Spark, have appeared to suit with large-scale data processing on clouds. In this paper we investigate the applicability of Spark to develop parallel DE schemes to be executed in a distributed environment. Both the master-slave and the island-based DE schemes usually found in the literature have been implemented using Spark. The speedup and efficiency of all the implementations were evaluated on the Amazon Web Services (AWS) public cloud, concluding that the island-based solution is the best suited to the distributed nature of Spark. It achieves a good speedup versus the serial implementation, and shows a decent scalability when the number of nodes grows.

ECJ+HADOOP: An easy way to deploy massive runs of evolutionary algorithm
Francisco Chavez, Francisco Fernandez, Cesar Benavides-Alvarez, Daniel Lanza, Juan Villegas, Leonardo Trujillo, Gustavo Olague, Graciela Roman
This paper describes initial steps towards allowing Evolutionary Algorithms (EAs) researchers to easily deploy computing intensive runs of EAs on Big Data infrastructures. Although many proposals have already been described in the literature, and a number of new software tools have been implemented embodying parallel versions of EAs, we present here a different approach. Given traditional resistance to change when adopting new software, we try instead to endow the well known ECJ tool with the MapReduce model. By using the Hadoop framework, we introduce changes in ECJ that allow researchers to launch any EA problem on a big data infrastructure similarly as when a single computer is used to run the algorithm. By means of a new parameter, researchers can choose where the run will be launched, whether in a Hadoop based infrastructure or in a desktop computer. This paper shows the tests performed, how the whole system has been tuned to optimize the running time for ECJ experiments, and finally a realworld problem is shown to describe how the MapReduce model can automatically deploy the tasks generated by ECJ without additional intervention.

Addressing high dimensional multi-objective optimization problems by coevolutionary islands with overlapping search spaces
Pablo Garcia-Sanchez, Julio Ortega, Jesús Gonzalez, Pedro A. Castillo, Juan J. Merelo
Large-scale multi-objective optimization problems with many decision variables have recently attracted the attention of researchers as many data mining applications involving high dimensional patterns can be leveraged using them. Current parallel and distributed computer architectures can provide the required computing capabilities to cope with these problems once efficient procedures are available. In this paper we propose a cooperative coevolutionary island-model procedure based on the parallel execution of sub-populations, whose individuals explore different domains of the decision variables space. More specifically, the individuals belonging to the same sub-population (island) explore the same subset of decision variables. Two alternatives to distribute the decision variables among the different sub-populations have been considered

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and compared here. In the first approach, individuals in different sub-population explore disjoint subsets of decision variables (i.e. the chromosomes are divided into disjoints subsets). Otherwise, in the second alternative there are some overlapping among the variables explored by individuals in different sub-populations. The analysis of the obtained experimental results, by using different metrics, shows that coevolutionary approaches provide statistically significant improvements with respect to the base algorithm, being the relation of the number of islands (subpopulations) to the length of the chromosome (number of decision variables) a relevant factor to determine the most efficient alternative to distribute the decision variables.

Leveraging Online Racing and Population Cloning in Evolutionary Multirobot Systems

Fernando Silva, Luis Correia, Anders Lyhne Christensen

Online evolution of controllers on real robots typically requires a prohibitively long evolution time to synthesise effective solutions. In this paper, we introduce two novel approaches to accelerate online evolution in multirobot systems. We introduce a racing technique to cut short the evaluation of poor controllers based on the task performance of past controllers, and a population cloning technique that enables individual robots to transmit an internal set of high-performing controllers to robots nearby. We implement our approaches over odNEAT, which evolves artificial neural network controllers. We assess the performance of our approaches in three tasks involving groups of e-puck-like robots, and we show that they facilitate: (i) controllers with higher performance, (ii) faster evolution in terms of wall-clock time, (iii) more consistent group-level performance, and (iv) more robust, well-adapted controllers.

Multi-Agent Behavior-Based Policy Transfer

Sabre Didi, Geoff Nitschke

A key objective of transfer learning is to improve and speed-up learning on a target task after training on a different, but related, source task. This study presents a neuro-evolution method that transfers evolved policies within multi-agent tasks of varying degrees of complexity. The method incorporates behavioral diversity (novelty) search as a means to boost the task performance of transferred policies (multi-agent behaviors). Results indicate that transferred evolved multi-agent behaviors are significantly improved in more complex tasks when adapted using behavioral diversity. Comparatively, behaviors that do not use behavioral diversity to further adapt transferred behaviors, perform relatively poorly in terms of adaptation times and quality of solutions in target tasks. Also, in support of previous work, both policy transfer methods (with and without behavioral diversity adaptation), out-perform behaviors evolved in target tasks without transfer learning.

EvoAPP session 7 : Bio-inspired algorithms and complex systems

Thursday 31 March 1130-1310

Room 1

chair : Carlos Cotta

Towards intelligent biological control: Controlling Boolean networks with Boolean networks

Nadia S. Taou, David W. Corne, Michael A. Lones

Gene regulatory networks (GRNs) are the complex dynamical systems that orchestrate the activities of biological cells. In order to design effective therapeutic interventions for diseases such as cancer, there is a need to control GRNs in more sophisticated ways. Computational control methods offer the potential for discovering such interventions, but the difficulty of the control problem means that current methods can only be applied to GRNs that are either very small or that are topologically restricted. In this paper, we consider an alternative approach that uses evolutionary algorithms to design GRNs that can control other GRNs. This is motivated by previous work showing that computational models of GRNs can express complex control behaviours in a relatively compact fashion. As a first step towards this goal, we consider abstract Boolean network models of GRNs, demonstrating that Boolean networks can be evolved to control trajectories within other Boolean networks. The Boolean approach also has the advantage of a relatively easy mapping to synthetic biology implementations, offering a potential path to in vivo 66ehavior66on of evolved controllers.

The Emergence of Cooperation in Public Goods Games on Randomly Growing Dynamic Networks

Steve Miller, Joshua Knowles

According to evolutionary game theory, cooperation in public goods games is eliminated by free-riders, yet in nature, cooperation is ubiquitous. Artificial models resolve this contradiction via the mechanism of network reciprocity. However, existing research only addresses pre-existing networks and does not specifically consider their origins. Further, much work has focused on scale-free networks and so pre-supposes attachment mechanisms which may not exist in nature. We present a coevolutionary model of public goods games in networks, growing by random attachment, from small founding populations of simple agents. The model demonstrates the emergence of cooperation in moderately heterogeneous networks, regardless of original founders' 66ehavior, and absent higher cognitive abilities such as recognition or memory. It may thus illustrate a more general mechanism for the evolution of cooperation, from early origins, in minimally cognitive organisms. It is the first example of a model explaining cooperation in public goods games on growing networks.

Influence Maximization in Social Networks with Genetic Algorithms

Doina Bucur, Giovanni Iacca

We live in a world of social networks. Our everyday choices are often influenced by social interactions. Word of mouth, meme diffusion on the Internet, and viral marketing are all examples of how social networks can affect our 66ehavior. In many practical applications, it is of great interest to determine which nodes have the highest influence over the network, i.e., which set of nodes will, indirectly, reach the largest audience when propagating information. These nodes might be, for instance, the target for early adopters of a product, the most influential endorsers in political elections, or the most important investors in financial operations, just to name a few examples. Here, we tackle the NP-hard problem of influence maximization on social networks by means of a Genetic Algorithm. We show that, by using simple genetic operators, it is possible to

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find in feasible runtime solutions of high-influence that are comparable, and occasionally better, than the solutions found by a number of known heuristics (one of which was previously proven to have the best possible approximation guarantee, in polynomial time, of the optimal solution). The advantages of Genetic Algorithms show, however, in them not requiring any assumptions about the graph underlying the network, and in them obtaining more diverse sets of feasible solutions than current heuristics.

Measuring Diversity of Socio-cognitively Inspired ACO Search

Ewelina Swiderska, Jakub Lasisz, Aleksander Byrski,Tom Lenaerts, Dana Samson, Bipin Indurkhya, Ann Nowe, Marek Kisiel-Dorohinicki

In our recent research, we implemented an enhancement of Ant Colony Optimization incorporating the socio-cognitive dimension of perspective taking. Our initial results suggested that increasing the diversity of ant population --- introducing different pheromones, different species and dedicated inter-species relations --- yielded better results. In this paper, we explore the diversity issue by introducing novel diversity measurement strategies for ACO. Based on these strategies we compare both classic ACO and its socio-cognitive variation.

Multiwinner Voting in Genetic Algorithms for Solving Ill-Posed Global Optimization Problems

Piotr Faliszewski, Jakub Sawicki, Robert Schaefer, Maciej Smolka

Genetic algorithms are a group of powerful tools for solving ill-posed global optimization problems in continuous domains. In case in which the insensitivity of the fitness function is the main obstacle, the most desired feature of a genetic algorithm is its ability to explore plateaus of the fitness function, surrounding its minimizers. In this paper we suggest a way of maintaining diversity of the population in the plateau regions, based on a new approach for the selection based on the theory of multiwinner elections among autonomous agents. The paper delivers a detailed description of the new selection algorithm, computational experiments that guide the choice of the proper multiwinner rule to use, and a preliminary experiment showing the proposed algorithm’s effectiveness in exploring a fitness function’s plateau.

EvoAPP session 8 : Bio-inspired algorithms in energy applications

Thursday 31 March 1130-1310

Room 3

chairs : Neil Urquhart & Kevin Sim

Stigmergy-Based Scheduling of Flexible Loads

Fredy Rios, Lukas Konig, Hartmut Schmeck

In this paper, we address the rescheduling of shiftable loads in a sub-section of the power grid (micro-grid) to maximize the utilization of renewable energy sources (RES). The objective is to achieve a schedule for all customers in the micro-grid such that the RES output utilization is maximized. Customers correspond to residential households provided with intelligent appliances with the ability to recalculate their operation times. We propose an approach based on stigmergy to efficiently find a close-to-optimal solution to the general problem. An empirical analysis of the internal functioning of the algorithm is performed. Furthermore, the performance of the algorithm is compared to a price-based approach.

A hybrid genetic algorithm for the interaction of electricity retailers with demand response

Maria Joao Alves, Carlos Henggeler Antunes, Pedro Carrasqueira

In this paper a bilevel programming model is proposed for modeling the interaction between electricity retailers and consumers endowed with energy management systems capable of providing demand response to variable prices. The model intends to determine the pricing scheme established by the retailer (upper level decision maker) to the consumer (lower level decision maker) and the optimal load schedule adopted by the consumer under this price setting. The lower level optimization problem is formulated as a mixed-integer linear programming (MILP) problem. A hybrid approach consisting of a genetic algorithm and an exact MILP solver is proposed. The individuals of the population represent the retailer's choices (electricity prices). For each price setting, the exact optimal solution to the consumer's problem is obtained in a very efficient way using the MILP solver. An illustrative case is analyzed and discussed.

Comparison of Multi-objective Evolutionary Optimization in Smart Building Scenarios *(best paper candidate)*

Marlon Braun, Thomas Dengiz, Ingo Mauser, Hartmut Schmeck

The optimization of operating times and operation modes of devices and systems that consume or generate electricity in buildings by building energy management systems promises to alleviate problems arising in today's electricity grids. Conflicting objectives may have to be pursued in this context, giving rise to a multi-objective optimization problem. This paper presents the optimization of appliances as well as heating and air-conditioning devices in two distinct settings of smart buildings, a residential and a commercial building, with respect to the minimization of energy costs, CO2 emissions, discomfort, and technical wearout. We propose new encodings for appliances that are based on a combined categorization of devices respecting both, the optimization of operating times as well as operation modes, e.g., of hybrid devices. To identify an evolutionary algorithm that promises to lead to good optimization results of the devices in our real-world lab environments, we compare four state-of-the-art algorithms in realistic simulations: ESPEA, NSGA-II, NSGA-III, and SPEA2. The results show that ESPEA and NSGA-II significantly outperform the other two algorithms in our scenario.

EvoAPP session 8 : Bio-inspired algorithms in energy applications

Thursday 31 March 1130-1310

Room 3

Electrical Load Pattern Shape Clustering using Ant Colony Optimization

Fernando Lezama, Ansel Y. Rodriguez, Enrique Munoz de Cote

Electrical Load Pattern Shape (LPS) clustering of customers is an important part of the tariff formulation process. Nevertheless, the patterns describing the energy consumption of a customer have some characteristics (e.g., a high number of features corresponding to time series reflecting the measurements of a typical day) that make their analysis different from other pattern recognition applications. In this paper, we propose a clustering algorithm based on ant colony optimization (ACO) to solve the LPS clustering problem. We use four well-known clustering metrics (i.e., CDI, SI, DEV and CONN), showing that the selection of a clustering quality metric plays an important role in the LPS clustering problem. Also, we compare our LPS-ACO algorithm with traditional algorithms, such as k-means and single-linkage, and a state-of-the-art Electrical Pattern Ant Colony Clustering (EPACC) algorithm designed for this task. Our results show that LPS-ACO performs remarkably well using any of the metrics presented here.

A Decentralized PSO with Decoder for Scheduling Distributed Electricity Generation

Jorg Bremer, Sebastian Lehnhoff

A steadily increasing pervasion of the distribution grid with rather small renewable energy resources imposes fluctuating and hardly predictable feed-in and thus calls for new predictive load planning strategies. On the other hand, combined with controllable, shiftable loads and electrical storages, these energy units set up a flexibility potential for fine-grained control. To tap the full potential, distributed control strategies are discussed for scheduling due to the expected large number of controlled entities. Decoder strategies for unit independent algorithm implementation and feasibility assurance had recently been applied to some first optimization approaches for scheduling in smart grid. We extended a distributed particle swarm to harnesses such decoder approach for model independent constraint-handling and achieved a higher accuracy compared with other approaches. A multi swarm is integrated after the island model into a decentralized agent-based solution and compared with an established decentralized approach for predictive scheduling within virtual power plants. We demonstrate the superiority of the particle swarm in terms of achieved solution accuracy and the competitiveness in terms of sent messages.

EvoAPP session 9 : Natural computing methods in finance

Thursday 31 March 1415-1555

Room 1

chairs : Anthony Brabazon & Michael Kampouridis

Portfolio Optimization, a Decision-Support Methodology for Small Budgets

Igor Deplano, Giovanni Squillero, Alberto Tonda

Several machine learning paradigms have been applied to financial forecasting, attempting to predict the market's behavior, with the final objective of profiting from trading shares. While anticipating the performance of such a complex system is far from trivial, this issue becomes even harder when the investors do not have large amounts of money available. In this paper, we present an evolutionary portfolio optimizer for the management of small budgets. The expected returns are modeled resorting to Multi-layer Perceptrons, trained on past market data, and the portfolio composition is chosen by approximating the solution to a multi-objective constrained problem. An investment simulator is then used to measure the portfolio performance. The proposed approach is tested on real-world data from Milan stock exchange, exploiting information from January 2000 to June 2010 to train the framework, and data from July 2010 to August 2011 to validate it. The presented tool is finally proven able to obtain a more than satisfying profit for the considered time frame.

Improving Fitness Functions in Genetic Programming for Classification on Unbalanced Credit Card Data

Van Loi Cao, Nhien-An Le-Khac, Michael O'Neill, Miguel Nicolau, James McDermott

Credit card classification based on machine learning has attracted considerable interest from the research community. One of the most important tasks in this area is the ability of classifiers to handle the imbalance in credit card data. In this scenario, classifiers tend to yield poor accuracy on the minority class despite realizing high overall accuracy. This is due to the influence of the majority class on traditional training criteria. In this paper, we aim to apply genetic programming to address this issue by adapting existing fitness functions. We examine two fitness functions from previous studies and develop two new fitness functions to evolve GP classifiers with superior accuracy on the minority class and overall. Two UCI credit card datasets are used to evaluate the effectiveness of the proposed fitness functions. The results demonstrate that the proposed fitness functions augment GP classifiers, encouraging fitter solutions on both the minority and the majority classes.

Enhanced Multi-objective Population-Based Incremental Learning with Applications in Risk Treaty Optimization

Omar Andres Carmona Cortes, Andrew Rau-Chaplin

The purpose of this paper is to revisit the Multiobjective Population-Based Incremental Learning method and show how its performance can be improved in the context of a real-world financial optimization problem. The proposed enhancements lead to both better performance and improvements in the quality of solutions. Its performance was assessed in terms of runtime and speedup when parallelized. Also, metrics such as the average number of solutions, the average hypervolume, and coverage have been used in order to compare the Pareto frontiers obtained by both the original and enhanced methods. Results indicated that the proposed method is 22.1\% faster, present more solutions in the average (better defining the Pareto frontier) and often generates solutions having larger hypervolumes. The enhanced method achieves a speedup of 15.7 on 16 cores of a dual socket Intel multi-core machine when solving a Reinsurance Contract Optimization problem involving 15 Layers or sub-contracts.

EvoAPP session 9 : Natural computing methods in finance

Thursday 31 March 1415-1555

Room 1

Evolutionary Multi-objective Optimization for Portfolios in Emerging Markets: Contrasting Higher Moments and Median Models

Mai Ibrahim, Mohammed El-Beltagy, Motaz Khorshid

Multi-objective Evolutionary algorithms are well suited to Portfolio Optimization and hence have been applied in complex situations were traditional mathematical programming falls short. Often they were used in portfolios scenario of classical Mean-Variance which are not applicable to the Emerging Markets. Emerging Markets are characterized by return distributions that have shown to exhibit significance departure from normality and are characterized by skewness and fat tails. Therefore higher moments models and median models have been suggested in the literature for asset allocation in this case. Three higher moment models namely the Mean-Variance-Skewness, Mean-Variance-Skewness-Kurtosis, Mean-Variance-Skewness-Kurtosis for return and liquidity and three median models namely the Median-Value at Risk, Median-Conditional Value at Risk and Median-Mean Absolute Deviation are formulated as a multi-objective problem and solved using a multi-objective evolutionary algorithm namely the non-dominated sorting genetic algorithm II .The six models are compared and tested on real financial data of the Egyptian Index EGX. The median models were found in general to outperform the higher moments models. The performance of the median models was found to be better as the out-sample time increases.

Genetic Programming with Memory for Financial Trading

Alexandros Agapitos, Anthony Brabazon, Michael O'Neill

A memory-enabled program representation in strongly-typed Genetic Programming (GP) is compared against the standard representation in a number of financial time-series modelling tasks. The paper first presents a survey of GP systems that utilise memory. Thereafter, a number of simulations show that memory-enabled programs generalise better than their standard counterparts in most datasets of this problem domain.

EvoAPP session 10 : Evolutionary algorithms in industrial and simulated environments

Thursday 31 March 1415-1555

Room 3

chairs : Kevin Sim & Neil Urquhart

Constrained Level Generation through Grammar-Based Evolutionary Algorithms

Jose M. Font, Roberto Izquierdo, Daniel Manrique, Julian Togelius

This paper introduces an evolutionary method for generating levels for adventure games, combining speed, guaranteed solvability of levels and authorial control. For this purpose, a new graph-based two-phase level encoding scheme is developed. This method encodes the structure of the level as well as its contents into two abstraction layers: the higher level defines an abstract representation of the game level and the distribution of its content among different inter-connected game zones. The lower level describes the content of each game zone as a set of graphs containing rooms, doors, monsters, keys and treasure chests. Using this representation, game worlds are encoded as individuals in an evolutionary algorithm and evolved according to an evaluation function meant to approximate the entertainment provided by the game level. The algorithm is implemented into a design tool that can be used by game designers to specify several constraints of the worlds to be generated. This tool could be used to facilitate the design of game levels, for example to make professional-level content production possible for non-experts.

Can Evolutionary Algorithms Beat Dynamic Programming for Hybrid Car Control?

Tobias Rodemann, Ken Nishikawa

Finding the best possible sequence of control actions for a hybrid car in order to minimize fuel consumption is a well-studied problem. A standard method is Dynamic Programming (DP) that is generally considered to provide solutions close to the global optimum in relatively short time. To our knowledge Evolutionary Algorithms (EAs) have so far not been used for this setting, due to the success of DP. In this work we compare DP and EA for a well-studied example and find that for the basic scenario EA is indeed clearly outperformed by DP in terms of calculation time and quality of solutions. But, we also find that when going beyond the standard scenario towards more realistic (and complex) scenarios, EAs can actually deliver a performance en par or in some cases even exceeding DP, making them useful in a number of relevant application scenarios.

Environment-Model Based Testing with Differential Evolution in an Industrial Setting

Annamaria Szenkovits, Noemi Gasko, Erwan Jahier

Reactive systems interact continuously with their environments. In order to test such systems, one needs to design executable environment models. Such models are intrinsically stochastic, because environment may vary a lot, and also because they are not perfectly known. We propose an environment-model based testing framework optimized for reactive systems, where Differential Evolution (DE) is used to fine-tune the environment model and to optimize test input generation. In order to evaluate the proposed method, we present a case study involving a real-world SCADE system from the domain of railway automation. The problem specification was proposed by our industrial partner, Siemens. Our experimental data shows that DE can be used efficiently to increase the structural coverage of the System Under Test.

EvoAPP session 10 : Evolutionary algorithms in industrial and simulated environments

Thursday 31 March 1415-1555

Room 3

Workforce Scheduling in Inbound Customer Call Centres With a Case Study
Goran Molnar, Domagoj Jakobovic, Matija Pavelic
Call centres are an important tool that businesses use to interact with their clients. Their efficiency is especially significant since long queuing times can reduce customer satisfaction. Assembling the call centre work schedule is a complex task that needs to take various and often mutually conflicting goals into account. In this paper, we present a workforce scheduling system suited for small to medium call centres and adjusted to the needs of two real-world client institutions. The scheduling problem is to minimise the difference between allocated and forecasted number of staff members while also caring for numerous legal and organisational constraints as well as staff preferences. A flexible constraint handling framework is devised to enable rapid prototyping methodology used during the development. Based on it, two metaheuristics are devised for schedule construction: GRASP and iterated local search. Performance analysis and comparisons for these two methods are provided, on a real-world problem example. The devised system is successfully implemented in a real world setting of call centres at PBZCard, Croatian largest credit card vendor and PBZ (Intesa Sanpaolo), one of the largest Croatian banks.

Optimization of Operation and Control Strategies for Battery Energy Storage Systems by Evolutionary Algorithms
Jan Muller, Matthias Marz, Ingo Mauser, Hartmut Schmeck
To support the utilization of renewable energies, an optimized operation of energy systems is important. Often, the use of battery energy storage systems is stated as one of the most important measures to support the integration of intermittent renewable energy sources into the energy system. Additionally, the complexity of the energy system with its many interdependent entities as well as the economic efficiency call for an elaborate dimensioning and control of these storage systems. In this paper, we present an approach that combines the forward-looking nature of optimization and prediction with the feedback control of closed-loop controllers. An evolutionary algorithm is used to determine the parameters for a closed-loop controller that controls the charging and discharging control strategy of a battery in a smart building. The simulation and evaluation of a smart residential building scenario demonstrates the ability to improve the operation and control of a battery energy storage system. The optimization of the control strategy allows for the optimization with respect to variable tariffs while being conducive for the integration of renewable energy sources into the energy system.

EvoAPP session 11 : Biological applications

Thursday 31 March 1615-1745

Room 1

chair : Federico Divina

On Combinatorial Optimisation in Analysis of Protein-Protein Interaction and Protein Folding Networks

David Chalupa

Protein-protein interaction networks and protein folding networks represent prominent research topics at the intersection of bioinformatics and network science. In this paper, we present a study of these networks from combinatorial optimisation point of view. Using a combination of classical heuristics and stochastic optimisation techniques, we were able to identify several interesting combinatorial properties of biological networks of the COSIN project. We obtained optimal or near-optimal solutions to maximum clique and chromatic number problems for these networks. We also explore patterns of both non-overlapping and overlapping cliques in these networks. Optimal or near-optimal solutions to partitioning of these networks into non-overlapping cliques and to maximum independent set problem were discovered. Maximal cliques are explored by enumerative techniques. Domination in these networks is briefly studied, too. Applications and extensions of our findings are discussed.

Automating biomedical data science through tree-based pipeline optimization

Randal Olson, Ryan Urbanowicz, Peter Andrews, Nicole Lavender, La Creis Kidd, Jason Moore ***(best paper candidate)***

Over the past decade, data science and machine learning has grown from a mysterious art form to a staple tool across a variety of fields in academia, business, and government. In this paper, we introduce the concept of tree-based pipeline optimization for automating one of the most tedious parts of machine learning---pipeline design. We implement a Tree-based Pipeline Optimization Tool (TPOT) and demonstrate its effectiveness on a series of simulated and real-world genetic data sets. In particular, we show that TPOT can build machine learning pipelines that achieve competitive classification accuracy and discover novel pipeline operators---such as synthetic feature constructors---that significantly improve classification accuracy on these data sets. We also highlight the current challenges to pipeline optimization, such as the tendency to produce pipelines that overfit the data, and suggest future research paths to overcome these challenges. As such, this work represents an early step toward fully automating machine learning pipeline design.

EvoAPP session 11 : Biological applications

Thursday 31 March 1615-1745

Room 1

Bicliques in Graphs with Correlated Edges: From Artificial to Biological Networks

Aaron Kershenbaum, Alicia Cutillo, Christian Darabos, Murray Keitha, Schiaffino Robert, Jason H. Moore

Networks representing complex biological interactions are often very intricate and rely on algorithmic tools for thorough quantitative analysis. In bi-layered graphs, identifying subgraphs of potential biological meaning relies on identifying bicliques between two sets of associated nodes, or variables -- for example, diseases and genetic variants. Researchers have developed multiple approaches for forming bicliques and it is important to understand the features of these models and their applicability to real-life problems. We introduce a novel algorithm specifically designed for finding maximal bicliques in large datasets. In this study, we applied this algorithm to a variety of networks, including artificially generated networks as well as biological networks based on phenotype-genotype and phenotype-pathway interactions. We analyzed performance with respect to network features including density, node degree distribution, and correlation between nodes, with density being the major contributor to computational complexity. We also examined sample bicliques and postulate that these bicliques could be useful in elucidating the genetic and biological underpinnings of shared disease etiologies and in guiding hypothesis generation. Moving forward, we propose additional features, such as weighted edges between nodes, that could enhance our study of biological networks.

A Multi-objective Genetic Programming Biomarker Detection Approach in Mass Spectrometry Data

Soha Ahmed, Mengjie Zhang, Lifeng Peng, Bing Xue

Mass spectrometry is currently the most commonly used technology in biochemical research for proteomic analysis. The main goal of proteomic profiling using mass spectrometry is the classification of samples from different clinical states. This requires the identification of proteins or peptides (biomarkers) that are expressed differentially between different clinical states. However, due to the high dimensionality of the data and the small number of samples, classification of mass spectrometry data is a challenging task. Therefore, an effective feature manipulation algorithm either through feature selection or construction is needed to enhance the classification performance and at the same time minimise the number of features. Most of the feature manipulation methods for mass spectrometry data treat this problem as a single objective task which focuses on improving the classification performance. This paper presents two new methods for biomarker detection through multi-objective feature selection and feature construction. The results show that the proposed multi-objective feature selection method can obtain better subsets of features than the single-objective algorithm and two traditional multi-objective approaches for feature selection. Moreover, the multi-objective feature construction algorithm further improves the perfomance over the multi-objective feature selection algorithm. This paper is the first multi-objective genetic programming approach for biomarker detection in mass spectrometry data.

EvoAPP session 12 : Interactive Presentations I

Thursday 31 March 1645-1745

Room 3

chair : Antonio Mora

Dangerousness Metric for Gene Regulated Car Driving

Sylvain Cussat-Blanc, Jean Disset, Stephane Sanchez

In this paper, we show how a dangerousness metric can be used to modify the input of a gene regulatory network when plugged to a virtual car. In the context of the 2015 Simulated Car Racing Championship organized during GECCO 2015, we have developed a new cartography methodology able to inform the controller of the car about the incoming complexity of the track: turns (slipperiness, angle, etc.) and bumps. We show how this dangerousness metric improves the results of our controller and outperforms other approaches on the tracks used in the competition.

Using Isovists to Evolve Terrains with Gameplay Elements

Andrew William Pech, Chiou-Peng Lam, Philip Hingston, Martin Masek

The virtual terrain for a video game generally needs to exhibit a collection of gameplay elements, such as some areas suitable for hiding and others for large scale battles. A key problem in automating terrain design is the lack of a quantitative definition of terrain gameplay elements. In this paper, we ad-dress the problem by proposing a representation for gameplay elements based on a combination of space-based isovist measures from the field of architecture and graph-connectivity metrics. We then propose a genetic algorithm-based approach that evolves a set of modifications to an existing terrain so as to exhibit the gameplay element characteristics. The potential for this approach in the design of computer game environments is examined by generating terrain containing instances of the “hidden area” game element type. Results from four preliminary tests are described to show the potential of this research.

A spatially-structured PCG method for content diversity in a Physics-based simulation game

Raul Lara-Cabrera, Alejandro Gutierrez-Alcoba, Antonio Jose' Fernandez-Leiva

This paper presents a spatially-structured evolutionary algorithm (EA) to procedurally generate game maps of different levels of difficulty to be solved, in Gravityvolve!, a physics-based simulation videogame that we have implemented and which is inspired by the n-body problem, a classical problem in the field of physics and mathematics. The proposal consists of a steady-state EA whose population is partitioned into three groups according to the difficulty of the generated content (hard, medium or easy) which can be easily adapted to handle the automatic creation of content of diverse nature in other games. In addition, we present three fitness functions, based on multiple criteria (i.e:, intersections, gravitational acceleration and simulations), that were used experimentally to conduct the search process for creating a database of maps with different difficulty in Gravityvolve!

EvoAPP session 12 : Interactive Presentations I

Thursday 31 March 1645-1745

Room 3

Design and Evaluation of an Extended Learning Classifier-based StarCraft Micro AI
Stefan Rudolph, Sebastian von Mammen, Johannes Jungbluth, Jorg Hahner
Due to the manifold challenges that arise when developing an artificial intelligence that can compete with human players, the popular realtime-strategy game \SC\ (BW) has received attention from the computational intelligence research community. It is an ideal testbed for methods for \textit{self-adaption at runtime} designed to work in complex technical systems. In this work, we utilize the broadly-used Extended Classifier System (XCS) as a basis to develop different models of BW micro AIs: the Defender, the Attacker, the Explorer and the Strategist. We evaluate theses AIs with a focus on their adaptive and co-evolutionary behaviors. To this end, we stage and analyze the outcomes of a tournament among the proposed AIs and we also test them against a non-adaptive player to provide a proper baseline for comparison and learning evolution. Of the proposed AIs, we found the Explorer to be the best performing design, but, also that the Strategist shows an interesting behavioral evolution.

Benchmarking languages for evolutionary algorithms
JJ Merelo, Pedro Castillo, Israel Blancas, Gustavo Romero, Pablo Garcia-Sánchez, Antonio Fernandez-Ares, Víctor Rivas, Mario Garcia-Valdez
Although performance is important, several other issues should be taken into account when choosing a particular language for implementing an evolutionary algorithm, such as the fact that the speed of different languages when carrying out an operation will depend on several factors, including the size of the operands, the version of the language and underlying factors such as the operating system. However, it is usual to rely on compiled languages, namely Java or C/C++, for carrying out any implementation without considering other languages or rejecting them outright on the basis of performance. Since there are a myriad of languages nowadays, it is interesting however to measure their speed when performing operations that are usual in evolutionary algorithms. That is why in this paper we have chosen three evolutionary algorithm operations: bitflip mutation, crossover and the fitness function OneMax evaluation, and measured the speed for several popular, and some not so popular, languages. Our measures confirm that, in fact, Java, C and C++ not only are the fastest, but also have a behaviour that is independent of the size of the chromosome. However, we have found other compiled language such as Go or interpreted languages such as Python to be fast enough for most purposes. Besides, these experiments show which of these measures are, in fact, the best for choosing an implementation language based on its performance.

On the Closest Averaged Hausdorff Archive for a Circularly Convex Pareto Front
Gunter Rudolph, Oliver Schutze, Heike Trautmann
The averaged Hausdorff distance has been proposed as an indicator for assessing the quality of finitely sized approximations of the Pareto front of a multiobjective problem. Since many set-based, iterative optimization algorithms store their currently best approximation in an internal archive these approximations are also termed archives. In case of two objectives and continuous variables it is known that the best approximations in terms of averaged Hausdorff distance are subsets of the Pareto front if it is concave. If it is linear or circularly concave the points of the best approximation are equally spaced. Here, it is proven that the optimal averaged Hausdorff approximation and the Pareto front have an empty intersection if the Pareto front is circularly convex. But the points of the best approximation are equally spaced and they rapidly approach the Pareto front for increasing size of the approximation.

EvoAPP session 12 : Interactive Presentations I

Thursday 31 March 1645-1745

Room 3

Evolving Smoothing Kernels for Global Optimization

Paul Manns, Kay Hamacher

The Diffusion-Equation Method (DEM) - sometimes synonymously called the Continuation Method - is a well-known natural computation approach in optimization. The DEM continuously transforms the objective function by a (Gaussian) kernel technique to reduce barriers separating local and global minima. Now, the DEM can successfully solve problems of small sizes. Here, we present a generalization of the DEM to use convex combinations of smoothing kernels in Fourier space. We use a genetic algorithm to incrementally optimize the (meta-)combinatorial problem of finding better performing kernels for later optimization of an objective function. For two test applications we derive and show their transferability to larger problems. Most strikingly, the original DEM failed on a number of the test instances to find the global optimum while our transferable kernels - obtained via evolutionary computations - were able to find the global optimum.

On-line Evolution of Foraging Behaviour in a Population of Real Robots

Jacqueline Heinerman, Alessandro Zonta, Evert Haasdijk, A.E.Eiben

This paper describes a study in evolutionary robotics conducted completely in hardware without using simulations. The experiments employ on-line evolution, where robot controllers evolve on-the-fly in the robots' environment as the robots perform their tasks. The main issue we consider is the feasibility of tackling a non-trivial task in a realistic timeframe. In particular, we investigate whether a population of six robots can evolve foraging behaviour in one hour. The experiments demonstrate that this is possible and they also shed light on some of the important features of our evolutionary system. Further to the specific results we also advocate the system itself. It provides an example of a replicable and affordable experimental set-up for other researches to engage in research into on-line evolution in a population of real robots.

EvoAPP session 13 : Pattern recognition & numerical optimisation

Friday 1 April 1130-1300

Room 1

chair : Anna I Esparcia-Alcázar

Mutual Information Estimation for Filter Based Feature Selection Using Particle Swarm Optimization

Bach Hoai Nguyen, Bing Xue, Peter Andreae

Feature selection is a pre-processing step in classification, which selects a small set of important features to improve the classifi- cation performance and efficiency. Mutual information is very popular in feature selection because it is able to detect non-linear re- lationship between features. However the existing mutual information approaches only consider two-way interaction between features. In ad- dition, in most methods, mutual information is calculated by counting approach, which might lead to an inaccurate results. This paper proposes a filter feature selection algorithm based on particle swarm optimization (PSO) named PSOMIE, which employs a novel fitness function using nearest neighbor mutual information estimation (NNE) to measure the quality of a feature set. PSOMIE is compared with using all features and two traditional feature selection approaches. The experiment results show that the mutual information estimation successfully guides PSO to search for a small number of features while maintaining or improving the classification performance over using all features and the traditional feature selection methods. In addition, PSOMIE provides a strong con- sistency between training and test results, which may be used to avoid overfitting problem.

A Wrapper Feature Selection Approach to Classification with Missing Data

Cao Truong Tran, Mengjie Zhang, Peter Andreae, Bing Xue

Many industrial and real-world datasets suffer from an unavoidable problem of missing values. The problem of missing data has been addressed extensively in the statistical analysis literature, and also, but to a lesser extent in the classification literature. The ability to deal with missing data is an essential requirement for classification because inadequate treatment of missing data may lead to large errors on classification. Feature selection has been successfully used to improve classification, but it has been applied mainly to complete data. This paper develops a wrapper feature selection approach to classification with missing data and investigates the impact of this approach. Empirical results on 10 datasets with missing values using C4.5 for an evaluation and particle swarm optimisation as a search technique in feature selection show that a wrapper feature selection for missing data not only can help to improve accuracy of the classifier, but also can help to reduce the complexity of the learned classification model.

EvoAPP session 13 : Pattern recognition & numerical optimisation

Friday 1 April 1130-1300

Room 1

Local Fitness Meta-Models with Nearest Neighbor Regression

Oliver Kramer

In blackbox function optimization, the results of fitness function evaluations can be used to train a regression model. This meta-model can be used to replace function evaluations and thus reduce the number of fitness function evaluations in evolution strategies (ES). In this paper, we show that a reduction of the number of fitness function evaluations of a (1+1)-ES is possible with a combination of a nearest neighbor regression model, a local archive of fitness function evaluations, and a comparatively simple meta-model management. We analyze the reduction of fitness function evaluations on set of benchmark functions.

Validating the Grid Diversity Operator: an Infusion Technique for Diversity Maintenance in Population-based Optimisation Algorithms

Ahmed Salah, Emma Hart, Kevin Sim

We describe a novel diversity method named Grid Diversity Operator (GDO) that can be incorporated into population-based optimization algorithms that support the use of {\em infusion} techniques to inject new material into a population. By replacing the random infusion mechanism used in many optimisation algorithms, the GDO guides the containing algorithm towards creating new individuals in sparsely visited areas of the search space. Experimental tests were performed on a set of 39 multimodal benchmark problems from the literature using GDO in conjunction with a popular immune-inspired algorithm (opt-ainet) and a sawtooth genetic algorithm. The results show that the GDO operator leads to better quality solutions in all of the benchmark problems as a result of maintaining higher diversity, and makes more efficient usage of the allowed number of objective function evaluations. Specifically, we show that the performance gain from using GDO increases as the dimensionality of the problem instances increases. An exploration of the parameter settings for the two main parameters of the new operator enabled the performance of the operator to be tuned empirically.

EvoAPP session 14 : Interactive Presentations II

Friday 1 April 1130-1300

Room 3

chair : Evert Haasdijk

Hybrid biclustering algorithms for data mining

Patryk Orzechowski, Krzysztof Boryczko

Hybrid methods are a branch of biclustering algorithms that emerge from combining selected aspects of pre-existing approaches. The syncretic nature of their construction enriches the existing methods providing them with new properties. In this paper the concept of hybrid biclustering algorithms is explained. A representative hybrid biclustering algorithm, inspired by neural networks and associative artificial intelligence, is introduced and the results of its application to microarray data are presented. Finally, the scope and application potential for hybrid biclustering algorithms is discussed.

Discovering potential clinical profiles of Multiple Sclerosis from clinical and pathological free text data with Constraint Non-negative Matrix Factorization

Jacopo Acquarelli, Elena Marchiori, Monica Bianchini

Constrained non-negative matrix factorization (CNMF) is an effective machine learning technique to cluster documents in the presence of class label constraints. In this work, we provide a novel application of this technique in research on neuro-degenerative diseases. Specifically, we consider a dataset of documents from the Netherlands Brain Bank containing free text describing clinical and pathological information about donors affected by Multiple Sclerosis. The goal is to use CNMF for identifying clinical profiles with pathological information as constraints. After pre-processing the documents by means of standard filtering techniques, a feature representation of the documents in terms of bi-grams is constructed. The high dimensional feature space is reduced by applying a trimming procedure. The resulting datasets of clinical and pathological bi-grams are then clustered using non-negative matrix factorization (NMF) and, next, clinical data are clustered using CNMF with constraints induced by the clustering of pathological data. Results indicate the presence of interesting clinical profiles, for instance related to vision or movement problems. In particular, the use of CNMF leads to the identification of a clinical profile related to diabetes mellitus. Pathological characteristics and duration of disease of the identified profiles are analysed. Although highly promising, results of this investigation should be interpreted with care due to the relatively small size of the considered datasets.

Application of Evolutionary Algorithms for the Optimization of Genetic Regulatory Networks

Elise Rosati, Morgan Madec, Abir Rezgui, Quentin Colman, Nicolas Toussaint, Christophe Lallement, Pierre Collet

Synthetic biology aims at reinvesting theoretical knowledge from various domains (biology, engineering, microelectronics) for the development of new biological functions. Concerning the design of such functions, the classical trial-error approach is expensive and time consuming. Computer-aided design is therefore of key interest in this field. As for other domains, such as microelectronics or robotics, evolutionary algorithms can be used to this end. This article is a first step in this direction: it describes the optimization of an existing artificial gene regulatory network (a band-pass detector) using evolutionary algorithms. Evolutionary algorithms successfully find a good set of parameters (the simulated response of the system which fits at 99% the expected response) in about 200 seconds (corresponding to 5000 generations) on a standard computer. This is the proof of concept of our approach. Moreover, results analysis allows the biologist not only to save time during the design process but also to study the specificity of a system.

EvoAPP session 14 : Interactive Presentations II

Friday 1 April 1130-1300

Room 3

A Distributed Intrusion Detection Framework based on Evolved Specialized Ensembles of Classifiers

Gianluigi Folino, Francesco Sergio Pisani, Pietro Sabatino

Modern intrusion detection systems must handle many complicated issues in real-time, as they have to cope with a real data stream; indeed, for the task of classification, typically the classes are unbalanced and, in addition, they have to cope with distributed attacks and they have to quickly react to changes in the data. Data mining techniques and, in particular, ensemble of classifiers permit to combine different classifiers that together provide complementary information and can be built in an incremental way. This paper introduces the architecture of a distributed intrusion detection framework and in particular, the detector module based on a meta-ensemble, which is used to cope with the problem of detecting intrusions, in which typically the number of attacks is minor than the number of normal connections. To this aim, we explore the usage of ensembles specialized to detect particular types of attack or normal connections, and Genetic Programming is adopted to generate a non-trainable function to combine each specialized ensemble. Non-trainable functions can be evolved without any extra phase of training and, therefore, they are particularly apt to handle concept drifts, also in the case of real-time constraints. Preliminary experiments, conducted on the well-known KDD dataset and on a more up-to-date dataset, ISCX IDS, show the effectiveness of the approach.

UAV Fleet Mobility Model with Multiple Pheromones for Tracking Moving Observation Targets

Christophe Atten, Loubna Channouf, Gregoire Danoy, Pascal Bouvry

The last years, UAVs have been developed to address a variety of applications ranging from searching and tracking to the surveillance of an area. However, using a single UAV limits the range of possible applications. Therefore, fleets of UAVs are nowadays considered to work together on a common goal which requires novel distributed mobility management models. This work proposes a novel nature-inspired mobility model for UAV fleets based on Ant Colony Optimisation approaches (ACO). It relies on two types of pheromones, a repulsive pheromone to cover the designated area in an efficient way, and an attractive pheromone to detect and to track the maximum number of targets. Furthermore, all decision takings are taken online by each UAV and are fully distributed. Experimental results demonstrate promising target tracking performances together with a small increase in the exhaustivity of the coverage.

Compilable phenotypes: Accelerating the evaluation of individuals in Grammatical Evolution

J. Manuel Colmenar, J. Ignacio Hidalgo, Juan Lanchares, Oscar Garnica, Jose-L. Risco-Martín, Ivan Contreras, Almudena Sanchez, J. Manuel Velasco

This paper presents a method for accelerating the evaluation of individuals in Grammatical Evolution. The method is applied for identification and modeling problems, where, in order to obtain the fitness value of one individual, we need to compute a mathematical expression for different time events. We propose to evaluate all necessary values of each individual using only one mathematical Java code. For this purpose we take profit of the flexibility of grammars, which allows us to generate Java compilable expressions. We test the methodology with a real problem: modeling glucose level on diabetic patients. Experiments confirms that our approach (compilable phenotypes) can get up to 300x reductions in execution time.

EvoAPP session 14 : Interactive Presentations II

Friday 1 April 1130-1300

Room 3

GPU Accelerated Molecular Docking Simulation with Genetic Algorithms

Serkan Altuntas, Zeki Bozkus, Basilio B. Fraguela

Receptor-Ligand Molecular Docking is a very computationally expensive process used to predict possible drug candidates for many diseases. A faster docking technique would help life scientists to discover better therapeutics with less effort and time. The requirement of long execution times may mean using a less accurate evaluation of drug candidates potentially increasing the number of false-positive solutions, which require expensive chemical and biological procedures to be discarded. Thus the development of fast and accurate enough docking algorithms greatly reduces wasted drug development resources, helping life scientists discover better therapeutics with less effort and time. In this article we present the GPU-based acceleration of our recently developed molecular docking code. We focus on offloading the most computationally intensive part of any docking simulation, which is the genetic algorithm, to accelerators, as it is very well suited to them. We show how the main functions of the genetic algorithm can be mapped to the GPU. The GPU-accelerated system achieves a speedup of around ~14x with respect to a single CPU core. This makes it very productive to use GPU for small molecule docking cases.

Hybrid Control for a Real Swarm Robotics System in an Intruder Detection Task

Miguel Duarte, Jorge Gomes, Vasco Costa, Sancho Moura Oliveira, Anders Lyhne Christensen

Control design is one of the prominent challenges in the field of swarm robotics. Evolutionary robotics is a promising approach to the synthesis of self-organized behaviors for robotic swarms but it has, so far, only been shown in relatively simple collective behaviors. In this paper, we explore the use of a hybrid control synthesis approach to produce control for a swarm of aquatic surface robots that must perform an intruder detection task. The robots have to go to a predefined area, monitor it, detect and follow intruders, and manage their energy levels by regularly recharging at a base station. The hybrid controllers used in our experiments rely on evolved behavior primitives that are combined through a manually programmed high-level behavior arbitrator. In simulation, we show how simple modifications to the behavior arbitrator can result in different swarm behaviors that use the same underlying behavior primitives, and we show that the composed behaviors are scalable with respect to the swarm size. Finally, we demonstrate the synthesized controller in a real swarm of robots, and show that the behavior successfully transfers from simulation to reality.

Conference Reception

The EvoStar conference reception will be held on Wednesday evening from 8 - 9.30 pm at the **Museu do Vinho do Porto**, which is within walking distance of the conference venue. Join the walking guides leaving at 7.15 pm or make your own way to Rua de Monchique 98, 4050-394 Porto.

The Museum is housed in an 18th century warehouse and provides an interesting history of the production of port wine which has been at the heart of Porto and the Duoro valley for hundreds of years.

YOU NEED TO BRING YOUR RECEPTION TICKET for entry. Light refreshments will be served.

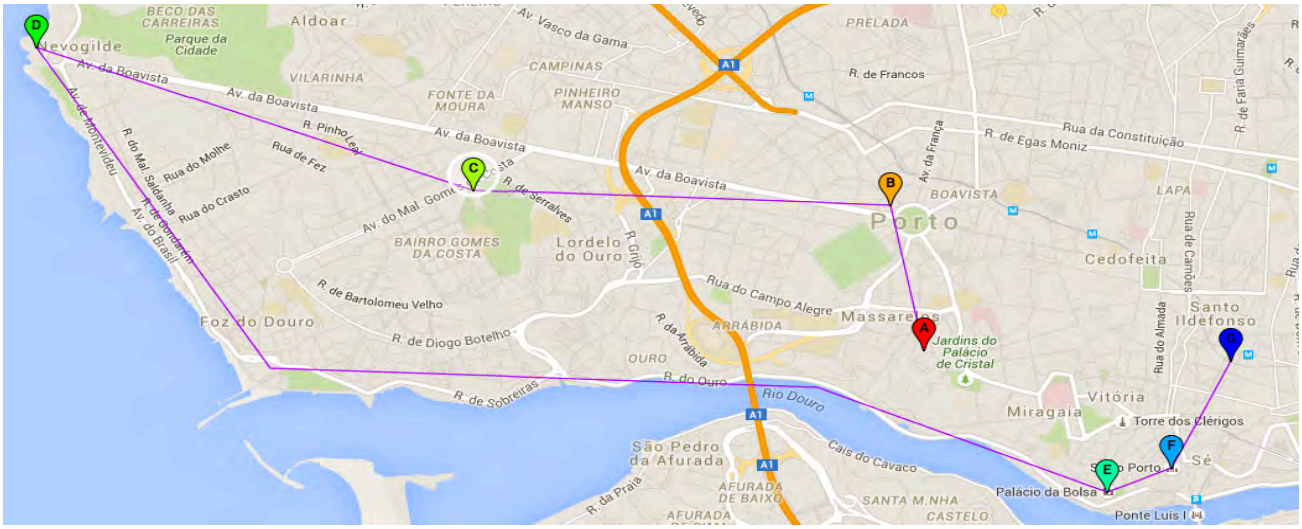
Conference Dinner

The EvoStar conference dinner will take place on Thursday 31 March from 7.30 - 10pm at the **Ferreira wine cellars** at Gaia on the southern side of the Duoro, at Av. Ramos Pinto 70, 4400-266 Vila Nova de Gaia. Coaches will depart from the conference venue at 7pm however the 30 – 40 minute walk through Porto's bustling Ribiera and across the double-decked high arched bridge to Gaia is also highly recommended.

The Ferreira family have been Duoro winemakers since 1751 and a tour of their wonderful "cave do vinho" and some sampling of different port wines will take place before dinner.

DO NOT FORGET TO BRING YOUR DINNER TICKET (in your registration bag). If you do not need your dinner ticket, please return it o the conference desk to be re-used for others to attend.

Optional Friday afternoon tour



The coach tour on Friday afternoon presents some interesting highlights of Porto. It leaves from the conference venue at 2.30 pm and returns at 5pm. Tickets are 15 euros and available at the conference desk (cash only).

First stop is the Casa da Música (Music House) a major concert hall with modern architectural interest having two walls made completely of glass.

Then to the Museu de Serralves (Serralves Museum), a modern art museum with a most beautiful garden.

A short drive to the Castelo do Queijo (Cheese Castle), an old castle near the Atlantic Ocean follows.

Optional Friday afternoon tour

We then proceed to the Palácio da Bolsa (Stock Exchange Palace), an example of neoclassicism and romanticism from the 19th and 20th centuries.

And then we continue to the Sé Catedral (Oporto's Cathedral), one of the oldest cathedrals in Portugal, combining baroque, gothic and romanic styles

The tour will finish at Mercado do Bolhão (Bolhão Market), in the center of the town where you can visit other famous sites like the Café Majestic, an art nouveau coffee house, or the Livraria Lello (Lello Bookstore), considered one of the most beautiful bookstores in the world.

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