EvoStar 2017
Conference Notebook

EvoStar 2017 conference programme

Wednesday 19 April

0900-0930	Registrations			
0930-0945	Conference opening by SPECIES Society President Marc Schoenauer			
0945-1045	Plenary invited talk: Kenneth de Jong *"EC: Past, Present and Future"*			
1045-1110	Coffee break			
		room 1	room 2	room 3
1110-1300		EuroGP 1	EvoApplications 1	EvoApplications 2
1300-1415	Lunch (with panel discussion on Open Access Publishing in room 2 from 1315-1400)			
1415-1605		EuroGP 2	EvoApplications 3	EvoApplications 4
1605-1625	Coffee break			
1625-1815		EuroGP 3	EvoApplications 5	EvoApplications 6
1830-2000	EvoStar poster session and conference reception (sponsored by Edinburgh Napier University)			

Thursday 20 April

		room 1	room 2	room 3
0930-1110		EuroGP 4 best papers	EvoMusArt 1	EvoApplications 7
1110-1130	Coffee break			
1130-1310		EvoCOP 1	EvoMusArt 2	EvoApplications 8
1310-1415	Lunch			
1415-1555		EvoCOP 2	EvoMusArt 3	EvoApplications 9
1555-1615	Coffee break			
1615-1745		EvoCOP 3	EvoMusArt 4 best papers	EvoApplications 10
1900-2130	Conference dinner			

Friday 21 April

		room 1	room 2	room 3
0945-1115		EvoCOP 4 best papers	EvoApplications 11	EvoApplications 12
1115-1130	Coffee break			
1130-1230	Plenary invited talk: Arthur Kordon *"Evolutionary Computation in Industry: A Realistic Overview"*			
1230-1300	Conference closing, best paper presentations, general announcements including 2018 location			
1300-1345	Lunch			
1345-1445	SPECIES society AGM open to all EvoStar participants			
1500-1800	Optional afternoon social trip : canal tour of Amsterdam (various departures, one hour duration)			

MY EVOSTAR

CONFERENCE NOTEBOOK

EvoStar conferences held in Amsterdam
19 - 21 April 2017

Acknowledgements

EvoStar gratefully acknowledges:

Invited speakers
Kenneth De Jong & Arthur Kordon

the Programme Chairs and Programme Committees
of all EvoStar conferences

local organisers Evert Haasdijk & Jacqueline Heinerman
(Vrije Universiteit Amsterdam)

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

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

and support from

The Mayor and Aldermen of the City of Amsterdam
BEACON
Springer-Verlag
Edinburgh Napier University
NWO, Netherlands Organisation for Scientific Research
Springer journal Memetic Computing
Frontiers in Robotics and AI

EvoStar Handbook and graphics produced by
Jennifer Willies, EvoStar Coordinator

Contents

Welcome to EvoStar

On behalf of all the EvoStar 2017 organisers, we are pleased to welcome you to Amsterdam for the four co-located EvoStar conferences of EuroGP, EvoCOP, EvoMUSART and EvoAPPLICATIONS. This is the 20th edition of EvoStar, with the first EuroGP and EvoROB workshops being held in Paris in 1998. Many of the people originally participating then still continue to come to EvoStar, or are now represented by their students, or even the students of those students! Many from the hundreds attending EvoStar conferences over the years have subsequently become programme chairs or local chairs in later years, and this contributes to a rich and vibrant community.

This year we are presenting a total of 25 conference sessions with 134 papers presented over two and a half days. In addition we are pleased to have two eminent invited speakers for the opening and closing talks, Kenneth De Jong and Arthur Kordon. We offer an exciting program with many high-quality contributions from the diverse fields within bio-inspired computation. The EvoStar events provide excellent opportunities to meet friends and establish new collaborative relationships within enjoyable social settings. Please do enjoy EvoStar2017 and if you want more information or need any help, do not hesitate to ask at the conference desk or any of the local organisers.

EvoStar arose out of workshops originally developed by EvoNet, the Network of Excellence in Evolutionary Computing, established by the European Commission and coordinated at Edinburgh Napier University in the UK. These events now represent a continuity of research collaboration stretching back over 20 years. We gratefully acknowledge the support provided by Edinburgh Napier University in helping EvoStar to continue over the years especially in employing coordinator Jennifer Willies.

SPECIES was formally set up in 2014 to provide an appropriate legal structure for future organisation and support of the EvoStar Conferences. SPECIES stands for the Society for the Promotion of Evolutionary Computation in Europe and its Surroundings, and its goal is to promote evolutionary algorithmic thinking.

The SPECIES Annual General Meeting will take place immediately after lunch on Friday at 1.45 pm and an Executive Board will be duly elected. Your conference registration includes SPECIES membership if you agreed to it, so we hope you will come to the AGM and contribute to the well-being of our society.

Marc Schoenauer
President

Anna I Esparcia
Vice President

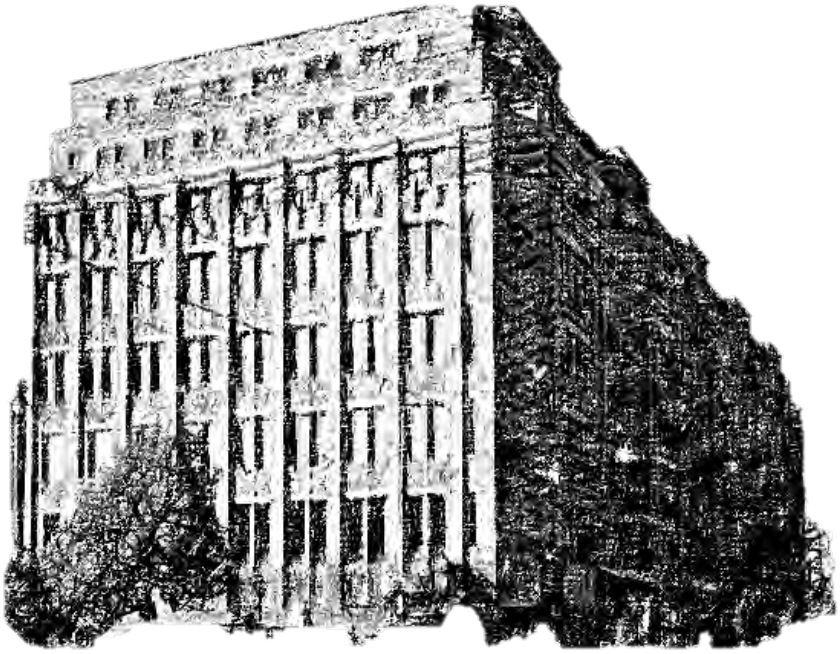
Wolfgang Banzhaf
Treasurer

De Bazel Venue

EvoStar 2017 is held at De Bazel located on Vijzelstraat 32, in the canal ring area of central Amsterdam and near the corner of Keizergracht.

Getting there from Amsterdam's Schiphol International (AMS) Airport is easy by train and a direct line connects the airport directly to Centraal Station, with 7-8 trains per hour. The trip takes around 15-20 minutes and most trains leave from platform 1, 2 or 3. A single ticket costs 4.20 euros. More travel info from www.ns.nl or www.amsterdam.info or www.iamsterdam.com

Once at Centraal Station you have several public transport options to get to De Bazel. Take **tram number 4 or 9,** and then get off at the third stop at the Munt Tower and turn right into the Vijzelstaat. Walk for approx 100m and across the first bridge, De Bazel is just ahead. Alternatively, from Centraal Station take **tram number 16, 24 or 25**, and get off at the fourth stop at the Vijzelstraat corner with Herengracht. De Bazel is opposite from the tram stop. Another option is **tram number 1 or 2** where you get off at the Keizergracht stop and head east along Keizergracht for approx. 100m. The building is large and stretches from Herrengracht to Keizergracht, and the entrance is halfway between on Vijzelstraat 32,. Look for the EvoStar banner beside the statues.



De Bazel is an impressive art deco building bult between 1919 en 1926. It was named after architect Karel de Bazel (1869-1923) and was completed three years after he had died. It is said to be an example of Brick Expressionism. It originally housed the The Dutch Treading Company (Nederlandsche Handel-Maatschappij) which King Willem I had founded in 1824 to stimulate the declining Dutch economy. The architecture of De Bazel with its impressive street frontage, its lovely paneling and floors and stained glass windows reflects its colonial trading past The EvoStar conference rooms will take place in the board rooms where previous Dutch trading routes were disussed.

Later De Bazel was used as headquarters for the Algemene Bank Nederland and then Dutch bank ABN AMRO. In 1999 the city of Amsterdam bought the building and after renovatation, it was reopened in 2007 to house the Amsterdam City Archives.

EvoStar 2017 Organisers

EuroGP

20th European Conference on Genetic Programming

EuroGP programme chairs :
Mauro Castelli, NOVA IMS, Universidade Nova de Lisboa, Portugal
James McDermott, University College Dublin, Ireland

EuroGP publication chair :
Lukáš Sekanina, Brno University of Technology, Czech Republic

EvoCOP

17th European Conference on Evolutionary Computation in Combinatorial Optimisation

EvoCOP programme chairs :
Bin Hu, Austrian Institute of Technology, Austria
Manuel López-Ibáñez, University of Manchester, UK

EvoMUSART

6th International Conference on Evolutionary and Biologically Inspired Music, Sound, Art and Design

EvoMUSART programme chairs :
João Correia, University of Coimbra, Portugal
Vic Ciesielski, RMIT University, Australia

EvoMUSART Publication chair :
Antonios Liapis, Institute of Digital Games, University of Malta, Malta

EvoAPPLICATIONS

20th European Conference on the Applications of Evolutionary Computation

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

EvoAPPS publication chair :
Kevin Sim, Edinburgh Napier University, UK

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 for Biology and Medicine
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
Ernesto Tarantino, ICAR/CNR, Italy
Fabio D'Andreagiovanni, Zuse Insitute Berlin, Germany
Giovanni Iacca, INCAS³, The Netherlands

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

EvoStar 2017 Organisers

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

***EvoGAMES* : Bio-inspired Algorithms in Games**
Antonio M. Mora Garcia, Universidad de Granada, Spain
Alberto Tonda, INRA, France
Paolo Burelli, Aalborg University Copenhagen, Denmark

***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

***EvoKNOW* : Knowledge Incorporation in Evolutionary Computation**
Giovanni Iacca, INCAS3, The Netherlands
Matt Coler, INCAS3, The Netherlands
Gerd Ascheid, RWTH Aachen University, Germany

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

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

***EvoROBOT* : Evolutionary Computation in Robotics**
Evert Haasdijk, VU University Amsterdam, The Netherlands
Jacqueline Heinerman, VU University Amsterdam, The Netherlands

***EvoSET* : Nature-inspired algorithms in Software Engineering and Testing**
Anna I Esparcia-Alcázar, Universitat Politècnica de València, Spain
Sara Silva, Universidade de Lisboa, Portugal

***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 2017 publicity chair
Pablo García Sánchez, University of Granada, Spain

EvoStar 2017 local chairs
Evert Haasdijk, VU University Amsterdam, The Netherlands
Jacqueline Heinerman, VU University Amsterdam, The Netherlands

EvoStar coordinator
Jennifer Willies, UK

Invited speakers

Opening Talk on Wednesday, 19 April at 0945

Kenneth De Jong

"Evolutionary Computation: Past, Present and Future"

I've had the privilege of involvement in this field from its early days. The result is a rather unique and comprehensive perspective on its development and growth. In this talk I use that perspective to highlight some important milestones, discuss some current issues and suggest some directions for the future.

Kenneth A De Jong received his Ph.D. in computer science from the University of Michigan in 1975. He joined George Mason University in 1984 and is currently a Professor Emeritus of Computer Science, head of the Evolutionary Computation Laboratory, and Associate Director of the Krasnow Institute. His research interests include genetic algorithms, evolutionary computation, machine learning, and complex adaptive systems. He is currently involved in research projects involving the development of new evolutionary algorithm (EA) theory, the use of EAs as high-performance optimization techniques, and the application of EAs to the problem of learning task programs in domains such as robot navigation and game playing. He is an active member of the Evolutionary Computation research community and has been involved in organizing many of the workshops and conferences in this area. He is the founding editor-in-chief of the journal Evolutionary Computation (MIT Press), and a member of the board of ACM SIGEVO. He is the recipient of an IEEE Pioneer award in the field of Evolutionary Computation and a lifetime achievement award from the Evolutionary Programming Society.
computing.

Invited speakers

Closing Talk on Friday, 21 April at 11:30

Arthur Kordon

"Evolutionary Computation in Industry: A Realistic Overview"

This talk will give a realistic overview of the current state of the art of EC in industry based on 20 years experience from applying these systems in several large global corporations. It includes a short analysis of the differences between academic and industrial research, examples of the key implementation areas of EC in manufacturing and business, a discussion about the main factors for success and failure of industrial EC systems, and an estimate of the projected industrial needs that may drive future applications.

Arthur Kordon is CEO of Kordon Consulting LLC and an internationally recognized expert in applying data science, advanced analytics and computational intelligence in industry. The list of his current projects for large corporations includes: customer churn analysis, classifying patterns in office occupancy, nonlinear price forecasting, etc. In his previous position as Advanced Analytics Leader at Dow Chemical, Dr. Kordon has successfully applied advanced analytics solutions in various business problems in forecasting, business cycles analysis, price elasticity analysis, fraud detection in Auditing, etc. He also successfully introduced several novel technologies for improved manufacturing and new product design based on computational intelligence, such as robust inferential sensors, process optimization based on empirical emulators, automated operating discipline, and accelerated fundamental model building. He holds a US patent and has published more than 70 papers and 14 book chapters in the area of applied computational intelligence and advanced analytics. Recently he published the book *Applying Computational Intelligence*, published by Springer and is a co-author of the book *Applied Data Mining for Forecasting*, published by SAS Press.

Best paper nominations

Best paper prizes are presented during the EvoStar closing ceremony on Friday, 21 April at 12:30

EuroGP candidates

Symbolic Regression on Network Properties
Marcus Märtens, Fernando Kuipers, Piet Van Mieghem

A general feature engineering wrapper for machine learning using epsilon-lexicase survival
William La Cava, Jason Moore

Differentiable Genetic Programming
Dario Izzo, Francesco Biscani, Alessio Mereta

Emergent Tangled Graph Representations for Atari Game Playing Agents
Stephen Kelly, Malcolm Heywood

EvoCOP candidates

Understanding Phase Transitions with Local Optima Networks: Number Partitioning as a Case Study
Gabriela Ochoa, Nadarajen Veerapen, Fabio Daolio, Marco Tomassini

The Weighted Independent Domination Problem: ILP Model and Algorithmic Approaches
Pedro Pinacho Davidson, Christian Blum, Jose A. Lozano

A memetic algorithm to maximise the employee substitutability in personnel shift scheduling
Jonas Ingels, Broos Maenhout

LCS-Based Selective Route Exchange Crossover for Pickup and Delivery with Time Windows
Miroslaw Blocho, Jakub Nalepa

EvoMUSART candidates

Predicting Expressive Bow Controls for Violin and Viola
Lauren Yu, Andrea Danyluk

Deep Artificial Composer: A Creative Neural Network Model for Automated Melody Generation
Florian Colombo, Alexander Seeholzer, Wulfram Gerstner

Niche Constructing Drawing Robots
Jon McCormack

Best paper nominations

EvoAPPS candidates

The Two Regimes of Neutral Evolution: Convergence on Hubs and Diffusion
David Shorten, Geoff Nitschke

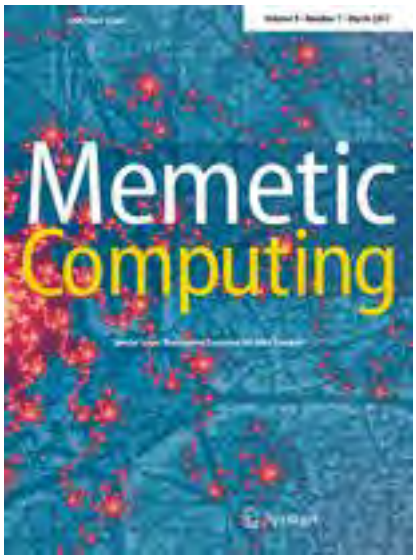
Use of a Multi-Objective Evolutionary Algorithm for Influence Maximization in Social Networks
Doina Bucur, Giovanni Iacca, Andrea Marcelli, Giovanni Squillero, Alberto Tonda

Local Misfit Approximation in Memetic Solving of Ill-posed Inverse Problems
Marcin Łoś, Robert Schaefer, Jakub Sawicki, Maciej Smołka

Automated Game Balancing in Ms Pacman and StarCraft using Evolutionary Algorithms
Mihail Morosan, Riccardo Poli

DICE: A New Family of Bivariate Estimation of Distribution Algorithms based on Dichotomised Multivariate Gaussian Distributions
Fergal Lane, R. Muhammad Atif Azad, Conor Ryan

An extended version of the EvoAPPLICATIONS best paper will be published in a special issue of the Springer journal Memetic Computing (Impact Factor: 1.00)



frontiers in Robotics and AI

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 in Evolutionary Robotics journal.

Evo* Outstanding Contribution to EC in Europe Award

Each year EvoStar recognizes those who have made an outstanding contribution to evolutionary computation in Europe. The award is presented during the conference dinner, this year on Thursday, 20 April. Previous recipients of the award are :

Penousal Machado
2016 - Porto

Anna Esparcia & Leo Vanneschi
2015 - Copenhagen

Terry Fogarty
2014- Granada

Una-May O'Reilly & Elena Marchiori
2013 - Vienna

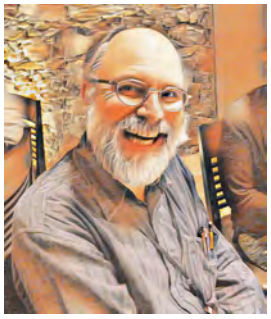
Günther Raidl
2012 - Malaga

Julian Miller
2011 - Torino

Marco Tomassini
2010 - Istanbul

Stefano Cagnoni & Ernesto Costa
2009 - Tübingen

Marc Schoenauer & Bill Langdon
2008 - Naples



Wolfgang Banzhaf & Riccardo Poli
2007 - Valencia

Jennifer Willies
2006 - Budapest

WIFI and access to online proceedings

Free WIFI is available to all evoStar participants :

Network : De Bazel Amsterdam
Password : Welcome01

Springer has made online access available for EvoStar participants for the conference proceedings for the period 12 April - 10 May 2017 via links at

http://www.evostar.org

The EvoStar volume numbers are as listed below,

- **LNCS 10196: EuroGP 2017**
- **LNCS 10197: EvoCOP 2017**
- **LNCS 10198: EvoMUSART 2017**
- **LNCS 10199: EvoAPPS 2017 (I)**
- **LNCS 10200: EvoAPPS 2017 (II)**

EvoStar Poster Session and Conference Reception

The EvoStar conference reception will be held on Wednesday evening from 1830-2000 in conjunction with the EvoStar poster session. We are grateful to Edinburgh Napier University for sponsoring this event. Light refreshments will be served.

The Wedding Dance – Peter Bruegel

The following posters will be presented :

A Grammar Design Pattern for Arbitrary Program Synthesis Problems in Genetic Programming
Stefan Forstenlechner, David Fagan, Miguel Nicolau, Michael O'Neill

A New Subgraph Crossover for Cartesian Genetic Programming
Roman Kalkreuth, Guenter Rudolph, Andre Droschinsky

A Comparative Analysis of Dynamic Locality and Redundancy in Grammatical Evolution
Eric Medvet

Geometric Semantic Crossover with an Angle-aware Mating Scheme in Genetic Programming for Symbolic Regression
Qi Chen, Bing Xue, Yi Mei, Mengjie Zhang

A Comparative Study of Different Grammar-based Genetic Programming Approaches
Nuno Lourenço, Joaquim Ferrer, Francisco B. Pereira, Ernesto Costa

EvoStar Poster Session

Improving the Tartarus Problem as a Benchmark in Genetic Programming
Thomas David Griffiths, Aniko Ekart

RECIPE: A Grammar-based Framework for Automatically Evolving Classification Pipelines
Alex de Sá, Walter José Pinto, Luiz Otavio Oliveira, Gisele Pappa

Evolving Mondrian-Style Artworks
Miri Weiss Cohen, Leticia Cherchiglia, Rachel Costa

Play it Again: Flexible Synthesizer and Audio Effects Preset Recreation
Benjamin Smith

Evolved Aesthetic Analogies to Improve Artistic Experience
Aidan Breen, Colm O'Riordan, Jerome Sheahan

Evolutionary Image Transition Using Random Walks
Aneta Neumann, Bradley Alexander, Frank Neumann

Fashion Design Aid System with Application of Interactive Genetic Algorithms
Nazanin Alsadat Tabatabaei Anaraki

On symmetry, aesthetics and quantifying symmetrical complexity
Mohammad Majid al-Rifaie, Anna Ursyn, Robert Zimmer, Mohammad Ali Javaheri Javid

A Swarm Environment for Experimental Performance and Improvisation
Frank Mauceri, Stephen Majercik

Generalisation Performance of Western Instrument Recognition Models in Polyphonic Mixtures with Ethnic Samples
Igor Vatolkin

Evaluation Rules for Evolutionary Generation of Drum Patterns in Jazz Solos
Fabian Ostermann, Igor Vatolkin, Günter Rudolph

EvoFashion: Customising Fashion Through Evolution
Nuno Lourenço, Filipe Assunção, Catarina Maçãs, Penousal Machado

A Kind of Bio-inspired Learning of mUsic style
Clelia De Felice, Roberto De Prisco, Delfina Malandrino, Gianluca Zaccagnino, Rocco Zaccagnino, Rosalba Zizza

Automated Shape Design by Grammatical Evolution
Manuel Muehlbauer, Jane Burry, Andy Song

Integration of Reaction Kinetics Theory and Gene Expression Programming to Infer Reaction Mechanism
Jason White, Ranjan Srivastava

Meta-heuristics for improved RF emitter localization
Sondre Andreas Engebraaten, Jonas Moen, Kyrre Glette

De Novo DNA Assembly with Genetic Operators Finds Accurate Genomes Even with Suboptimal Fitness
Doina Bucur

Meta-heuristically Seeded Genetic Algorithm for Independent Job Scheduling in Grid Computing
Muhanad Younis, Shengxiang Yang, Benjamin Passow

Evolutionary Art using the Fly Algorithm
Zainab Abbood, Othman Amlal, Franck Vidal

Ranking programming languages for evolutionary algorithm operations
JJ Merelo, Israel Blancas-Álvarez, Gustavo Romero, Pedro Castillo, Pablo García Sánchez, Víctor Rivas, Ma
Román

EVE: Cloud-based Annotation of Human Genetic Variants
Brian Cole, Jason Moore

Container Vessel Stowage Planning system using Genetic Algorithm
Miri Weiss Cohen, Vitor N. Coelho, Adi Dahan, Itzzik Kaspi

Presenting the ECO: Evolutionary Computation Ontology
Anil Yaman, Ahmed Hallawa, Matt Coler, Giovanni Iacca

A new multi-swarm particle swarm optimization for robust optimization over time
Danial Yazdani, Trung Thanh Nguyen, Juegen Branke, Jin Wang

The Static and Stochastic VRP with Time Windows and both random Customers and Reveal Times
Michael Saint-Guillain, Christine Solnon, Yves Deville

A VNS with Parallel Evaluation of Solutions for the Inverse Lighting Problem
Ignacio Decia, Rodrigo Leira, Martín Pedemonte, Eduardo Fernández, Pablo Ezzatti

Analysis of Average Communicability in Complex Networks
Qi Bu, Kwok Yip Szeto

Driving in TORCS using modular fuzzy controllers
Mohammed SALEM, Antonio Miguel MORA, Juan Julian MERELO, Pablo García-Sánchez

Automated Design of Genetic Programming Classification Algorithms using a Genetic Algorithm
thambo nyathi, nelishia pillay

Overcoming Initial Convergence in Multi-Objective Evolution of Robot Control and Morphology Using a Two-Phase Approach
Tønnes F. Nygaard, Eivind Samuelsen, Kyrre Glette

Evolving Cut-off Mechanisms and other Work-Stealing Parameters for Parallel Programs
Alcides Fonseca, Nuno Lourenço, Bruno Cabral

Lamarckian and Lifelong Memetic Search in Agent-based Computing
Wojciech Korczynski, Marek Kisiel-Dorohinicki, Aleksander Byrski

Evolutionary Adaptation to Social Information Use without Learning
James M. Borg, Alastair Channon

Interactive Evolution of Complex Behaviors through Skill Encapsulation
Pablo González de Prado Salas, Sebastian Risi

Hybrid Algorithms Based on Integer Programming for the Search of Prioritized Test Data in Software Product Lines
Javier Ferrer, Francisco Chicano, Enrique Alba

Evolution and Morphogenesis of Simulated Modular Robots: A Comparison Between a Direct and Generative Encoding
Frank Veenstra, Andres Faina, Sebastian Risi, Kasper Stoy

On the Use of Smelly Examples to Detect Code Smells in JavaScript
Ian Shoenberger, Wiem Mkaouer, Marouane Kessentini

Pre-Scheduled Colony Size Variation in Dynamic Environments
Michalis Mavrovouniotis, Anastasia Ioannou, Shengxiang Yang

Deep Parameter Tuning of Concurrent Divide and Conquer Algorithms in Akka
David White, Leonid Joffe, Edward Bowles, Jerry Swan

Improving the reproducibility of genetic association results using genotype resampling methods
Elizabeth Piette, Jason Moore

BEACON Researchers Study Evolutionary Computation!

How can YOU get involved in BEACON?

BEACON researchers work on many aspects of EC, including genetic programming, genetic algorithms, multi/many-objective optimization, innovization, open-ended digital evolution, evolving networks of logic gates (Markov brains), constrained optimization, novel nature-inspired search algorithms, and customized approaches to solving many real-world problems!

Some of our EC faculty leaders include:

Wolfgang Banzhaf, Kalyanmoy Deb, Erik Goodman, Charles Ofria, Betty Cheng, Bill Punch, Phil McKinley, Xiaobo Tan, Chris Adami, Kevin Liu, Arend Hintze, Rob Pennock, Risto Miikkulainen, Jeff Barrick, Gerry Dozier, Abie Homaifar, Terry Soule, Rob Heckendorn, and James Foster.

http://beacon-center.org/

BEACON

- Hosts many visiting scholars (graduate students, postdocs, faculty) sent by their governments/universities
- Recruits outstanding graduate students to Michigan State U., North Carolina A&T State U., U. of Idaho, U. of Texas Austin, and U. of Washington, including offering research assistantships and “top-up” fellowships
- Hires many great postdocs
- Invites speakers for seminars/ collaboration visits
- Sends its students and faculty to visit other research labs
- Provides funding for members to participate in international research collaborations
- Collaborates with many other centers/institutions/societies on education/outreach projects about EC or biological evolution

Talk with us at BEACON’s table at EvoStar near the registration desk!

Lunchtime Panel Discussion

Open Access Publishing

Wednesday 19 April 1315-1400
room 2

*Sponsored by **NWO, Netherlands Organisation for Scientific Research**, an open discussion session will take place over lunchtime on the topic of Open Access Publishing*

*This session is chaired by **Wolfgang Banzhaf**, who is the* John R. Koza-Endowed Chair of Genetic Programming *at Michigan State University, USA,*

And the panelists include

***Ronan Nugent**, senior editor, computer science, Springer-Verlag, Germany*

***Emma Hart**, editor-in-chief of Evolutionary Computation Journal and director of the Centre for Algorithms, Visualisation and Evolving Systems at Edinburgh Napier University, UK*

***Arjan Schalken**, deputy director and manager academic support, University Library, Vrije Universiteit Amsterdam, the Netherlands*

Please bring your lunch into room 2 and join in the discussion!

Meet the ECJ Editor

Emma Hart *has now taken over as Editor-in-Chief of Evoutionary Computation Journal, a role which was previously held by Hans-Georg Beyer since 2010, She will be at EvoStar on Wednesday 19 April and is available during the coffee and lunch breaks and also during the poster session in the evening, running informal meet-the-editor sessions.*

Professor Hart is the Director of the Centre for Algorithms, Visualisation and Evolving Systems at Edinburgh Napier University and her research is focused on biologically inspired computing.

See the interview with her at *https://mitpress.mit.edu/blog/welcome-emma-hart*

Evolutionary Computation is the leading journal in its field. It provides an international forum for facilitating and enhancing the exchange of information among researchers involved in both the theoretical and practical aspects of computational systems drawing their inspiration from nature, with particular emphasis on evolutionary models of computation such as genetic algorithms, evolutionary strategies, classifier systems, evolutionary programming, genetic programming, and related fields such as swarm intelligence (Ant Colony Optimization and Particle Swarm Optimization), and other evolutionary computation techniques.

Published by MIT Press Journals, ECJ has an impact factor of 3.6 (2016 Journal Citation Report, Science Edition)

Evolutionary Computation

Springer - Verlag

Continuing its relationship with Springer-Verlag for 20 years, EvoStar is pleased to see senior editor ***Ronan Nugent*** *again this year. He will be displaying some recent Springer titles during the coffee and lunch breaks.*

EvoStar's conference proceedings have been published in the LNCS series every year since 1998. A complete set of all LNCS Published Volumes are avaialable at www.springer.com/computer/lncs

Conference Dinner

The EvoStar conference dinner will take place on Thursday 20 April from 7.00 – 9.30 pm at the ***Central Hall of De Bazel***

The Peasant Wedding – Peter Bruegel

DO NOT FORGET TO BRING YOUR DINNER TICKET *(slotted into your conference badge holder). If you cannot attend the dinner, we request that you return your dinner ticket to the conference desk so it can be recycled and given to others wanting to join the dinner.*

Optional Friday afternoon tour

The Mayor and Aldermen of the City of Amsterdam cordially invite EvoStar participants to a cruise through Amsterdam's historic and enchanting canals on Friday afternoon.

Canal crusie vouchers are available at the Registration Desk and these entitle you to free admission to the 100 Highlights Cruise which takes about one hour.

***Canal boats depart approximately every 15 minutes** from Stromma Netherlands at Prins Hendrikkade 33a (opposite Centraal Station), Amsterdam. Your voucher can also be used on Friday evening from 6-10 pm when boats leave every 30 minutes.*

Remember to collect your free voucher from the Registration Desk on Friday as you will need to hand this in at the Canal Company entrance at Prins Hendrikkade 33a before boarding. More information at www.canal.nl/en/canal-cruises-amsterdam or telephone +31 20 217 0500

Wednesday 19 April, room 1

1110-1300	**EuroGP 1 : GP for Programming** **chair : Mengjie Zhang** **Visualising the Search Landscape of the Triangle Program** *William B. Langdon, Nadarajen Veerapen, Gabriela Ochoa* **Exploring Fitness and Edit Distance of Mutated Python Programs** *Saemundur O. Haraldsson, John R. Woodward, Alexander I.E. Brownlee, David Cairns* **Evolutionary Program Sketching** *Iwo Błądek, Krzysztof Krawiec* **A Grammar Design Pattern for Arbitrary Program Synthesis Problems in Genetic Programming** *Stefan Forstenlechner, David Fagan, Miguel Nicolau, Michael O'Neill* **A Comparative Analysis of Dynamic Locality and Redundancy in Grammatical Evolution** *Eric Medvet* **A Comparative Study of Different Grammar-based Genetic Programming Approaches** Nuno Lourenço, Joaquim Ferrer, Francisco B. Pereira, Ernesto Costa
1300-1415	**Lunch**
1415-1605	**EuroGP 2 : GP for Regression & Feature Learning** **chair : Krzysztof Krawiec** **RANSAC-GP: Dealing with Outliers in Symbolic Regression with Genetic Programming** *Uriel López, Leonardo Trujillo, Yuliana Martinez, Pierrick Legrand, Enrique Naredo, Sara Silva* **Using Feature Clustering for GP-Based Feature Construction on High-Dimensional Data** *Binh Tran, Bing Xue, Mengjie Zhang* **Strategies for Improving the Distribution of Random Function Outputs in GSGP** *Luiz Otavio V. B. Oliveira, Felipe Casadei, Gisele Pappa* **Evolving Game State Features from Raw Pixels** *Baozhu Jia, Marc Ebner* **Geometric Semantic Crossover with an Angle-aware Mating Scheme in Genetic Programming for Symbolic Regression** *Qi Chen, Bing Xue, Yi Mei, Mengjie Zhang* **On Evolutionary Approximation of Sigmoid Function for HW/SW Embedded Systems** Milos Minarik, Lukas Sekanina

Wednesday 19 April, room 1

1605-1625	**Coffee break**
1625-1815	**EuroGP 3 : GP for Operations Research** **chair : Lukas Sekanina** **Grammatical Evolution of Robust Controller Structures using Wilson Scoring and Criticality Ranking** *Elias Reichensdörfer, Dirk Odenthal, Dirk Wollherr* **Synthesis of Mathematical Programming Constraints with Genetic Programming** *Tomasz P. Pawlak, Krzysztof Krawiec* **Evolving Time-Invariant Dispatching Rules in Job Shop Scheduling with Genetic Programming** *Yi Mei, Su Nguyen, Mengjie Zhang* **A New Subgraph Crossover for Cartesian Genetic Programming** *Roman Kalkreuth, Günter Rudolph, Andre Droschinsky* **Improving the Tartarus Problem as a Benchmark in Genetic Programming** *Thomas D. Griffiths, Anikó Ekárt* **RECIPE: A Grammar-based Framework for Automatically Evolving Classification Pipelines** *Alex G. C. de Sá, Walter José G. S. Pinto, Luiz Otavio V. B. Oliveira, Gisele Pappa*
1830-2000	**EvoStar Poster Session** **Including conference reception hosted by Edinburgh Napier University**

Thursday 20 April, room 1

0930-1110	**EuroGP 4 : Best Paper Candidates** **chairs : James McDermott & Mauro Castelli** **Symbolic Regression on Network Properties** *Marcus Märtens, Fernando Kuipers, Piet Van Mieghem* **A General Feature Engineering Wrapper for Machine Learning Using ϵ-Lexicase Survival** *William La Cava, Jason Moore* **Differentiable Genetic Programming** *Dario Izzo, Francesco Biscani, Alessio Mereta* **Emergent Tangled Graph Representations for Atari Game Playing Agents** Stephen Kelly, Malcolm I. Heywood

EuroGP session 1 : GP for Programming

Wednesday 19 April 1110-1300

Room 1

session chair : Mengjie Zhang

Visualising the Search Landscape of the Triangle Program

William B. Langdon, Nadarajen Veerapen, Gabriela Ochoa

High order mutation analysis of a software engineering benchmark, including schema and local optima networks, suggests program improvements may not be as hard to find as is often assumed. 1) Bit-wise genetic building blocks are not deceptive and can lead to all global optima. 2) There are many neutral networks, plateaux and local optima, nevertheless in most cases near the human written C source code there are hill climbing routes including neutral moves to solutions.

Exploring Fitness and Edit Distance of Mutated Python Programs

Saemundur O. Haraldsson, John R. Woodward, Alexander I.E. Brownlee, David Cairns

Genetic Improvement (GI) is the process of using computational search techniques to improve existing software e.g. in terms of execution time, power consumption or correctness. As in most heuristic search algorithms, the search is guided by fitness with GI searching the space of program variants of the original software. The relationship between the program space and fitness is seldom simple and often quite difficult to analyse. This paper makes a preliminary analysis of GI's fitness distance measure on program repair with three small Python programs. Each program undergoes incremental mutations while the change in fitness as measured by proportion of tests passed is monitored. We conclude that the fitnesses of these programs often does not change with single mutations and we also confirm the inherent discreteness of bug fixing fitness functions. Although our findings cannot be assumed to be general for other software they provide us with interesting directions for further investigation.

Evolutionary Program Sketching

Iwo Błądek, Krzysztof Krawiec

Program synthesis can be posed as a satisfiability problem and approached with generic SAT solvers. Only short programs can be however synthesized in this way. Program sketching by Solar-Lezama assumes that a human provides a partial program (sketch), and that synthesis takes place only within the uncompleted parts of that program. This allows synthesizing programs that are overall longer, while maintaining manageable computational effort. In this paper, we propose Evolutionary Program Sketching (EPS), in which the role of sketch provider is handed over to genetic programming (GP). A GP algorithm evolves a population of partial programs, which are being completed by a solver while evaluated. We consider several variants of EPS, which vary in program terminals used for completion (constants, variables, or both) and in the way the completion outcomes are propagated to future generations. When applied to a range of benchmarks, EPS outperforms the conventional GP, also when the latter is given similar time budget.

A Grammar Design Pattern for Arbitrary Program Synthesis Problems in Genetic Programming

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

Grammar Guided Genetic Programming has been applied to many problem domains. It is well suited to tackle program synthesis, as it has the capability to evolve code in arbitrary languages. Nevertheless, grammars designed to evolve code have always been tailored to specific problems resulting in bespoke grammars, which makes them difficult to reuse. In this study a more general approach to grammar design in the program synthesis domain is presented. The approach undertaken is to create a grammar for each data type of a language and combine these grammars for the problem at hand, without having to tailor a grammar for every single problem. The approach can be applied to arbitrary problem instances of program synthesis and can be used with any programming language. The approach is also extensible to use libraries available in a given language. The grammars presented can be applied to any grammar-based Genetic Programming approach and make it easy for researches to rerun experiments or test new problems. The approach is tested on a suite of benchmark problems and compared to PushGP, as it is the only GP system that has presented results on a wide range of benchmark problems. The object of this study is to match or outperform PushGP on these problems without tuning grammars to solve each specific problem.

EuroGP session 1 : GP for Programming

Wednesday 19 April 1110-1300

Room 1

session chair : Mengjie Zhang

A Comparative Analysis of Dynamic Locality and Redundancy in Grammatical Evolution

Eric Medvet

The most salient feature of Grammatical Evolution (GE) is a procedure which maps genotypes to phenotypes using the grammar production rules; however, the search effectiveness of GE may be affected by low locality and high redundancy, which can prevent GE to comply with the basic principle that offspring should inherit some traits from their parents. Indeed, many studies previously investigated the locality and redundancy of GE as originally proposed in [1]. In this paper, we extend those results by considering redundancy and locality during the evolution, rather than statically, hence trying to understand if and how they are influenced by the selective pressure determined by the fitness. Moreover, we consider not only the original GE formulation, but three other variants proposed later (BGE, piGE, and SGE). We experimentally find that there is an interaction between locality/redundancy and other evolution-related measures, namely diversity and growth of individual size. In particular, the combined action of the crossover operator and the genotype-phenotype mapper makes SGE less redundant at the beginning of the evolution, but with very high redundancy after some generations, due to the low phenotype diversity.

A Comparative Study of Different Grammar-based Genetic Programming Approaches

Nuno Lourenço, Joaquim Ferrer, Francisco B. Pereira, Ernesto Costa

Grammars are useful formalisms to specify constraints, and not surprisingly, they have attracted the attention of Evolutionary Computation (EC) researchers to enforce problem restrictions. Context-Free-Grammar GP (CFG-GP) established the foundations for the application of grammars in Genetic Programming (GP), whilst Grammatical Evolution (GE) popularised the use of these approaches, becoming one of the most used GP variants. However, studies have shown that GE suffers from issues that have impact on its performance. To minimise these issues, several extensions have been proposed, which made the distinction between GE and CFG-GP less noticeable. Another direction was followed by Structured Grammatical Evolution (SGE) that maintains the separation between genotype and phenotype from GE, but overcomes most of its issues. Our goal is to perform a comparative study between CFG-GP, GE and SGE to examine their relative performance. The results show that in most of the selected benchmarks, CFG-GP and SGE have a similar performance, showing that SGE is a good alternative to GE.

EuroGP session 2 : GP for Regression & Feature Learning

Wednesday 19 April 1415-1605

Room 1

session chair : Krzysztof Krawiec

RANSAC-GP: Dealing with Outliers in Symbolic Regression with Genetic Programming
Uriel López, Leonardo Trujillo, Yuliana Martinez, Pierrick Legrand, Enrique Naredo, Sara Silva
Genetic programming (GP) has been shown to be a powerful tool for automatic modeling and program induction. It is often used to solve difficult symbolic regression tasks, with many examples in real-world domains. However, the robustness of GP-based approaches has not been substantially studied. In particular, the present work deals with the issue of outliers, data in the training set that represent severe errors in the measuring process. In general, a datum is considered an outlier when it sharply deviates from the true behavior of the system of interest. GP practitioners know that such data points usually bias the search and produce inaccurate models. Therefore, this work presents a hybrid methodology based on the RAndom SAmpling Consensus (RANSAC) algorithm and GP, which we call RANSAC-GP. RANSAC is an approach to deal with outliers in parameter estimation problems, widely used in computer vision and related fields. On the other hand, this work presents the first application of RANSAC to symbolic regression with GP, with impressive results. The proposed algorithm is able to deal with extreme amounts of contamination in the training set, evolving highly accurate models even when the amount of outliers reaches 90%.

Using Feature Clustering for GP-Based Feature Construction on High-Dimensional Data
Binh Tran, Bing Xue, Mengjie Zhang
Feature construction is a pre-processing technique to create new features with better discriminating ability from the original features. Genetic programming (GP) has been shown to be a prominent technique for this task. However, applying GP to high-dimensional data is still challenging due to the large search space. Feature clustering groups similar features into clusters, which can be used for dimensionality reduction by choosing representative features from each cluster to form the feature subset. Feature clustering has been shown promising in feature selection; but has not been investigated in feature construction for classification. This paper presents the first work of utilising feature clustering in this area. We propose a cluster-based GP feature construction method called CGPFC which uses feature clustering to improve the performance of GP for feature construction on high-dimensional data. Results on eight high-dimensional datasets with varying difficulties show that the CGPFC constructed features perform better than the original full feature set and features constructed by the standard GP constructor based on the whole feature set.

Strategies for Improving the Distribution of Random Function Outputs in GSGP
Luiz Otavio V. B. Oliveira, Felipe Casadei, Gisele Pappa
In the last years, different approaches have been proposed to introduce semantic information to genetic programming. In particular, the geometric semantic genetic programming (GSGP) and the interesting properties of its evolutionary operators have gotten the attention of the community. This paper is interested in the use of GSGP to solve symbolic regression problems, where semantics is defined by the output set generated by a given individual when applied to the training cases. In this scenario, both mutation and crossover operators defined with fitness function based on Manhattan distance use randomly built functions to generate offspring. However, the outputs of these random functions are not guaranteed to be uniformly distributed in the semantic space, as the functions are generated considering the syntactic space. We hypothesize that the non-uniformity of the semantics of these functions may bias the search, and propose three different standard normalization techniques to improve the distribution of the outputs of these random functions over the semantic space. The results are compared with a popular strategy that uses a logistic function as a wrapper to the outputs, and show that the strategies tested can improve the results of the previous method. The experimental analysis also indicates that a more uniform distribution of the semantics of these functions does not necessarily imply in better results in terms of test error.

EuroGP session 2 : GP for Regression & Feature Learning

Wednesday 19 April 1415-1605

Room 1

session chair : Krzysztof Krawiec

Evolving Game State Features from Raw Pixels

Baozhu Jia, Marc Ebner

General video game playing is the art of designing artificial intelligence programs that are capable of playing different video games with little domain knowledge. One of the great challenges is how to capture game state features from different video games in a general way. The main contribution of this paper is to apply genetic programming to evolve game state features from raw pixels. A voting method is implemented to determine the actions of the game agent. Three different video games are used to evaluate the effectiveness of the algorithm: Missile Command, Frogger, and Space Invaders. The results show that genetic programming is able to find useful game state features for all three games.

Geometric Semantic Crossover with an Angle-aware Mating Scheme in Genetic Programming for Symbolic Regression

Qi Chen, Bing Xue, Yi Mei, Mengjie Zhang

Recent research shows that incorporating semantic knowledge into the genetic programming (GP) evolutionary process can improve its performance. This work proposes an angle-aware mating scheme for geometric semantic crossover in GP for symbolic regression. The angle-awareness guides the crossover operating on parents which have a large angle between their relative semantics to the target semantics. The proposed idea of angle-awareness has been incorporated into one state-of-the-art geometric crossover, the locally geometric semantic crossover. The experimental results show that, compared with locally geometric semantic crossover and the regular GP crossover, the locally geometric crossover with angle-awareness not only has a significantly better learning performance but also has a notable generalisation gain on unseen test data. Further analysis has been conducted to see the difference between the angle distribution of crossovers with and without angle-awareness, which confirms that the angle-awareness changes the original distribution of angles by decreasing the number of parents with zero degree while increasing their counterparts with large angles, leading to better performance.

On Evolutionary Approximation of Sigmoid Function for HW/SW Embedded Systems

Milos Minarik, Lukas Sekanina

Providing machine learning capabilities on low cost electronic devices is a challenging goal especially in the context of the Internet of Things paradigm. In order to deliver high performance machine intelligence on low power devices, suitable hardware accelerators have to be introduced. In this paper, we developed a method enabling to evolve a hardware implementation together with a corresponding software controller for key components of smart embedded systems. The proposed approach is based on a multi-objective design space exploration conducted by means of extended linear genetic programming. The approach was evaluated in the task of approximate sigmoid function design which is an important component of hardware implementations of neural networks. During these experiments, we automatically re-discovered some approximate sigmoid functions known from the literature. The method was implemented as an extension of an existing platform supporting concurrent evolution of hardware and software of embedded systems.

EuroGP session 3 : GP for Operations Research

Wednesday 19 April 1625-1815

Room 1

session chair : Lukas Sekanina

Grammatical Evolution of Robust Controller Structures using Wilson Scoring and Criticality Ranking

Elias Reichensdörfer, Dirk Odenthal, Dirk Wollherr

In process control it is essential that disturbances and parameter uncertainties do not affect the process in a negative way. Simultaneously optimizing an objective function for different scenarios can be solved in theory by evaluating candidate solutions on all scenarios. This is not feasible in real-world applications, where the scenario space often forms a continuum. A traditional approach is to approximate this evaluation using Monte Carlo sampling. To overcome the difficulty of choosing an appropriate sampling count and to reduce evaluations of low-quality solutions, a novel approach using Wilson scoring and criticality ranking within a grammatical evolution framework is presented. A nonlinear spring mass system is considered as benchmark example from robust control. The method is tested against Monte Carlo sampling and the results are compared to a backstepping controller. It is shown that the method is capable of outperforming state of the art methods.

Synthesis of Mathematical Programming Constraints with Genetic Programming

Tomasz P. Pawlak, Krzysztof Krawiec

We identify a novel application of Genetic Programming to automatic synthesis of mathematical programming (MP) models for business processes. Given a set of examples of states of a business process, the proposed Genetic Constraint Synthesis (GenetiCS) method constructs well-formed constraints for an MP model. The form of synthesized constraints (e.g., linear or polynomial) can be chosen accordingly to the nature of the process and the desired type of MP problem. In experimental part, we verify syntactic and semantic fidelity of the synthesized models to the actual benchmark models of varying complexity. The obtained symbolic models of constraints can be combined with an objective function of choice, fed into an off-shelf MP solver, and optimized.

Evolving Time-Invariant Dispatching Rules in Job Shop Scheduling with Genetic Programming

Yi Mei, Su Nguyen, Mengjie Zhang

Genetic Programming (GP) has achieved success in evolving dispatching rules for job shop scheduling problems, particularly in dynamic environments. However, there is still great potential to improve the performance of GP. One challenge that is yet to be addressed is the huge search space. In this paper, we propose a simple yet effective approach to improve the effectiveness and efficiency of GP. The new approach is based on a newly defined time-invariance property of dispatching rules, which is derived from the idea of translational invariance from machine learning. Then, we develop a new terminal selection scheme to guarantee the time-invariance throughout the GP process. The experimental studies show that by considering the time-invariance, GP can achieve much better rules in a much shorter time.

A New Subgraph Crossover for Cartesian Genetic Programming

Roman Kalkreuth, Günter Rudolph, Andre Droschinsky

While tree-based Genetic Programming is often used with crossover,
Cartesian Genetic Programming is mostly used only with mutation as genetic operator. In this paper, a new crossover technique is introduced which recombines subgraphs of two selected graphs. Experiments on symbolic regression, boolean functions and image operator design problems indicate that the use of the subgraph crossover improves the search performance of Cartesian Genetic Programming. A preliminary comparison to a former proposed crossover technique indicates that the subgraph crossover performs better on our tested problems.

EuroGP session 3 : GP for Operations Research

Wednesday 19 April 1625-1815

Room 1

session chair : Lukas Sekanina

Improving the Tartarus Problem as a Benchmark in Genetic Programming

Thomas D. Griffiths, Anikó Ekárt

For empirical research on computer algorithms, it is essential to have a set of benchmark problems on which the relative performance of different methods and their applicability can be assessed. In the majority of computational research fields there are established sets of benchmark problems; however, the field of genetic programming lacks a similarly rigorously defined set of benchmarks. There is a strong interest within the genetic programming community to develop a suite of benchmarks. Following recent surveys, the desirable characteristics of a benchmark problem are now better defined. In this paper the Tartarus problem is proposed as a tunably difficult benchmark problem for use in Genetic Programming. The justification for this proposal is presented, together with guidance on its usage as a benchmark.

RECIPE: A Grammar-based Framework for Automatically Evolving Classification Pipelines

Alex G. C. de Sá, Walter José G. S. Pinto, Luiz Otavio V. B. Oliveira, Gisele Pappa

Automatic Machine Learning is a growing area of machine learning that has a similar objective to the area of hyper-heuristics: to automatically recommend optimized pipelines, algorithms or appropriate parameters to specific tasks without much dependency on user knowledge. The background knowledge required to solve the task at hand is actually embedded into a search mechanism that builds personalized solutions to the task. Following this idea, this paper proposes RECIPE (REsilient ClassifIcation Pipeline Evolution), a framework based on grammar-based genetic programming that builds customized classification pipelines. The framework is flexible enough to receive different grammars and can be easily extended to other machine learning tasks. RECIPE overcomes the drawbacks of previous evolutionary-based frameworks, such as generating invalid individuals, and organizes a high number of possible suitable data pre-processing and classification methods into a grammar. Results of f-measure obtained by RECIPE are compared to those two state-of-the-art methods, and shown to be as good as or better than those previously reported in the literature. RECIPE represents a first step towards a complete framework for dealing with different machine learning tasks with the minimum required human intervention.

EuroGP session 4 : Best paper candidates

Thursday 20 April 0930 - 1110

Room 1

session chairs : James McDermott & Mauro Castelli

Symbolic Regression on Network Properties

Marcus Märtens, Fernando Kuipers, Piet Van Mieghem

Networks are continuously growing in complexity, which creates challenges for determining their most important characteristics. While analytical bounds are often too conservative, the computational effort of algorithmic approaches does not scale well with network size. This work uses Cartesian Genetic Programming for symbolic regression to evolve mathematical equations that relate network properties directly to the eigenvalues of network adjacency and Laplacian matrices. In particular, we show that these eigenvalues are powerful features to evolve approximate equations for the network diameter and the isoperimetric number, which are hard to compute algorithmically. Our experiments indicate a good performance of the evolved equations for several real-world networks and we demonstrate how the generalization power can be influenced by the selection of training networks and feature sets.

A General Feature Engineering Wrapper for Machine Learning Using ϵ-Lexicase Survival

William La Cava, Jason Moore

We propose a general wrapper for feature learning that interfaces with other machine learning methods to compose effective data representations. The proposed feature engineering wrapper (FEW) uses genetic programming to represent and evolve individual features tailored to the machine learning method with which it is paired. In order to maintain feature diversity, ϵ-lexicase survival is introduced, a method based on ϵ-lexicase selection. This survival method preserves semantically unique individuals in the population based on their ability to solve difficult subsets of training cases, thereby yielding a population of uncorrelated features. We demonstrate FEW with five different off-the-shelf machine learning methods and test it on a set of real-world and synthetic regression problems with dimensions varying across three orders of magnitude. The results show that FEW is able to improve model test predictions across problems for several ML methods. We discuss and test the scalability of FEW in comparison to other feature composition strategies, most notably polynomial feature expansion.

EuroGP session 4 : Best paper candidates

Thursday 20 April 0930 - 1110

Room 1

session chairs : James McDermott & Mauro Castelli

Differentiable Genetic Programming
Dario Izzo, Francesco Biscani, Alessio Mereta
We introduce the use of high order automatic differentiation, implemented via the algebra of truncated Taylor polynomials, in genetic programming. Using the Cartesian Genetic Programming encoding we obtain a high-order Taylor representation of the program output that is then used to back-propagate errors during learning. The resulting machine learning framework is called differentiable Cartesian Genetic Programming (dCGP). In the context of symbolic regression, dCGP offers a new approach to the long unsolved problem of constant representation in GP expressions. On several problems of increasing complexity we find that dCGP is able to find the exact form of the symbolic expression as well as the constants values. We also demonstrate the use of dCGP to solve a large class of differential equations and to find prime integrals of dynamical systems, presenting, in both cases, results that confirm the efficacy of our approach.

Emergent Tangled Graph Representations for Atari Game Playing Agents
Stephen Kelly, Malcolm I. Heywood
Organizing code into coherent programs and relating different programs to each other represents an underlying requirement for scaling genetic programming to more difficult task domains. Assuming a model in which policies are defined by teams of programs, in which team and program are represented using independent populations and coevolved, has previously been shown to support the development of variable sized teams. In this work, we generalize the approach to provide a complete framework for organizing multiple teams into arbitrarily deep/wide structures through a process of continuous evolution; hereafter the Tangled Program Graph (TPG). Benchmarking is conducted using a subset of 20 games from the Arcade Learning Environment (ALE), an Atari 2600 video game emulator. The games considered here correspond to those in which deep learning was unable to reach a threshold of play consistent with that of a human. Information provided to the learning agent is limited to that which a human would experience. That is, screen capture sensory input, Atari joystick actions, and game score. The performance of the proposed approach exceeds that of deep learning in 15 of the 20 games, with 7 of the 15 also exceeding that associated with a human level of competence. Moreover, in contrast to solutions from deep learning, solutions discovered by TPG are also very `sparse'. Rather than assuming thatall of the state space contributes to every decision, each action in TPG is resolved following execution of a subset of an individual's graph. This results in significantly lower computational requirements for model building than presently the case for deep learning.

Thursday 20 April, room 2

0930-1110

EvoMusArt 1 : Music and Sound
chair: Antonios Liapis

Generating Polyphonic Music Using Tied Parallel Networks
Daniel D. Johnson

Algorithmic Songwriting with ALYSIA
Margareta Ackerman and David Loker

Assessing Augmented Creativity: Putting a Lovelace Machine for Interactive Title Generation through a Human Creativity Test
Yasser S. Arenas Rebolledo, Peter van der Putten, Maarten H. Lamers

Using autonomous agents to improvise music compositions in real-time
Patrick Hutchings and Jon McCormack

Play it Again: Evolved Audio Effects and Synthesizer Programming
Benjamin D. Smith

A Swarm Environment for Experimental Performance and Improvisation
Frank Mauceri and Stephen M. Majercik

1110-1130 **Coffee break**

1130-1310

EvoMusArt 2 : Images & Art
chair: João Nuno

Mixed-initiative Creative Drawing with weblconoscope
Antonios Liapis

Exploring the Exactitudes Portrait Series with Restricted Boltzmann Machines
Sam D. Verkoelen, Maarten H. Lamers, Peter van der Putten

Evolving Mondrian-Style Artworks
Miri Weiss Cohen, Leticia Cherchiglia, Rachel Costa

Evolved Aesthetic Analogies to Improve Artistic Experience
Aidan Breen, Colm OíRiordan, Jerome Sheahan

Evolutionary Image Transition Using Random Walks
Aneta Neumann, Bradley Alexander, Frank Neumann

On Symmetry, Aesthetics and Quantifying Symmetrical Complexity
Mohammad Majid al-Rifaie, Anna Ursyn, Robert Zimmer, Mohammad Ali Javaheri Javid

EvoFashion: Customising Fashion Through Evolution
Nuno Lourenco, Filipe Assuncòao, Catarina Macòas, Penousal Machado

Automated Shape Design by Grammatical Evolution
Manuel Muehlbauer, Jane Burry, Andy Song

1310-1415 **Lunch**

Thursday 20 April, room 2

1415-1555

EvoMusArt 3 : Focus on Algorithms

chair: Vic Ciesielski

Towards Polyphony Reconstruction Using Multidimensional Multiple Sequence Alignment
Dimitrios Bountouridis,Frans Wiering, Dan Brown, Remco C. Veltkamp

Melody Retrieval and Classification Using Biologically-Inspired Techniques
Dimitrios Bountouridis, Dan Brown, Hendrik Vincent Koops, Frans Wiering, Remco C. Veltkamp

Clustering Agents for the Evolution of Autonomous Musical Fitness
Roisin Loughran and Michael O'Neill

Generalisation Performance of Western Instrument Recognition Models in Polyphonic Mixtures with Ethnic Samples
Igor Vatolkin

Evaluation Rules for Evolutionary Generation of Drum Patterns in Jazz Solos
Fabian Ostermann, Igor Vatolkin, Günter Rudolph

A Kind of Bio-inspired Learning of mUsic stylE
Roberto De Prisco, Delfina Malandrino, Gianluca Zaccagnino, Rocco Zaccagnino, Rosalba Zizza

Fashion Design Aid System with Application of Interactive Genetic Algorithms
Nazanin Alsadat Tabatabaei Anaraki

1555-1615 **Coffee break**

1615-1745

EvoMusArt 4 : Best Papers

chair: Vic Ciesielski

Predicting Expressive Bow Controls for Violin and Viola
Lauren Jane Yu and Andrea Pohoreckyj Danyluk

Niche Constructing Drawing Robots
Jon McCormack

Deep Artificial Composer: A Creative Neural Network Model for Automated Melody Generation
Florian Colombo, Alexander Seeholzer, Wulfram Gerstner

EvoMUSART session 1 : Music and Sound

Thursday 20 April 0930-1110

Room 2

session chair : Antonios Liapis

Generating Polyphonic Music Using Tied Parallel Networks

Daniel D. Johnson

We describe a neural network architecture which enables prediction and composition of polyphonic music in a manner that preserves translation invariance of the dataset. Specifically, we demonstrate training a probabilistic model of polyphonic music using a set of parallel, tied-weight recurrent networks, inspired by the structure of convolutional neural networks. This model is designed to be invariant to transpositions, but otherwise is intentionally given minimal information about the musical domain, and tasked with discovering patterns present in the source dataset. We present two versions of the model, denoted TP-LSTM-NADE and BALSTM, and also give methods for training the network and for generating novel music. This approach attains high performance at a musical prediction task and successfully creates note sequences which possess measure-level musical structure.

Algorithmic Songwriting with ALYSIA

Margareta Ackerman and David Loker

This paper introduces ALYSIA: Automated LYrical Songwrlting Application. ALYSIA is based on a machine learning model using Random Forests, and we discuss its success at pitch and rhythm prediction. Next, we show how ALYSIA was used to create original pop songs that were subsequently recorded and produced. Finally, we discuss our vision for the future of Automated Songwriting for both co-creative and autonomous systems.

Assessing Augmented Creativity: Putting a Lovelace Machine for Interactive Title Generation through a Human Creativity Test

Yasser S. Arenas Rebolledo, Peter van der Putten, Maarten H. Lamers

The aim of this study is to find to what extent computers can assist humans in the creative process of writing titles, using psychological tests for creativity that are typically used for humans only . To this end, a computer tool was designed that generates new titles to users, based on knowledge generated from a pre-built corpus. This paper gives a description of both the development of the system as well as tests applied to the participants, derived from classical psycho- logical tests for human creativity. A total of 89 participants divided in two groups completed two tasks which consisted of generating titles for paintings. One group was allowed to use a template-based system for generating titles, the other group did not use any tools. The results of the experiments show higher creativity scores for the combination of participants augmented by a computational creativity tool.

Using autonomous agents to improvise music compositions in real-time

Patrick Hutchings and Jon McCormack

This paper outlines an approach to real-time music generation using melody and harmony focused agents in a process inspired by jazz improvisation. A harmony agent employs a Long Short-Term Memory (LSTM) artificial neural network trained on the chord progressions of 2986 jazz 'standard' compositions using a network structure novel to chord sequence analysis. The melody agent uses a rule-based system of manipulating provided, pre-composed melodies to improvise new themes and variations. The agents take turns in leading the direction of the composition based on a rating system that rewards harmonic consistency and melodic flow. In developing the multi-agent system it was found that implementing embedded spaces in the LSTM encoding process resulted in significant improvements to chord sequence learning.

EvoMUSART session 1 : Music and Sound

Thursday 20 April 0930-1110

Room 2

session chair : Antonios Liapis

Play it Again: Evolved Audio Effects and Synthesizer Programming
Benjamin D. Smith
Automatic programming of sound synthesizers and audio devices to match a given, desired sound is examined and a Genetic Algorithm (GA) that functions independent of specific synthesis techniques is proposed. Most work in this area has focused on one synthesis model or synthesizer, designing the GA and tuning the operator parameters to obtain optimal results. The scope of such inquiries has been limited by available computing power, however current software (Ableton Live, herein) and commercially available hardware is shown to quickly find accurate solutions, promising a practical application for music creators. Both software synthesizers and audio effects processors are examined, showing a wide range of performance times (from seconds to hours) and solution accuracy, based on particularities of the target devices. Random oscillators, phase synchronizing, and filters over empty frequency ranges are identified as primary challenges for GA based optimization.

A Swarm Environment for Experimental Performance and Improvisation
Frank Mauceri and Stephen M. Majercik
This paper describes Swarm Performance and Improvisation (Swarm-PI), a real-time computer environment for music improvisation that uses swarm algorithms to control sound synthesis and to mediate interactions with a human performer. Swarm models are artificial, multiagent systems where the organized movements of large groups are the result of simple, local rules between individuals. Swarms typically exhibit self-organization and emergent behavior. In Swarm-PI, multiple acoustic descriptors from a live audio feed generate parameters for an independent swarm among multiple swarms in the same space, and each swarm is used to synthesize a stream of sound using granular sampling. This environment demonstrates the effectiveness of using swarms to model human interactions typical to group improvisation and to generate organized patterns of synthesized sound.

EvoMUSART session 2 : Images and Art

Thursday 20 April 1130 - 1310

Room 2

session chair : João Nuno

Mixed-initiative Creative Drawing with webIconoscope

Antonios Liapis

This paper presents the webIcononscope tool for creative drawing, which allows users to draw simple icons composed of basic shapes and colors in order to represent abstract semantic concepts. The goal of this creative exercise is to create icons that are ambiguous enough to confuse other people attempting to guess which concept they represent. webIcononscope is available online and all creations can be browsed, rated and voted on by anyone; this democratizes the creative process and increases the motivation for creating both appealing and ambiguous icons. To complement the creativity of the human users attempting to create novel icons, several computational assistants provide suggestions which alter what the user is currently drawing based on certain criteria such as typicality and novelty. This paper reports trends in the creations of webIcononscope users, based also on feedback from an online audience.

Exploring the Exactitudes Portrait Series with Restricted Boltzmann Machines

Sam D. Verkoelen, Maarten H. Lamers, Peter van der Putten

In this paper we explore the use of deep neural networks to analyze semi-structured series of artworks. We train stacked Restricted Boltzmann Machines on the Exactitudes collection of photo series, and use this to understand the relationship between works and series, uncover underlying features and dimensions, and generate new images. The projection of the series on the two major decorrelated features (PCA on top of Boltzmann features) results in a visualization that clearly reflects the semi structured nature of the photos series, although the original features provide better classification results when assigning photographs to series. This work provides a useful case example of understanding structure that is uncovered by deep neural networks, as well as a tool to analyze the underlying structure of a collection of visual artworks, as a very first step towards a robot curator.

Evolving Mondrian-Style Artworks

Miri Weiss Cohen, Leticia Cherchiglia, Rachel Costa

This paper describes a Genetic Algorithm (GA) software system for automatically generating Mondrian-style symmetries and abstract artwork. The research examines Mondrian's paintings from 1922 through 1932 and analyses the balances, color symmetries and composition in these paintings. We used a set of eleven criteria to define the automated system. We then translated and formulized these criteria into heuristics and criteria that can be measured and used in the GA algorithm. The software includes a module that provides a range of GA parameter values for interactive selection. Despite a number of limitations, the method yielded high quality results with colors close to those of Mondrian and rectangles that did not overlap and fit the canvas.

Evolved Aesthetic Analogies to Improve Artistic Experience

Aidan Breen, Colm OíRiordan, Jerome Sheahan

It has been demonstrated that computational evolution can be utilised in the creation of aesthetic analogies between two artistic domains by the use of mapping expressions. When given an artistic input these mapping expressions can be used to guide the generation of content in a separate domain. For example, a piece of music can be used to create an analogous visual display. In this paper we examine the implementation and performance of such a system. We explore the practical implementation of real-time evaluation of evolved mapping expressions, possible musical input and visual output approaches, and the challenges faced therein. We also present the results of an exploratory study testing the hypothesis that an evolved mapping expression between the measurable attributes of musical and visual harmony will produce an improved aesthetic experience compared to a random mapping expression. Expressions of various fitness values were used and the participants were surveyed on their enjoyment, interest, and fatigue. The results of this study indicate that further work is necessary to produce a strong aesthetic response. Finally, we present possible approaches to improve the performance and artistic merit of the system.

EvoMUSART session 2 : Images and Art

Thursday 20 April 1130 - 1310

Room 2

session chair : João Nuno

Evolutionary Image Transition Using Random Walks

Aneta Neumann, Bradley Alexander, Frank Neumann

We present a study demonstrating how random walk algorithms can be used for evolutionary image transition. We design different mutation operators based on uniform and biased random walks and study how their combination with a baseline mutation operator can lead to interesting image transition processes in terms of visual effects and artistic features. Using feature-based analysis we investigate the evolutionary image transition behaviour with respect to different features and evaluate the images constructed during the image transition process.

On Symmetry, Aesthetics and Quantifying Symmetrical Complexity

Mohammad Majid al-Rifaie, Anna Ursyn, Robert Zimmer, Mohammad Ali Javaheri Javid

The concepts of order and complexity and their quantitative evaluation have been at the core of computational notion of aesthetics. One of the major challenges is conforming human intuitive perception and what we perceive as aesthetically pleasing with the output of a computational model. 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. In this work, following an overview on symmetry and its significance in the domain of aesthetics, a nature-inspired, swarm intelligence technique (Dispersive Flies Optimisation or DFO) is introduced and then adapted to detect symmetries and quantify symmetrical complexities in images. The 252 Jacobsen & Hˆfel's images used in this paper are created by researchers in the psychology and visual domain as part of an experimental study on human aesthetic perception. Some of the images are symmetrical and some are asymmetrical, all varying in terms of their aesthetics, which are ranked by humans. The results of the presented nature-inspired algorithm is then compared to what humans in the study aesthetically appreciated and ranked. Whilst the authors believe there is still a long way to have a strong correlation between a computational model of complexity and human appreciation, the results of the comparison are promising.

EvoFashion: Customising Fashion Through Evolution

Nuno Lourenco, Filipe Assuncòao, Catarina Macòas, Penousal Machado

In today's society, where everyone desires unique and fashionable products, the ability to customise products is almost mandatory in every online store. Despite of many stores allowing the users to personalize their products, they do not always do it in the most efficient and user-friendly manner. In order to have products that reflect the userís design preferences, they have to go through a laborious process of picking the components that they want to customise. In this paper we propose a framework that aims to relieve the design burden from the user side, by automating the design process through the use of Interactive Evolutionary Computation (IEC). The framework is based on a web-interface that facilitates the interaction between the user and the evolutionary process. The user can select between two types of evolution: (i) automatic; and (ii) partially-automatic. The results show the ability of the framework to promote evolution towards solutions that reflect the user aesthetic preferences.

Automated Shape Design by Grammatical Evolution

Manuel Muehlbauer, Jane Burry, Andy Song

This paper proposes a automated shape generation methodology based on grammatical genetic programming for specific design cases. Two cases of the shape generation are presented: architectural envelope design and facade design. Through the described experiments, the applicability of this evolutionary method for design applications is showcased. Through this study it can be seen that automated shape generation by grammatical evolution offers a huge potential for the development of performance-based creative systems.

EvoMUSART session 3 : Focus on Algorithms

Thursday 20 April 1415-1555

Room 2

session chair : Vic Ciesielski

Towards Polyphony Reconstruction Using Multidimensional Multiple Sequence Alignment
Dimitrios Bountouridis, Frans Wiering, Dan Brown, Remco C. Veltkamp
The digitization of printed music scores through the process of optical music recognition is imperfect. In polyphonic scores, with two or more simultaneous voices, errors of duration or position can lead to badly aligned and inharmonious digital transcriptions. We adapt biological sequence analysis tools as a post-processing step to correct the alignment of voices. Our multiple sequence alignment approach works on multiple musical dimensions and we investigate the contribution of each dimension to the correct alignment. Structural information, such musical phrase boundaries, is of major importance; therefore, we propose the use of the popular bioinformatics aligner Mafft which can incorporate such information while being robust to temporal noise. Our experiments show that a harmony-aware Mafft outperforms sophisticated, multidimensional alignment approaches and can achieve near-perfect polyphony reconstruction.

Melody Retrieval and Classification Using Biologically-Inspired Techniques
Dimitrios Bountouridis, Dan Brown, Hendrik Vincent Koops, Frans Wiering, Remco C. Veltkamp
Retrieval and classification are at the center of Music Information Retrieval research. Both tasks rely on a method to assess the similarity between two music documents. In the context of symbolically encoded melodies, pairwise alignment via dynamic programming has been the most widely used method. However, this approach fails to scale-up well in terms of time complexity and insufficiently models the variance between melodies of the same class. Compact representations and indexing techniques that capture the salient and robust properties of music content, are increasingly important. We adapt two existing bioinformatics tools to improve the melody retrieval and classification tasks. On two datasets of folk tunes and cover song melodies, we apply the extremely fast indexing method of the Basic Local Alignment Search Tool (BLAST) and achieve comparable classification performance to exhaustive approaches. We increase retrieval performance and efficiency by using multiple sequence alignment algorithms for locating variation patterns and profile hidden Markov models for incorporating those patterns into a similarity model.

Clustering Agents for the Evolution of Autonomous Musical Fitness
Roisin Loughran and Michael O'Neill
This paper presents a cyclical system that generates autonomous fitness functions or Agents for evolving short melodies. A grammar is employed to create a corpus of melodies, each of which is composed of a number of segments. A population of Agents are evolved to give numerical judgements on the melodies based on the spacing of these segments. The fitness of an individual Agent is calculated in relation to its clustering of the melodies and how much this clustering correlates with the clustering of the entire Agent population. A preparatory run is used to evolve Agents using 30 melodies of known 'clustering'. The full run uses these Agents as the initial population in evolving a new best Agent on a separate corpus of melodies of random distance measures. This evolved Agent is then used in combination with the original melody grammar to create a new melody which replaces one of those from the initial random corpus. This results in a complex adaptive system creating new melodies without any human input after initialisation. This paper describes the behaviour of each phase in the system and presents a number of melodies created by the system.

Generalisation Performance of Western Instrument Recognition Models in Polyphonic Mixtures with Ethnic Samples
Igor Vatolkin
Instrument recognition in polyphonic audio recordings is a very complex task. Most research studies until now were focussed on the recognition of Western instruments in Western classical and popular music, but also an increasing number of recent works addressed the classification of ethnic/world recordings. However, such studies are typically restricted to one kind of music and do not measure the bias of "Western" effect, i.e., the danger of overfitting towards Western music when the classification models are optimised only for such tracks. In this paper, we analyse the performance of several instrument classification models which are trained and optimised on polyphonic mixtures of Western instruments, but independently validated on mixtures created with randomly added ethnic samples. The conducted experiments include evolutionary multi-objective feature selection from a large set of audio signal descriptors and the estimation of individual feature relevance.

EvoMUSART session 3 : Focus on Algorithms

Thursday 20 April 1415-1555

Room 2

session chair : Vic Ciesielski

Evaluation Rules for Evolutionary Generation of Drum Patterns in Jazz Solos

Fabian Ostermann, Igor Vatolkin, Günter Rudolph

The learning of improvisation in jazz and other music styles requires years of practice. For music scholars which do not play in a band, technical solutions for automatic generation of accompaniment on home computers are very helpful. They may support the learning process and significantly improve the experience to play with other musicians. However, many up-to-date approaches can not interact with a solo player, generating static or random patterns without a direct musical dialogue between a soloist and accompanying instruments. In this paper, we present a novel system for the generation of drum patterns based on an evolutionary algorithm. As the main extension to existing solutions, we propose a set of musically meaningful jazz-related rules for the real-time validation and adjustment of generated drum patterns. In the evaluation study, musicians agreed that the system can be successfully used for learning of jazz improvisation and that the wide range of parameters helps to adapt the response of the virtual drummer to the needs of individual scholars.

A Kind of Bio-inspired Learning of mUsic stylE

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

In the field of Computer Music, computational intelligence approaches are very relevant for music information retrieval applications. A challenging task in this area is the automatic recognition of musical styles. The style of a music performer is the result of the combination of several factors such as experience, personality, preferences, especially in music genres where the improvisation plays an important role. In this paper we propose a new approach for both recognition and automatic composition of music of a specific performerís style. Such a system exploits: (1) a one-class machine learning classifier to learn a specific music performerís style, (2) a music splicing system to compose melodic lines in the learned style, and (3) a LSTM network to predict patterns coherent with the learned style and used to guide the splicing system during the composition. To assess the effectiveness of our system we performed several tests using transcriptions of solos of popular Jazz musicians. Specifically, with regard to the recognition process, tests were performed to analyze the capability of the system to recognize a style. Also, we show that performances of our classifier are comparable to that of traditional two-class SVM, and that it is able to achieve an accuracy of 97%. With regard to the composition process, tests were performed to verify whether the produced melodies were able to catch the most significant music aspects of the learned style.

Fashion Design Aid System with Application of Interactive Genetic Algorithms

Nazanin Alsadat Tabatabaei Anaraki

These days, consumers can make their choice from a wide variety of clothes provided in the market; however, some prefer to have their clothes custom-made. Since most of these consumers are not professional designers, they contact a designer to help them with the process. This approach, however, is not efficient in terms of time and cost and it does not reflect the consumerís personal taste as much as desired. This study proposes a design system using Interactive Genetic Algorithm (IGA) to overcome these problems. IGA differs from traditional Genetic Algorithm (GA) by leaving the fitness function to the personal preference of the user. The proposed system uses userís taste as a fitness value to create a large number of design options, and it is based on an encoding scheme either describing a dress as a whole or as a two-part piece of clothing. The system is designed in the Rhinoceros 3D software, using python, which provides good speed and interface options. The assessment experiments with several subjects indicated that the proposed system is effective.

EvoMUSART session 4 : Best paper candidates

Thursday 20 April 1615-1745

Room 2

session chair : Vic Ciesielski

Predicting Expressive Bow Controls for Violin and Viola

Lauren Jane Yu and Andrea Pohoreckyj Danyluk

Though computational systems can simulate notes on a staff of sheet music, capturing the artistic liberties professional musicians take to communicate their interpretation of those notes is a much more difficult task. In this paper, we demonstrate that machine learning methods can be used to learn models of expressivity, focusing on bow articulation for violin and viola. First we describe a new data set of annotated sheet music with information about specific aspects of bow control. We then present experiments for building and testing predictive models for these bow controls, as well as analysis that includes both general metrics and manual examination.

Niche Constructing Drawing Robots

Jon McCormack

This paper describes a series of experiments in creating autonomous drawing robots that generate aesthetically interesting and engaging drawings. Based on a previous method for multiple software agents that mimic the biological process of niche construction, the challenge in this project was to re-interpret the implementation of a set of evolving software agents into a physical robotic system. In this new robotic system, individual robots try to reinforce a particular niche defined by the density of the lines drawn underneath them. The paper also outlines the role of environmental interactions in determining the style of drawing produced.

Deep Artificial Composer: A Creative Neural Network Model for Automated Melody Generation

Florian Colombo, Alexander Seeholzer, Wulfram Gerstner

The inherent complexity and structure on long timescales make the automated composition of music a challenging problem. Here we present the Deep Artificial Composer (DAC), a recurrent neural network model of note transitions for the automated composition of melodies. Our model can be trained to produce melodies with compositional structures extracted from large datasets of diverse styles of music, which we exemplify here on a corpus of Irish folk and Klezmer melodies. We assess the creativity of DAC-generated melodies by a new measure, the novelty of musical sequences, showing that melodies imagined by the DAC are as novel as melodies produced by human composers. We further use the novelty measure to show that the DAC creates melodies musically consistent with either of the musical styles it was trained on. This makes the DAC a promising candidate for the automated composition of convincing musical pieces of any provided style.

Notes

Thursday 20 April, room 1

1130-1310	**EvoCOP 1 : Neighborhoods and search strategies** **chair : Bin Hu** **Construct, Merge, Solve and Adapt versus Large Neighborhood Search for Solving the Multi-Dimensional Knapsack Problem: Which One Works Better When?** *Evelia Lizárraga, María J. Blesa, and Christian Blum* **A Hybrid Feature Selection Algorithm Based on Large Neighborhood Search** *Gelareh Taghizadeh, Nysret Musliu* **A Computational Study of Neighborhood Operators for Job-shop Scheduling Problems with Regular Objectives** Hayfa Hammami, Thomas Stützle **Efficient Consideration of Soft Time Windows in a Large Neighborhood Search for the Districting and Routing Problem for Security Control** *Bong-Min Kim, Christian Kloimüllner, Günther Raidl*
1310-1415	**Lunch**
1415-1555	**EvoCOP 2 : Theory and hyperheuristics** **chair: Gabriela Ochoa** **Sparse, Continuous Policy Representations for Uniform Online Bin Packing via Regression of Interpolants** *John H. Drake, Jerry Swan, Geoff Neumann and Ender Özcan* **Selection of Auxiliary Objectives Using Landscape Features and Offline Learned Classifier** *Anton Bassin, Arina Buzdalova* **Decomposing SAT Instances with Pseudo Backbones** *Wenxiang Chen, Darrell Whitley* **Towards Landscape-Aware Automatic Algorithm Configuration: Preliminary Experiments on Neutral and Rugged Landscapes** *Arnaud Liefooghe, Bilel Derbel, Sébastien Verel, Hernán Aguirre, Kiyoshi Tanaka*
1555-1615	**Coffee break**

Thursday 20 April, room 1

1615-1745

EvoCOP 3 : Real-world applications and non-traditional problems
chair: Christian Blum

Multi-rendezvous Spacecraft Trajectory Optimization with Beam P-ACO
Luís F. Simões, Dario Izzo, Evert Haasdijk, A. E. Eiben

Optimizing Charging Station Locations for Electric Car-Sharing Systems
Benjamin Biesinger, Bin Hu, Martin Stubenschrott, Ulrike Ritzinger, Matthias Prandtstetter

Estimation of Distribution Algorithms for the Firefighter Problem
Krzysztof Michalak

A Genetic Algorithm for Multi-Component Optimization Problems: the Case of the Travelling Thief Problem
Daniel K. S. Vieira, Gustavo L. Soares, João A. Vasconcelos, and Marcus H. S. Mendes

Friday 21 April, room 1

0945-1115

EvoCOP 4 : Best Paper Candidates
chair : Manuel López-Ibáñez

LCS-Based Selective Route Exchange Crossover for the Pickup and Delivery Problem with Time Windows
Miroslaw Blocho, Jakub Nalepa

A memetic algorithm to maximise the employee substitutability in personnel shift scheduling
Jonas Ingels, Broos Maenhout

Understanding Phase Transitions with Local Optima Networks: Number Partitioning as a Case Study
Gabriela Ochoa, Nadarajen Veerapen, Fabio Daolio, Marco Tomassini

The Weighted Independent Domination Problem: ILP Model and Algorithmic Approaches
Pedro Pinacho Davidson, Christian Blum, and José A. Lozano

EvoCOP session 1 : Neighborhoods & search strategies

Thursday 20 April 1130-1310

Room 1

session chair : Bin Hu

Construct, Merge, Solve and Adapt versus Large Neighborhood Search for Solving the Multi-Dimensional Knapsack Problem: Which One Works Better When?

Evelia Lizárraga, María J. Blesa, and Christian Blum

Both, Construct, Merge Solve and Adapt (CMSA) and Large Neighborhood Search (LNS), are hybrid algorithms that are based on iteratively solving sub-instances of the original problem instances, if possible, to optimality. This is done by reducing the search space of the tackled problem instance in algorithm-specific ways which differ from one technique to the other. In this paper we provide first experimental evidence for the intuition that, conditioned by the way in which the search space is reduced, LNS should generally work better than CMSA in the context of problems in which solutions are rather large, and the opposite is the case for problems in which solutions are rather small. The size of a solution is hereby measured by the number of components of which the solution is composed, in comparison to the total number of solution components. Experiments are conducted in the context of the multi-dimensional knapsack problem.

A Hybrid Feature Selection Algorithm Based on Large Neighborhood Search

Gelareh Taghizadeh, Nysret Musliu

Feature selection aims at choosing a small number of relevant features of samples in a data set to achieve similar or even better classification accuracy than using all features. This paper presents the first study on Large Neighborhood Search (LNS) algorithm for the feature selection problem. We propose a novel hybrid Wrapper and Filter feature selection method using LNS algorithm (WFLNS). In LNS, an initial solution is gradually improved by alternately destroying and repairing the solution. We introduce the idea of using filter ranking method in the process of destroying and repairing to accelerate the search in identifying the core feature subsets. Particularly, WFLNS either adds or removes a feature from a candidate solution based on the correlation based feature ranking method. The proposed algorithm has been tested on twelve benchmark data sets and the results have been compared with ten most recent wrapper methods where WFLNS outperforms over methods in most of the data sets.

A Computational Study of Neighborhood Operators for Job-shop Scheduling Problems with Regular Objectives

Hayfa Hammami, Thomas Stützle

Job-shop scheduling problems have received a considerable attention in the literature. While the most tackled objective in this area is makespan, job-shop scheduling problems with other objectives such as the minimization of the weighted or unweighted tardiness, the number of late jobs, or the sum of the jobs' completion times have been considered. However, the problems under the latter objectives have been generally less studied than makespan. In this paper, we study job-shop scheduling under various objectives. In particular, we examine the impact various neighborhood operators have on the performance of iterative improvement algorithms, the composition of variable neighborhood descent algorithms, and the performance of metaheuristics such as iterated local search in dependence of the type of local search algorithm used.

Efficient Consideration of Soft Time Windows in a Large Neighborhood Search for the Districting and Routing Problem for Security Control

Bong-Min Kim, Christian Kloimüllner, Günther Raidl

For many companies it is important to protect their physical and intellectual property in an efficient and economically viable manner. Thus, specialized security companies are delegated to guard private and public property. These companies have to control a typically large number of buildings, which is usually done by teams of security guards patrolling different sets of buildings. Each building has to be visited several times within given time windows and tours to patrol these buildings are planned over a certain number of periods (days). This problem is regarded as the Districting and Routing Problem for Security Control. Investigations have shown that small time window violations do not really matter much in practice but can drastically improve solution quality. When softening time windows of the original problem, a new subproblem arises where the minimum time window penalty for a given set of districts has to be found for each considered candidate route: What are optimal times for the individual visits of objects that minimize the overall penalty for time window violations? We call this Optimal Arrival Time Problem. In this paper, we investigate this subproblem in particular and first give an exact solution approach based on linear programming. As this method is quite time-consuming we further propose a heuristic approach based on greedy methods in combination with dynamic programming. The whole mechanism is embedded in a large neighborhood search (LNS) to seek for solutions having minimum time window violations. Results show that using the proposed heuristic method for determining almost optimal starting times is much faster, allowing substantially more LNS iterations yielding in the end better overall solutions.

EvoCOP session 2: Theory and hyperheuristics

Thursday 20 April 1415-1555

Room 1

session chair : Gabriela Ochoa

Sparse, Continuous Policy Representations for Uniform Online Bin Packing via Regression of Interpolants

John H. Drake, Jerry Swan, Geoff Neumann and Ender Özcan

Online bin packing is a classic optimisation problem, widely tackled by heuristic methods. In addition to human-designed heuristic packing policies (e.g. first- or best- fit), there has been interest over the last decade in the automatic generation of policies. One of the main limitations of some previously-used policy representations is the trade-off between locality and granularity in the associated search space. In this article, we adopt an interpolation-based representation which has the jointly-desirable properties of being sparse and continuous (i.e. exhibits good genotype-to-phenotype locality). In contrast to previous approaches, the policy space is searchable via real-valued optimization methods. Packing policies using five different interpolation methods are comprehensively compared against a range of existing methods from the literature, and it is determined that the proposed method scales to larger instances than those in the literature.

Selection of Auxiliary Objectives Using Landscape Features and Offline Learned Classifier

Anton Bassin, Arina Buzdalova

In order to increase the performance of an evolutionary algorithm, additional auxiliary optimization objectives may be added. It is hard to predict which auxiliary objectives will be the most efficient at different stages of optimization. Thus, the problem of dynamic selection between auxiliary objectives appears. This paper proposes a new method for efficient selection of auxiliary objectives, which uses fitness landscape information and problem meta-features. An offline learned meta-classifier is used to dynamically predict the most efficient auxiliary objective during the main optimization run performed by an evolutionary algorithm. An empirical evaluation on two benchmark combinatorial optimization problems (Traveling Salesman and Job Shop Scheduling problems) shows that the proposed approach outperforms similar known methods of auxiliary objective selection.

Decomposing SAT Instances with Pseudo Backbones

Wenxiang Chen, Darrell Whitley

Two major search paradigms have been proposed for SAT solving: Systematic Search (SS) and Stochastic Local Search (SLS). In SAT competitions, while SLS solvers are effective on uniform random instances, SS solvers dominate SLS solvers on application instances with internal structures. One important structural property is decomposability. SS solvers have long been exploited the decomposability of application instances with success. We conjecture that SLS solvers can be improved by exploiting decomposability of application instances, and propose the first step toward exploiting decomposability with SLS solvers using pseudo backbones. We then propose two SAT-specific optimizations that lead to better decomposition than on general pseudo Boolean optimization problems. Our empirical study suggests that pseudo backbones can vastly simplify SAT instances, which further results in decomposing the instances into thousands of connected components. This decomposition serves as a key stepping stone for applying the powerful recombination operator, partition crossover, to the SAT domain. Moreover, we establish a priori analysis for identifying problem instances with potential decomposability using visualization of MAXSAT instances and treewidth.

Towards Landscape-Aware Automatic Algorithm Configuration: Preliminary Experiments on Neutral and Rugged Landscapes

Arnaud Liefooghe, Bilel Derbel, Sébastien Verel, Hernán Aguirre, Kiyoshi Tanaka

The proper setting of algorithm parameters is a well-known issue that gave rise to recent research investigations from the (offline) automatic algorithm configuration perspective. Besides, the characteristics of the target optimization problem is also a key aspect to elicit the behavior of a dedicated algorithm, and as often considered from a landscape analysis perspective. In this paper, we show that fitness landscape analysis can open a whole set of new research opportunities for increasing the effectiveness of existing automatic algorithm configuration methods. Specifically, we show that using landscape features in iterated racing both (i) at the training phase, to compute multiple elite configurations explicitly mapped with different feature values, and (ii) at the production phase, to decide which configuration to use on a feature basis, provides significantly better results compared against the standard landscape-oblivious approach. Our first experimental investigations on NK-landscapes, considered as a benchmark family having controllable features in terms of ruggedness and neutrality, and tackled using a memetic algorithm with tunable population size and variation operators, show that a landscape-aware approach is a viable alternative to handle the heterogeneity of (black-box) combinatorial optimization problems.

EvoCOP session 3 : Real-world applications & non-traditional problems

Thursday 20 April 1615-1745

Room 1

session chair : Christian Blum

Multi-rendezvous Spacecraft Trajectory Optimization with Beam P-ACO

Luís F. Simões, Dario Izzo, Evert Haasdijk, A. E. Eiben

The design of spacecraft trajectories for missions visiting multiple celestial bodies is here framed as a multi-objective bilevel optimization problem. A comparative study is performed to assess the performance of different Beam Search algorithms at tackling the combinatorial problem of finding the ideal sequence of bodies. Special focus is placed on the development of a new hybridization between Beam Search and the Population-based Ant Colony Optimization algorithm. An experimental evaluation shows all algorithms achieving exceptional performance on a hard benchmark problem. It is found that a properly tuned deterministic Beam Search always outperforms the remaining variants. Beam P-ACO, however, demonstrates lower parameter sensitivity, while offering superior worst-case performance. Being an anytime algorithm, it is then found to be the preferable choice for certain practical applications.

Optimizing Charging Station Locations for Electric Car-Sharing Systems

Benjamin Biesinger, Bin Hu, Martin Stubenschrott, Ulrike Ritzinger, Matthias Prandtstetter

This paper is about strategic decisions required for running an urban station-based electric car-sharing system. In such a system, users can rent and return publicly available electric cars from charging stations. We approach the problem of deciding on the location and size of these stations and on the total number of cars in such a system using a bi-level model. The first level of the model identifies the number of rental stations, the number of slots at each station, and the total number of cars to be acquired. Then, such a generated solution is evaluated by computing which trips can be accepted by the system using a path-based heuristic on a time-expanded location network. This path-based heuristic iteratively finds paths for the cars through this network. We compare three different pathfinder methods, which are all based on the concept of tree search using a greedy criterion. The algorithm is evaluated on a set of benchmark instances which are based on real-world data from Vienna, Austria using a demand model derived from taxi data of about 3500 taxis operating in Vienna. Computational tests show that for smaller instances the algorithm is able to find near optimal solutions and that it scales well for larger instances.

Estimation of Distribution Algorithms for the Firefighter Problem

Krzysztof Michalak

The firefighter problem is a graph-based optimization problem in which the goal is to effectively prevent the spread of a threat in a graph using a limited supply of resources. Recently, metaheuristic approaches to this problem have been proposed, including ant colony optimization and evolutionary algorithms. In this paper Estimation of Distribution Algorithms (EDAs) are used to solve the FFP. A new EDA is proposed in this paper, based on a model that represents the relationship between the state of the graph and positions that become defended during the simulation of the fire spreading. Another method that is tested in this paper, named EH-PBIL, uses an edge histogram matrix model with the learning mechanism used in the Population-based Incremental Learning (PBIL) algorithm with some modifications introduced in order to make it work better with the FFP. Apart from these two EDAs the paper presents results obtained using two versions of the Mallows model, which is a probabilistic model often used for permutation-based problems. For comparison, results obtained on the same test instances using an Ant Colony Optimization (ACO) algorithm, an Evolutionary Algorithm (EA) and a Variable Neighbourhood Search (VNS) are presented. The state-position model proposed in this paper works best for graphs with 1000 vertices and more, outperforming the comparison methods. For smaller graphs (with less than 1000 vertices) the VNS works best.

A Genetic Algorithm for Multi-Component Optimization Problems: the Case of the Travelling Thief Problem

Daniel K. S. Vieira, Gustavo L. Soares, João A. Vasconcelos, and Marcus H. S. Mendes

Real-world problems are often composed of multiple interdependent components. In this case, benchmark problems that do not represent that interdependence are not a good choice to assess algorithm performance. In recent literature, a benchmark problem called Travelling Thief Problem (TTP) was proposed to better represent real-world multi-component problems. TTP is a combination of two well-known problems: 0-1 Knapsack Problem (KP) and the Travelling Salesman Problem (TSP). This paper presents a genetic algorithm-based optimization approach called Multi-Component Genetic Algorithm (MCGA) for solving TTP. It aims to solve the overall problem instead of each sub-component separately. Starting from a solution for the TSP component, obtained by the Chained Lin-Kernighan heuristic, the MCGA applies the evolutionary process (evaluation, selection, crossover, and mutation) iteratively using different basic operators for KP and TSP components. The MCGA was tested on some representative instances of TTP available in the literature. The comparisons show that MCGA obtains competitive solutions in 20 of the 24 TTP instances with 195 and 783 cities.

EvoCOP session 4: Best Paper Candidates

Friday 21 April 0945-1115

Room 1

session chair : Manuel López-Ibáñez

LCS-Based Selective Route Exchange Crossover for the Pickup and Delivery Problem with Time Windows

Miroslaw Blocho, Jakub Nalepa

The pickup and delivery with time windows (PDPTW) is an NP-hard discrete optimization problem of serving transportation requests using a fleet of homogeneous trucks. Its main objective is to minimize the number of vehicles, and the secondary objective is to minimize the distance traveled during the service. In this paper, we propose the longest common subsequence based selective route exchange crossover (LCS-SREX), and apply this operator in the memetic algorithm (MA) for the PDPTW. Also, we suggest the new solution representation which helps handle the crossover efficiently. Extensive experimental study performed on the benchmark set showed that using LCS-SREX leads to very high-quality feasible solutions. The analysis is backed with the statistical tests to verify the importance of the elaborated results. Finally, we report one new world's best routing schedule found using a parallel version of the MA exploiting LCS-SREX.

A memetic algorithm to maximise the employee substitutability in personnel shift scheduling

Jonas Ingels, Broos Maenhout

Personnel rosters are typically constructed for a medium-term period under the assumption of a deterministic operating environment. However, organisations usually operate in a stochastic environment and are confronted with unexpected events in the short term. These unexpected events affect the workability of the personnel roster and need to be resolved efficiently and effectively. To facilitate this short-term recovery, it is important to consider robustness by adopting proactive scheduling strategies during the roster construction. In this paper, we discuss a proactive strategy that maximises the employee substitutability value in a personnel shift scheduling context. We propose a problem-specific population-based approach with local and evolutionary search heuristics to solve the resulting non-linear personnel shift scheduling problem and construct a medium-term personnel shift roster with a maximised employee substitutability value. Detailed computational experiments are presented to validate the design of our heuristic procedure and the selection of the heuristic operators.

Understanding Phase Transitions with Local Optima Networks: Number Partitioning as a Case Study

Gabriela Ochoa, Nadarajen Veerapen, Fabio Daolio, Marco Tomassini

Phase transitions play an important role in understanding search difficulty in combinatorial optimisation. However, previous attempts have not revealed a clear link between fitness landscape properties and the phase transition. We explore whether the global landscape structure of the number partitioning problem changes with the phase transition. Using the local optima network model, we analyse a number of instances before, during, and after the phase transition. We compute relevant network and neutrality metrics; and importantly, identify and visualise the funnel structure with an approach (monotonic sequences) inspired by theoretical chemistry. While most metrics remain oblivious to the phase transition, our results reveal that the funnel structure clearly changes. Easy instances feature a single or a small number of dominant funnels leading to global optima; hard instances have a large number of suboptimal funnels attracting the search. Our study brings new insights and tools to the study of phase transitions in combinatorial optimisation.

The Weighted Independent Domination Problem: ILP Model and Algorithmic Approaches

Pedro Pinacho Davidson, Christian Blum, and José A. Lozano

This work deals with the so-called weighted independent domination problem, which is an NP-hard combinatorial optimization problem in graphs. In contrast to previous theoretical work from the literature, this paper considers the problem from an algorithmic perspective. The first contribution consists in the development of an integer linear programming model and a heuristic that makes use of this model. Second, two greedy heuristics are proposed. Finally, the last contribution is a population-based iterated greedy algorithm that takes profit from the better one of the two developed greedy heuristics. The results of the compared algorithmic approaches show that small problem instances based on random graphs are best solved by an efficient integer linear programming solver such as CPLEX. Larger problem instances are best tackled by the population-based iterated greedy algorithm. The experimental evaluation considers random graphs of different sizes, densities, and ways of generating the node and edge weights.

EvoAPPLICATIONS conference programme

Wednesday 19 April

1110-1300 room 2

EvoApps 1 : Biological Applications
chair : Federico Divina

Enhancing Grammatical Evolution through Data Augmentation: Application to Blood Glucose Forecasting
Jose Manuel Velasco, Oscar Garnica, Sergio Contador, Jose Manuel Colmenar, Esther Maqueda, Marta Botella, Juan Lanchares, Jose Ignacio HIdalgo

Genetic programming representations for multi-dimensional feature learning in biomedical classification
William La Cava, Sara Silva, Lee Spector, Leonardo Vanneschi, Jason Moore

Objective Assessment of Cognitive Impairment in Parkinsons Disease using Evolutionary Algorithm
Chiara Picardi, Jeremy Cosgrove, Stephen L. Smith, Stuart Jamieson, Jane E. Alty

Improving the reproducibility of genetic association results using genotype resampling methods
Elizabeth Piette, Jason Moore

Characterising the influence of rule-based knowledge representations in biological knowledge extraction from transcriptomics data
Simon Baron, Nicola Lazzarini, Jaume Bacardit

1110-1300 room 3

EvoApps 2 : Evolutionary Computation for Gaming
chair : Alberto Tonda

Evolving game-specific UCB alternatives for General Video Game Playing
Ivan Bravi, Ahmed Khalifa, Christoffer Holmgård, Julian Togelius

Relief Camp Manager: A Serious Game using the World Health Organization's Relief Camp Guidelines
Hamna Aslam, Anton Sidorov, Nikita Bogomazov, Fedore Berezyuk, Joseph Alexander Brown

Darwin's Demons: Does Evolution Improve the Game?
Terence Soule, Barrie D. Robison, Samantha Heck, Thomas E. Haynes, David Street, Nicholas Wood

Automated Game Balancing in Ms Pacman and StarCraft using Evolutionary Algorithms
Mihail Morosan, Riccardo Poli

Analyisis of Vanilla Rolling Horizon Evolution Parameters in General Video Game Playing
Raluca D. Gaina, Jialin Liu, Simon M. Lucas, Diego Perez-Liebana

1300-1415 **Lunch**

Wednesday 19 April

1415-1605 room 2

EvoApps 3 : Homogeneous Approaches to Algorithm Improvement

chair : Kevin Sim

The Artificial Immune Ecosystem: a bio-inspired meta-algorithm for boosting time series anomaly detection with expert input
Fabio Guigou, Pierre Collet, Pierre Parrend

Empirical Analysis of Optimization Methods for the Real-World Dial-a-Ride Problem
Dilek Arikan, Cetin Oztoprak, Sanem Sariel

Hybrid Algorithms Based on Integer Programming for the Search of Prioritized Test Data in Software Product Lines
Javier Ferrer, Francisco Chicano, Enrique Alba

On the Use of Smelly Examples to Detect Code Smells in JavaScript
Ian Shoenberger, Wiem Mkaouer, Marouane Kessentini

Deep Parameter Tuning of Concurrent Divide and Conquer Algorithms in Akka
David White, Leonid Joffe, Edward Bowles, Jerry Swan

Ranking programming languages for evolutionary algorithm operations
JJ Merelo, Israel Blancas-Álvarez, Gustavo Romero, Pedro Castillo, Pablo García Sánchez, Víctor Rivas, Mario García-Valdez, Amaury Hernández-Águila, Mario Román

A VNS with Parallel Evaluation of Solutions for the Inverse Lighting Problem
Ignacio Decia, Rodrigo Leira, Martín Pedemonte, Eduardo Fernández, Pablo Ezzatti

Evolving Cut-off Mechanisms and other Work-Stealing Parameters for Parallel Programs
Alcides Fonseca, Nuno Lourenço, Bruno Cabral

Driving in TORCS using modular fuzzy controllers
Mohammed SALEM, Antonio Miguel MORA, Juan Julian MERELO, Pablo García-Sánchez

1415-1605 room 3

EvoApps 4 : Advances in Optimisation, Feature Selection and Parallelization on Evolutionary Computation

chair : Francisco Fernández De Vega

Numerical optimization of ESA's Messenger space mission benchmark
Martin Schlueter, Mohammed Wahib, Masaharu Munetomo

Preferences-Based Choice Prediction in Evolutionary Multi-Objective Optimization
Manish Aggarwal, Justin Heinermann, Stefan Oehmcke, Oliver Kramer

A performance assessment of evolutionary algorithms in volunteer computing environments: the importance of entropy
Paloma de las Cuevas, Pablo Garcia Sanchez, Mario Garcia-a-Valdez, Juan J. Merelo Guervós

Issues on GPU Parallel Implementation of Evolutionary High-dimensional Multi-objective Feature Selection
Juan José Escobar, Julio Ortega, Jesús González, Miguel Damas, Beatriz Prieto

Embedded Grammars for Grammatical Evolution on GPGPU
Jose Ignacio Hidalgo, Carlos Cervigón, Jose Manuel Velasco, Jose Manuel, Carlos García-Sánchez, Guillermo Botella

Wednesday 19 April

1625-1815 room 2	**EvoApps 5 : Stochastic & Dynamic Environments** **chair : Nguyen Trung Thanh** **Solving Dynamic Graph Coloring Problem Using Dynamic Pool Based Evolutionary Algorithm** *Betul Boz, Gizem Sungu* **Road Traffic Rules Synthesis using Grammatical Evolution** *Eric Medvet, Alberto Bartoli, Jacopo Talamini* **Advancing Dynamic Evolutionary Optimization Using In-Memory Database Technology** *Julia Jordan, Wei Cheng, Bernd Scheuermann* **An online packing heuristic for the three-dimensional container loading problem in dynamic environments and the Physical Internet** *Chi Trung Ha, Trung Thanh Nguyen, Lam Thu Bui, Ran Wang* **Pre-Scheduled Colony Size Variation in Dynamic Environments** *Michalis Mavrovouniotis, Anastasia Ioannou, Shengxiang Yang* **A new multi-swarm particle swarm optimization for robust optimization over time** *Danial Yazdani, Trung Thanh Nguyen, Juegen Branke, Jin Wang* **The Static and Stochastic VRP with Time Windows and both random Customers and Reveal Times** Michael Saint-Guillain, Christine Solnon, Yves Deville
1830-2000	**EvoStar Poster Session** **Including conference reception hosted by Edinburgh Napier University**

Wednesday 19 April

1625-1815 room 3

EvoApps 6 : Applications of Evolutionary Computation

chair : Neil Urquhart

EVE: Cloud-based Annotation of Human Genetic Variants
Brian Cole, Jason Moore

Integration of Reaction Kinetics Theory and Gene Expression Programming to Infer Reaction Mechanism
Jason White, Ranjan Srivastava

De Novo DNA Assembly with a Genetic Algorithm Finds Accurate Genomes Even with Suboptimal Fitness
Doina Bucur

Meta-heuristically Seeded Genetic Algorithm for Independent Job Scheduling in Grid Computing
Muhanad Younis, Shengxiang Yang, Benjamin Passow

Analysis of Average Communicability in Complex Networks
Qi Bu, Kwok Yip Szeto

Lamarckian and Lifelong Memetic Search in Agent-based Computing
Wojciech Korczynski, Marek Kisiel-Dorohinicki, Aleksander Byrski

Meta-Heuristics for Improved RF Emitter Localization
Sondre Andreas Engebraaten, Jonas Moen, Kyrre Glette

Evolutionary Art using the Fly Algorithm
Zainab Abbood, Othman Amlal, Franck Vidal

Container Vessel Stowage Planning System using Genetic Algorithm
Miri Weiss Cohen, Vitor N. Coelho, Adi Dahan, Itzzik Kaspi

Presenting the ECO: Evolutionary Computation Ontology
Anil Yaman, Ahmed Hallawa, Matt Coler, Giovanni Iacca

Evolutionary Adaptation to Social Information Use without Learning
James M. Borg, Alastair Channon

Evolution and Morphogenesis of Simulated Modular Robots: A Comparison Between a Direct and Generative Encoding
Frank Veenstra, Andres Faina, Sebastian Risi, Kasper Stoy

Overcoming Initial Convergence in Multi-Objective Evolution of Robot Control and Morphology Using a Two-Phase Approach
Tønnes F. Nygaard, Eivind Samuelsen, Kyrre Glette

Interactive Evolution of Complex Behaviours through Skill Encapsulation
Pablo González de Prado Salas, Sebastian Risi

Automated Design of Genetic Programming Classification Algorithms using a Genetic Algorithm
Thambo Nyathi, Nelishia Pillay

1830-2000

EvoStar Poster Session

Including conference reception hosted by Edinburgh Napier University

Thursday 20 April

0930-1110 room 3

EvoApps 7 : Bio-inspired Algorithms & Complex Systems
chair : Carlos Cotta

The Two Regimes of Neutral Evolution: Localization on Hubs and Delocalized Diffusion
David Shorten, Geoff Nitschke

Two-phase strategy managing insensitivity in global optimization
Jakub Sawicki, Maciej Smo\l{}ka, Marcin \L{}o\'s, Robert Schaefer, Piotr Faliszewski

Local Misfit Approximation in Memetic Solving of Ill-posed Inverse Problems
Marcin Łoś, Robert Schaefer, Jakub Sawicki, Maciej Smołka

Avenues for the Use of Multi–State Cellular Automata
Laura Diosan, Anca Andreica, Irina Voiculescu, Imre Boros

1130-1310 room 3

EvoApps 8 : Software Testing & Real World Applications
chair : Anna I Esparcia-Alcázar

Polytypic Genetic Programming
Jerry Swan, Krzysztof Krawiec, Neil Ghani

Evolving rules for action selection in automated testing via genetic programming - a first approach
Anna I Esparcia-Alcázar, Francisco Almenar, Urko Rueda, Tanja E.J. Vos

Focusing Learning-based Testing away from Known Weaknesses
Christian Fleischer, Jörg Denzinger

Adaptive Batteries Exploiting On-line Steady-State Evolution Strategy
Edoardo Fadda, Guido Perboli, Giovanni Squillero

Brain Programming and the Random Search in Object Categorization
Gustavo Olague, Eddie Clemente, Daniel E. Hernandez, Aaron Barrera

1415-1555 room 3

EvoApps 9 : Evolutionary Feature Selection
chair : Mengjie Zhang

Using Particle Swarm Optimisation and the Silhouette Metric to Estimate the Number of Clusters, Select Features, and Perform Clustering
Andrew Lensen, Bing Xue, Mengjie Zhang

Bagging and Feature Selection for Classification with Incomplete Data
Cao Truong Tran, Mengjie Zhang, Peter Andreae, Bing Xue

Surrogate-model based Particle Swarm Optimisation with Local Search for Feature Selection in Classification
Bach Nguyen, Bing Xue, Peter Andreae

Feature Selection in High Dimensional Data by a Filter-Based Genetic Algorithm
Claudio De Stefano, Franecsco Fontanella, Alessandra Scotto di Freca

EvoAPPLICATIONS conference programme

Thursday 20 April

1615-1745 room 3

EvoApplications 10 : Machine Learning Applications for Real World Problems

chair : Michael Kampouridis

Pricing Rainfall Based Futures Using Genetic Programming
Sam Cramer, Michael Kampouridis, Alex Freitas, Antonis Alexandridis

Minimization of Systemic Risk for Directed Network Using Genetic Algorithm
Wenshuo Guo, Kwok Yip Szeto

Dynamic Portfolio Optimization in Ultra-High Frequency Environment
Patryk Filipiak, Piotr Lipinski

Continual and One-Shot Learning through Neural Networks with Dynamic External Memory
Benno Lüders, Mikkel Schläger, Aleksandra Korach, Sebastian Risi

Friday 1 April

0945-1115 room 2

EvoApps 11 : Communication Networks & other Parallel & Distributed Systems

chair : Fabio D'Andreagiovanni

Configuring Dynamic Heterogeneous Wireless Communications Networks using a Customised Genetic Algorithm
David Lynch, Michael Fenton, Stepan Kucera, Holger Claussen, Michael O'Neill

Multi-Objective Evolutionary Algorithms for Influence Maximization in Social Networks
Doina Bucur, Giovanni Iacca, Andrea Marcelli, Giovanni Squillero, Alberto Tonda

A fast ILP-based Heuristic for the robust design of Body Wireless Sensor Networks
Fabio D'Andreagiovanni, Antonella Nardin, Enrico Natalizio

Hybrid Multi-Ensemble Scheduling
Joerg Bremer, Sebastian Lehnhoff

0945-1115 room 3

EvoApps 12 : Knowledge Incorporation in Evolutionary Computation

chair : Giovanni Iacca

A New Evolutionary Algorithm for Synchronization
Jakub Kowalski, Adam Roman

A Framework for Knowledge Integrated Evolutionary Algorithms
Ahmed Hallawa, Anil Yaman, Giovanni Iacca, Gerd Ascheid

Large Scale Problems in Practice: The effect of dimensionality on the interaction among variables
Fabio Caraffini, Ferrante Neri, Giovanni Iacca

DICE: A New Family of Bivariate Estimation of Distribution Algorithms based on Dichotomised Multivariate Gaussian Distributions
Fergal Lane, R. Muhammad Atif Azad, Conor Ryan

EvoAPPS session 1 : Biological Applications

Wednesday 19 April 1110-1300

Room 2

chair : Federico Divina

Enhancing Grammatical Evolution through Data Augmentation: Application to Blood Glucose Forecasting

Jose Manuel Velasco, Oscar Garnica, Sergio Contador, Jose Manuel Colmenar, Esther Maqueda, Marta Botella, Juan Lanchares, Jose Ignacio HIdalgo

Currently, Diabetes Mellitus Type 1 patients are waiting hopefully for the arrival of the Artificial Pancreas (AP) in a near future. AP systems will control the blood glucose of people that suffer the disease, improving their lives and reducing the risks they face everyday. At the core of the AP, an algorithm will forecast future glucose levels and estimate insulin bolus sizes. Grammatical Evolution (GE) has been proved as a suitable algorithm for predicting glucose levels. Nevertheless, one the main obstacles that researches have found for training the GE models is the lack of significant amounts of data. As in many other fields in medicine, the collection of data from real patients is very complex. In this paper, we propose a data augmentation algorithm that generates synthetic glucose time series from real data. The synthetic time series can be used to train a unique GE model or to produce several GE models that work together in a combining system. Our experimental results show that, in a scarce data context, Grammatical Evolution models can get more accurate and robust predictions using data augmentation.

Genetic programming representations for multi-dimensional feature learning in biomedical classification

William La Cava, Sara Silva, Lee Spector, Leonardo Vanneschi, Jason Moore

We present a new classification method that uses genetic programming (GP) to evolve feature transformations for a deterministic, distanced-based classifier. This method, called M4GP, differs from common approaches to classifier representation in GP in that it does not enforce arbitrary decision boundaries and it allows individuals to produce multiple outputs via a stack-based GP system. In comparison to typical methods of classification, M4GP can be advantageous in its ability to produce readable models. We conduct a comprehensive study of M4GP, first in comparison to other GP classifiers, and then in comparison to six common machine learning classifiers. We conduct full hyper-parameter optimization for all of the methods on a suite of 16 biomedical data sets, ranging in size and difficulty. The results indicate that M4GP outperforms other GP methods for classification. M4GP performs competitively with other machine learning methods in terms of the accuracy of the produced models for most problems. M4GP also exhibits the ability to detect epistatic interactions better than the other methods.

Objective Assessment of Cognitive Impairment in Parkinsons Disease using Evolutionary Algorithm

Chiara Picardi, Jeremy Cosgrove, Stephen L. Smith, Stuart Jamieson, Jane E. Alty

Parkinsons disease (PD) is a common and disabling condition without cure. An early and accurate diagnosis is important for monitoring the disease and managing symptoms. Over time, the majority of patients with PD develop cognitive impairment, which is diagnosed using global tests of cognitive function or more detailed neuropsychological assessment. This paper presents an approach to detect PD and to discriminate different degrees of PD cognitive impairment in an objective way, considering a simple and non-invasive ‚Äúreach and grasp‚Äù task performed with the patient wearing sensor-enabled data gloves recording movements in real-time. The PD patients comprised three subgroups: 22 PD patients with normal cognition (PD-NC), 23 PD patients with mild cognitive impairment (PD-MCI) and 10 PD patients with dementia (PDD). In addition, 30 age-matched healthy subjects (Controls) were also measured. From the experimental data, 25 kinematic features were extracted with the aim of generating a classifier that is able to discriminate not only between Controls and PD patients, but also between the PD cognitive subgroups. The technique used to find the best classifier was an Evolutionary Algorithm - Cartesian Genetic Programming (CGP), and this is compared with Support Vector Machine (SVM) and Artificial Neural Network (ANN). In all cases, the CGP classifiers were comparable with SVM and ANN, and in some cases performed better. The results are promising and show both the potential of the computed features and of CGP in aiding PD diagnosis.

EvoAPPS session 1 : Biological Applications

Wednesday 19 April 1110-1300
Room 2

chair : Federico Divina

Improving the reproducibility of genetic association results using genotype resampling methods
Elizabeth Piette, Jason Moore
Replication may be an inadequate gold standard for substantiating the significance of results from genome-wide association studies (GWAS). Successful replication provides evidence supporting true results and against spurious findings, but vari-ous population attributes contribute to observed significance of a genetic effect. We hypothesize that failure to replicate an interaction observed to be significant in a GWAS of one population in a second population is sometimes attributable to differences in minor allele frequencies, and resampling the replication dataset by genotype to match the minor allele frequencies of the discovery data can improve estimates of the interaction significance. We show via simulation that resampling of the replication data produced results more concordant with the discovery find-ings. We recommend that failure to replicate GWAS results should not immedi-ately be considered to refute previously-observed findings and conversely that replication does not guarantee significance, and suggest that datasets be compared more critically in biological context.

Characterising the influence of rule-based knowledge representations in biological knowledge extraction from transcriptomics data
Simon Baron, Nicola Lazzarini, Jaume Bacardit
Currently, there is a wealth of biotechnologies (e.g. sequencing, proteomics, lipidomics) able to generate a broad range of data types out of biological samples. However, the knowledge gained from such data sources is constrained by the limitations of the analytics techniques. The state-of-the-art machine learning algorithms are able to capture complex patterns with high prediction capacity. However, often it is very difficult if not impossible to extract human-understandable knowledge out of these patterns. In recent years evolutionary machine learning techniques have shown that they are competent methods for biological/biomedical data analytics. They are able to generate interpretable prediction models and, beyond just prediction models, they are able to extract useful knowledge in the form of biomarkers or biological networks. The focus of this paper is to thoroughly characterise the impact that a core component of the evolutionary machine learning process, its knowledge representations, has in the process of extracting biologically-useful knowledge out of transcriptomics datasets. Using the FuNeL evolutionary machine learning-based network inference method, we evaluate several variants of rule knowledge representations on a range of transcriptomics datasets to quantify the volume and complementarity of the knowledge that each of them can extract. Overall we show that knowledge representations, often considered a minor detail, greatly impact on the downstream biological knowledge extraction process.

EvoAPPS session 2 : Evolutionary Computation for Gaming

Wednesday 19 April 1110-1300

Room 3

chair : Alberto Tonda

Evolving game-specific UCB alternatives for General Video Game Playing

Ivan Bravi, Ahmed Khalifa, Christoffer Holmgård, Julian Togelius

At the core of the most popular version of the Monte Carlo Tree Search (MCTS) algorithm is the UCB1 (Upper Confidence Bound) equation. This equation decides which node to explore next, and therefore shapes the behavior of the search process. If the UCB1 equation is replaced with another equation, the behavior of the MCTS algorithm changes, which might increase its performance on certain problems (and decrease it on others). In this paper, we use genetic programming to evolve replacements to the UCB1 equation targeted at playing individual games in the General Video Game AI (GVGAI) Framework. Each equation is evolved to maximize playing strength in a single game, but is then also tested on all other games in our test set. For every game included in the experiments, we found a UCB replacement that performs significantly better than standard UCB1. Additionally, evolved UCB replacements also tend to improve performance in some GVGAI games for which they are not evolved, showing that improvements generalize across games to clusters of games with similar game mechanics or algorithmic performance. Such an evolved portfolio of UCB variations could be useful for a hyper-heuristic game-playing agent, allowing it to select the most appropriate heuristics for particular games or problems in general.

Relief Camp Manager: A Serious Game using the World Health Organization's Relief Camp Guidelines

Hamna Aslam, Anton Sidorov, Nikita Bogomazov, Fedore Berezyuk, Joseph Alexander Brown

Emergency management plans rely on training in order to provide support to first responders, government planners, and affected persons in potential disaster zone. Serious Games have proved to be useful in capturing and invoking people's attention and emergency management education is also being delivered through games. The paper presents a relief camp game developed using the figures from World Health Organization's (WHO) report on water, sanitation and hygiene guidelines in emergencies. The game play provides player an understanding of the management of relief camps by giving them a supervisory role to design and organize camp areas. It also encourages players to introduce their own ideas in setting up relief camps. The player is competing against evolutionary computation algorithm. The aims are to create awareness about relief camp management strategies and improving the present approaches for better plans via human competitive testing.

Darwin's Demons: Does Evolution Improve the Game?

Terence Soule, Barrie D. Robison, Samantha Heck, Thomas E. Haynes, David Street, Nicholas Wood

It is widely assumed that evolution has the potential to make better video games. However, relatively few commercial games have been released that use evolution as a core game mechanic, and of these games only a very small sub-set have shown that evolution occurs as expected and improves game play as intended. Thus, there remains a critical gap between studies showing the clear potential of evolution to improve video games and studies showing that evolution did improve game play in a commercially released game. We have developed Darwin's Demons, a space shooter inspired by old style arcade games, with the added feature of evolving enemies. In August, 2016 Darwin's Demons was Green-lit for sale on Steam, a standard benchmark for commercialization of games. In this paper we present and test four hypotheses that form the basis for the claim that evolution occurs and improves game play in Darwin's Demons. More generally, these hypotheses can be used to confirm that evolution meets the intended design goals for other evolutionary games. Our results support the hypotheses that evolution makes Darwin's Demons get progressively more difficult over the course of a game, and that the fitness function, player choices, and player strategy all affect the evolutionary trajectory during a single game. This suggests that in Darwin's Demons, the enemies adapt to the player's decisions and strategy, making the game interesting and increasing its replayability.

EvoAPPS session 2 : Evolutionary Computation for Gaming

Wednesday 19 April 1110-1300

Room 3

chair : Alberto Tonda

Automated Game Balancing in Ms Pacman and StarCraft using Evolutionary Algorithms
Mihail Morosan, Riccardo Poli
Games, particularly online games, have an ongoing requirement to exhibit the ability to react to player behaviour and change their mechanics and available tools to keep their audience both entertained and feeling that their strategic choices and in-game decisions have value. Game designers invest time both gathering data and analysing it to introduce minor changes that bring their game closer to a state of balance, a task with a lot of potential that has recently come to the attention of researchers. This paper first provides a method for automating the process of finding the best game parameters to reduce the difficulty of Ms PacMan through the use of evolutionary algorithms and then applies the same method to a much more complex and commercially successful PC game, StarCraft, to curb the prowess of a dominant strategy. Results show both significant promise and several avenues for future improvement that may lead to a useful balancing tool for the games industry.

Analyisis of Vanilla Rolling Horizon Evolution Parameters in General Video Game Playing
Raluca D. Gaina, Jialin Liu, Simon M. Lucas, Diego Perez-Liebana
Monte Carlo Tree Search techniques have generally dominated General Video Game Playing, but recent research has started looking at Evolutionary Algorithms and their potential at matching Tree Search level of play or even outperforming these methods. Online or Rolling Horizon Evolution is one of the options available to evolve sequences of actions for planning in General Video Game Playing, but no research has been done up to date that explores the capabilities of the vanilla version of this algorithm in multiple games. This study aims to critically analyse the different configurations regarding population size and individual length in a set of 20 games from the General Video Game AI corpus. Distinctions are made between deterministic and stochastic games, and the implications of using superior time budgets are studied. Results show that there is scope for the use of these techniques, which in some configurations outperform Monte Carlo Tree Search, and also suggest that further research in these methods could boost their performance.

EvoAPPS session 3 : Homogeneous Approaches to Algorithm Improvement

Wednesday 19 April 1415-1605

Room 2

chair : Kevin Sim

The Artificial Immune Ecosystem: a bio-inspired meta-algorithm for boosting time series anomaly detection with expert input

Fabio Guigou, Pierre Collet, Pierre Parrend

One of the challenges in machine learning, especially in the Big Data era, is to obtain labeled data sets. Indeed, the difficulty of labeling large amounts of data had lead to an increasing reliance on unsupervised classifiers, such as deep autoencoders. In this paper, we study the problem of involving a human expert in the training of a classifier instead of using labeled data. We use anomaly detection in network monitoring as a field of application. We demonstrate how using crude, already existing monitoring software as a heuristic to choose which points to label can boost the classification rate with respect to both the monitoring software and the classifier trained on a fully labeled data set, with a very low computational cost. We introduce the Artificial Immune Ecosystem meta-algorithm as a generic framework integrating the expert, the heuristic and the classifier.

Empirical Analysis of Optimization Methods for the Real-World Dial-a-Ride Problem

Dilek Arikan, Cetin Oztoprak, Sanem Sariel

This paper deals with solving the Dial-a-Ride Problem (DARP) for an on-demand delivery start-up company which delivers products to its customers from their corresponding pick-up points within guaranteed time intervals. The primary goal of the company is to minimize its operational costs while fulfilling the orders under the constraints on time window, duration, carrier capacity and ride time. This problem is formulated as the real-world DARP, and two methods are empirically evaluated by using Mixed Integer Programming (MIP) and Genetic Algorithm (GA) frameworks. The experiments are done on the simulated data provided by the company. The results show that a heuristic approach is more suitable for the real-world problem to meet the time window limitations.

Hybrid Algorithms Based on Integer Programming for the Search of Prioritized Test Data in Software Product Lines

Javier Ferrer, Francisco Chicano, Enrique Alba

In Software Product Lines (SPLs) it is not possible, in general, to test all products of the family. The number of products denoted by a SPL is very high due to the combinatorial explosion of features. For this reason, some coverage criteria have been proposed which try to test at least all feature interactions without the necessity to test all products, e.g., all pairs of features (pairwise coverage). In addition, it is desirable to first test products composed by a set of priority features. This problem is known as the Prioritized Pairwise Test Data Generation Problem. In this work we propose two hybrid algorithms using Integer Programming (IP) to generate a prioritized test suite. The first one is based on an integer linear formulation and the second one is based on a integer quadratic (nonlinear) formulation. We compare these techniques with two state-of-the-art algorithms, the Parallel Prioritized Genetic Solver (PPGS) and a greedy algorithm called prioritized-ICPL. Our study reveals that our hybrid nonlinear approach is clearly the best in both, solution quality and computation time. Moreover, the nonlinear variant (the fastest one) is 27 and 42 times faster than PPGS in the two groups of instances analyzed in this work

On the Use of Smelly Examples to Detect Code Smells in JavaScript

Ian Shoenberger, Wiem Mkaouer, Marouane Kessentini

JavaScript has become one of the widely-used languages. However, as the size of JavaScript-based applications grows, the number of defects grows as well. Re-cent studies have produced a set of manually defined rules to identify these de-fects. We propose, in this work, the automation of deriving these rules to ensure scalability and potentially the detection of a wider set of defects without requiring any extensive knowledge on rules tuning. To this end, we rely on a base of exist-ing code smells that is used to train the detection rules using Genetic Program-ming and find the best threshold of metrics composing the rules. The evaluation of our work on 9 JavaScript web projects has shown promising results in terms of detection precision of 92% and recall of 85%, with no threshold tuning required.

Deep Parameter Tuning of Concurrent Divide and Conquer Algorithms in Akka

David White, Leonid Joffe, Edward Bowles, Jerry Swan

Akka is a widely-used high-performance and distributed computing toolkit for fine-grained concurrency, written in Scala for the Java Virtual Machine. Although Akka elegantly simplifies the process of building complex parallel software, many crucial decisions that affect system performance are deferred to the user. Employing the method of Deep Parameter Tuning to extract embedded `magic numbers' from source code, we use the CMA-ES evolutionary computation algorithm to optimise the concurrent implementation of three widely-used divide-and-conquer algorithms within the Akka toolkit: Quicksort, Strassen's matrix multiplication, and the Fast Fourier Transform.

EvoAPPS session 3 : Homogeneous Approaches to Algorithm Improvement

Wednesday 19 April 1415-1605

Room 2

chair : Kevin Sim

Ranking programming languages for evolutionary algorithm operations
JJ Merelo, Israel Blancas-Álvarez, Gustavo Romero, Pedro Castillo, Pablo García Sánchez, Víctor Rivas, Mario García-Valdez, Amaury Hernández-Águila, Mario Román
In this paper we measure the speed of several popular and recent programming languages performing the most usual operators in the canonical evolutionary algorithm, mutation and crossover, as well as an usual fitness function, OneMax, which is representative of the kind of operations performed in binary chromosomes. Our main objective is, first, to create programs in programming languages that use the fastest implementation available available. Second, to find out the differences in speeds for the different languages. Third, to find out whether the usual assumptions about the speed of languages really holds. And, finally, to find if the assumed order of speed in languages used in evolutionary algorithms holds true for all kinds of operations. In order to do that, we use available implementations or perform our own, concluding that the evolutionary algorithm scenario is more complex than usually assumed and finding out some surprising {\em winners} and {\em losers} among the languages tested.

A VNS with Parallel Evaluation of Solutions for the Inverse Lighting Problem
Ignacio Decia, Rodrigo Leira, Martín Pedemonte, Eduardo Fernández, Pablo Ezzatti
Lighting design is a key issue in architectural design. The Inverse Lighting Problem (ILP) is an optimization problem that arises in lighting design and consist in finding the best configuration of lights that meets a set of goals that designers would like to achieve. In this paper, we present three different VNS that evaluate several solutions in parallel, improving the performance of a traditional VNS that has already been proposed for solving the ILP. These methods exploit the block matrix multiplication algorithms in order to increase the computational intensity of the algorithm and are specially well suited for parallel computation in GPUs architectures. The experimental analysis performed in two CPU/GPU hardware platforms for two scenarios with different complexity shows that the proposed methods provide fast results and are able to allow the interactive lighting design.

Evolving Cut-off Mechanisms and other Work-Stealing Parameters for Parallel Programs
Alcides Fonseca, Nuno Lourenço, Bruno Cabral
Optimizing parallel programs is a complex task because the interference among many different parameters. Work-stealing runtimes, used to dynamically balance load among different processor cores, are no exception. This work explores the automatic configuration of the following runtime parameters: dynamic granularity control algorithms, granularity control cache, work-stealing algorithm, lazy binary splitting parameter, the maximum queue size and the unparking interval. The performance of the program is highly sensible to the granularity control algorithm, which can be a combination of other granularity algorithms.In this work, we address two search-based problems: finding a globally efficient work-stealing configuration, and finding the best configuration just for an individual program. For both problems, we propose the use of a Genetic Algorithm (GA). The genotype of the GA is able to represent combinations of up to three cut-off algorithms, as well as other work-stealing parameters. The proposed GA has been evaluated in its ability to obtain a more efficient solution across a set of programs, in its ability to generalize the solution to a larger set of programs, and its ability to evolve single programs individually. The GA was able to improve the performance of the set of programs in the training set, but the obtained configurations were not generalized to a larger benchmark set. However, it was able to successfully improve the performance of each program individually.

Driving in TORCS using modular fuzzy controllers
Mohammed SALEM, Antonio Miguel MORA, Juan Julian MERELO, Pablo García-Sánchez
When driving a car it is essential to take into account all possible factors; even more so when, like in the TORCS simulated race game, the objective is not only to avoid collisions, but also to win the race within a limited budget. In this paper, we present the design of an autonomous driver for racing car in a simulated race. Unlike previous controllers, that only used fuzzy logic approaches for either acceleration or steering, the proposed driver uses simultaneously two fuzzy controllers for steering and computing the target speed of the car at every moment of the race. They use the track border sensors as inputs and besides, for enhanced safety, it has also taken into account the relative position of the other competitors. The proposed fuzzy driver is evaluated in practise and timed races giving good results across a wide variety of racing tracks, mainly those that have many turning points.

EvoAPPS session 4 : Advances in Optimisation, Feature Selection & Parallelisation on Evolutionary Computation

Wednesday 19 April 1415-1605

Room 3

chair : Francisco Fernández De Vega

Numerical optimization of ESA's Messenger space mission benchmark

Martin Schlueter, Mohammed Wahib, Masaharu Munetomo

The design and optimization of interplanetary space mission trajectories is known to be a difficult challenge. The trajectory of the Messenger mission (launched by NASA in 2004) is one of the most complex ones ever created. The European Space Agency (ESA) makes available a numerical optimization benchmark which resembles an accurate model of Messengers full mission trajectory. This contribution presents an optimization approach which is capable to (robustly) solve ESA's Messenger full mission benchmark to its putative global solution within 24 hours run time on a moderate sized computer cluster. The considered algorithm, named MXHPC, is a parallelization framework for the MIDACO optimization algorithm which is an evolutionary method particularly suited for space trajectory design. The presented results demonstrate the effectiveness of evolutionary computing for complex real-world problems which have been previously considered intractable.

Preferences-Based Choice Prediction in Evolutionary Multi-Objective Optimization

Manish Aggarwal, Justin Heinermann, Stefan Oehmcke, Oliver Kramer

Evolutionary multi-objective algorithms (EMOAs) of the type of NSGA-2 approximate the Pareto-front, after which a decision-maker (DM) is confounded with the primary task of selecting the best solution amongst all the equally good solutions on the Pareto-front. In this paper, we complement the popular NSGA-2 EMOA by posteriori identifying a DM's best solution among the candidate solutions on the Pareto-front, generated through NSGA-2. To this end, we employ a preference-based learning approach to learn an abstract ideal reference point of the DM on the multi-objective space, which reflects the compromises the DM makes against a set of conflicting objectives. The solution that is closest to this reference-point is then predicted as the DM's best solution. The pairwise comparisons of the candidate solutions provides the training information for our learning model. The experimental results on ZDT1 dataset shows that the proposed approach is not only intuitive, but also easy to apply, and robust to inconsistencies in the DM's preference statements.

A performance assessment of evolutionary algorithms in volunteer computing environments: the importance of entropy

Paloma de las Cuevas, Pablo Garcia Sanchez, Mario Garcia-a-Valdez, Juan J. Merelo Guervós

In a volunteer distributed computing system, users run a program on their own machine to contribute to a common effort. If the program is embedded in a web page, collaboration is straightforward, but also ephemeral. In this paper, we analyze a volunteer evolutionary computing system called NodIO, by running several experiments, some of them massive. Our objective is to discover rules that encourage volunteer participation and also the interplay of these contributions with the dynamics of the algorithm itself, making it efficient enough. We will show different measures of participation and contribution to the algorithm, as well as how different volunteer usage patterns and tweaks in the algorithm, such as restarting clients when a solution has been found, contribute to improvements and leveraging of these contributions. We will also try to find out what is the key factor in the early termination of the experiments, measuring entropy in the contributions and other large scale indicators.

EvoAPPS session 4 : Advances in Optimisation, Feature Selection & Parallelisation on Evolutionary Computation

Wednesday 19 April 1415-1605

Room 3

chair : Francisco Fernández De Vega

Issues on GPU Parallel Implementation of Evolutionary High-dimensional Multi-objective Feature Selection

Juan José Escobar, Julio Ortega, Jesús González, Miguel Damas, Beatriz Prieto

The interest on applications that analyse large volumes of high dimensional data has grown recently. Many of these applications related to the so-called Big Data show different implicit parallelism that can benefit from the efficient use, in terms of performance and power consumption, of Graphics Processing Unit (GPU) accelerators. Although the GPU microarchitectures make possible the acceleration of applications by exploiting parallelism at different levels, the characteristics of their memory hierarchy and the location of GPUs as coprocessors require a careful organization of the memory access patterns and data transferences to get efficient speedups. This paper aims to take advantage of heterogeneous parallel codes on GPUs to accelerate evolutionary approaches in Electroencephalogram (EEG) classification and feature selection in the context of Brain Computer Interface (BCI) tasks. The results show the benefits of taking into account not only the data parallelism achievable by GPUs, but also the memory access patterns, in order to increase the speedups achieved by superscalar cores.

Embedded Grammars for Grammatical Evolution on GPGPU

Jose Ignacio Hidalgo, Carlos Cervigón, Jose Manuel Velasco, Jose Manuel, Carlos García-Sánchez, Guillermo Botella

This paper presents an implementation of Grammatical Evolution on a GPU architecture. Our proposal, \textit{Embedded Grammars}, implements the grammar directly in the code. Although more rigid, it allows to compute the decodification in parallel with the evaluation of the individuals. We tested three different grammars with a set of eight symbolic regression problems. The symbolic regression problems consists on obtaining a mathematical expression in the form $y=f(x)$, in our case, from a set of 288 pairs x, y. The analysis of the results shows that \textit{Embedded Grammars} are better not only in terms of execution time, but also in quality when compared with an implementation on a CPU. Speed-up results are also better than those presented in the literature.

EvoAPPS session 5 : Stochastic & Dynamic Environments

Wednesday 19 April 1625-1815

Room 2

chair : Nguyen Trung Thanh

Solving Dynamic Graph Coloring Problem Using Dynamic Pool Based Evolutionary Algorithm

Betul Boz, Gizem Sungu

Graph coloring problem is one of the main optimization problems from the literature. Many real world problems interacting with changing environments can be modeled with dynamic graphs. Genetic algorithms are a good choice to solve dynamic graph coloring problem because they can adopt to dynamic environments and are suitable for problems with NP-hard complexity. In this paper, we propose a dynamic pool based evolutionary algorithm (DPBEA) for solving the dynamic graph coloring problem, which contains a partition based representation to adopt to the dynamic changes of the graph and carry the valuable information obtained in history. The proposed algorithm uses a novel special purpose pool based crossover operator that targets to minimize the number of colors used in the solutions and a local search method that tries to increase the diversity of the solutions. We compared the performance of our algorithm with a well known heuristic for solving the graph coloring problem and a genetic algorithm with a dynamic population using a large number of dynamic graphs. The experimental evaluation indicates that our algorithm outperforms these algorithms with respect to number of colors used by the algorithms in most of the test cases provided.

Road Traffic Rules Synthesis using Grammatical Evolution

Eric Medvet, Alberto Bartoli, Jacopo Talamini

We consider the problem of the automatic synthesis of road traffic rules, motivated by a future scenario in which human and machine-based drivers will coexist on the roads: in that scenario, current road rules may be either unsuitable or inefficient. We approach the problem using Grammatical Evolution (GE). To this end, we propose a road traffic model which includes concepts amenable to be regulated (e.g., lanes, intersections) and which allows drivers to temporarily evade traffic rules when there are no better alternatives. In our GE framework, each individual is a set of rules and its fitness is a weighted sum of traffic efficiency and safety, as resulting from a number of simulations where all drivers are subjected to the same rules. Experimental results show that our approach indeed generates rules leading to a safer and more efficient traffic than enforcing no rules or rules similar to those currently used.

Advancing Dynamic Evolutionary Optimization Using In-Memory Database Technology

Julia Jordan, Wei Cheng, Bernd Scheuermann

This paper reports on IMDEA (In-Memory database Dynamic Evolutionary Algorithm), an approach to dynamic evolutionary optimization exploiting in-memory database (IMDB) technology to expedite the search process subject to change events arising at runtime. The implemented system benefits from optimization knowledge persisted on an IMDB serving as associative memory to better guide the optimizer through changing environments. For this, specific strategies for knowledge processing, extraction and injection are developed and evaluated. Moreover, prediction methods are embedded and empirical studies outline to which extent these methods are able to anticipate forthcoming dynamic change events by evaluating historical records of previous changes and other optimization knowledge managed by the IMDB.

An online packing heuristic for the three-dimensional container loading problem in dynamic environments and the Physical Internet

Chi Trung Ha, Trung Thanh Nguyen, Lam Thu Bui, Ran Wang

In this paper, we consider the online three-dimensional container loading problem. We develop a novel online packing algorithm to solve the three-dimensional bin packing problem in the online case where items are not known well in advance and they have to be packed in real-time when they arrive. This is relevant in many real-world scenarios such as automated cargo loading in warehouses. This is also relevant in the new logistics model of Physical Internet. The effectiveness of the online packing heuristic is evaluated on a set of generated data. The experimental results show that the algorithm could solve the 3D container loading problems in online fashion and is competitive against other algorithms both in the terms of running time, space utilization and the number of bins.

EvoAPPS session 5 : Stochastic & Dynamic Environments

Wednesday 19 April 1625-1815

Room 2

chair : Nguyen Trung Thanh

Pre-Scheduled Colony Size Variation in Dynamic Environments

Michalis Mavrovouniotis, Anastasia Ioannou, Shengxiang Yang

The performance of theMAX-MIN ant system (MMAS) in dynamic optimization problems (DOPs) is sensitive to the colony size. In particular, a large colony size may waste computational resources whereas a small colony size may restrict the searching capabilities of the algorithm. There is a trade off in the behaviour of the algorithm between the early and later stages of the optimization process. A smaller colony size leads to better performance on shorter runs whereas a larger colony size leads to better performance on longer runs. In this paper, pre-scheduling of varying the colony size of MMAS is investigated in dynamic environments.

A new multi-swarm particle swarm optimization for robust optimization over time

Danial Yazdani, Trung Thanh Nguyen, Juegen Branke, Jin Wang

Dynamic optimization problems (DOPs) are optimization problems that change over time, and most investigations in this area focus on tracking the moving op-timum efficiently. However, continuously tracking a moving optimum is not practical in many real-world problems because changing solutions frequently is not possible or very costly. Recently, another practical way to tackle DOPs has been suggested: robust optimization over time (ROOT). In ROOT, the main goal is to find solutions that can remain acceptable over an extended period of time. In this paper, a new multi-swarm PSO algorithm is proposed in which different swarms track peaks and gather information about their behavior. This information is then used to make decisions about the next robust solution. The main goal of the proposed algorithm is to maximize the average number of environments dur-ing which the selected solutionsí quality remains acceptable. The experimental re-sults show that our proposed algorithm can perform significantly better than ex-isting work in this aspect.

The Static and Stochastic VRP with Time Windows and both random Customers and Reveal Times

Michael Saint-Guillain, Christine Solnon, Yves Deville

Static and stochastic vehicle routing problems (SS-VRP) aim at modeling and solving real life problems by considering uncertainty on the data. In particular, customer data may not be known with certainty. Before the beginning of the day, probability distributions on customer data are used to compute a first-stage solution that optimizes an expected cost. Customer data are revealed online, while the solution is executed, and a recourse strategy is applied on the first-stage solution to quickly adapt it. Existing SS-VRP variants usually make a strong assumption on the time at which a stochastic customer reveals its data ({\em e.g.}, when a vehicle arrives at the corresponding location). We introduce a new SS-VRP where customer reveal times are stochastic. We define first-stage solutions and a recourse strategy for this new problem. A key point is to introduce waiting locations that are used in the first stage-solution to wait for the realization of customer stochastic data. We show how to compute the expected cost of a first-stage solution in pseudo polynomial time, in the particular case where the vehicles are not constrained by a maximal capacity. We also introduce a local search-based approach for optimizing the first-stage solution, and introduce a {\em scale} parameter to tune the precision and cost of the expected cost computation. Experimental results on small to large instances demonstrate its efficiency and flexibility.

EvoAPPS session 6 : Applications of Evolutionary Computation

Wednesday 19 April 1625-1815

Room 3

chair : Neil Urquhart

EVE: Cloud-based Annotation of Human Genetic Variants

Brian Cole, Jason Moore

Annotation of human genetic variants enables genotype-phenotype association studies at the gene, pathway, and tissue level. ¬†Annotation results are difficult to reproduce across study sites due to shifting software versions and a lack of a unified hardware interface between study sites. ¬†Cloud computing offers a promising solution by integrating hardware and software into reproducible virtual appliances which may be utilized on-demand and shared across institutions. We developed ENSEMBL VEP on EC2 (EVE), a cloud-based virtual appliance for annotation of human genetic variants built around the ENSEMBL Variant Effect Predictor. We integrated virtual hardware infrastructure, open-source software, and publicly available genomic datasets to provide annotation capability for genetic variants in the context of genes/transcripts, Gene Ontology pathways, tissue-specific expression from the Gene Expression Atlas, miRNA annotations, minor allele frequencies from the 1000 Genomes Project and the Exome Aggregation Consortium, and deleteriousness scores from Combined Annotation Dependent Depletion. ¬†We demonstrate the utility of EVE by annotating the genetic variants in a case-control study of glaucoma. Cloud computing can reduce the difficulty of replicating complex software pipelines such as annotation pipelines across study sites. ¬†We provide a publicly available CloudFormation template of the EVE virtual appliance which can automatically provision and deploy a parameterized, preconfigured hardware/software stack ready for annotation of human genetic variants (github.com/epistasislab/EVE). ¬†This approach offers increased reproducibility in human genetic studies by providing a unified appliance to researchers across the world.

Integration of Reaction Kinetics Theory and Gene Expression Programming to Infer Reaction Mechanism

Jason White, Ranjan Srivastava

Mechanistic mathematical models of biomolecular systems have been used to de-scribe biological phenomena in the hope that one day these models may be used to enhance our fundamental understanding of these phenomena, as well as to op-timize and engineer biological systems. An evolutionary algorithm capable of formulating mass action kinetic models of biological systems from time series da-ta sets was developed for a system of n-species. The strategy involved using a gene expression programming (GEP) based approach and heuristics based on chemical kinetic theory. The resulting algorithm was successfully validated by recapitulating a nonlinear model of viral dynamics using only a ìnoisyî set of time series data. While the system analyzed for this proof-of-principle study was relatively small, the approach presented here is easily parallelizable making it amenable for use with larger systems. Additionally, greater efficiencies may po-tentially be realized by further taking advantage of the problem domain along with future breakthroughs in computing power and algorithmic advances.

De Novo DNA Assembly with a Genetic Algorithm Finds Accurate Genomes Even with Suboptimal Fitness

Doina Bucur

We design an evolutionary heuristic for the combinatorial problem of de-novo DNA assembly with short, overlapping, accurately sequenced single DNA reads of uniform length, from both strands of a genome without long repeated sequences. The representation of a candidate solution is a novel segmented permutation: an ordering of DNA reads into contigs, and of contigs into a DNA scaffold. Mutation and crossover operators work at the contig level. The fitness function minimizes the total length of scaffold (i.e., the sum of the length of the overlapped contigs) and the number of contigs on the scaffold. We evaluate the algorithm with read libraries uniformly sampled from genomes 3835 to 48502 base pairs long, with genome coverage between 5 and 7, and verify the biological accuracy of the scaffolds obtained by comparing them against reference genomes. We find the correct genome as a contig string on the DNA scaffold in over 95% of all assembly runs. For the smaller read sets, the scaffold obtained consists of only the correct contig; for the larger read libraries, the fitness of the solution is suboptimal, with chaff contigs present; however, a simple post-processing step can realign the chaff onto the correct genome. The results support the idea that this heuristic can be used for consensus building in de-novo assembly.

EvoAPPS session 6 : Applications of Evolutionary Computation

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Room 3

chair : Neil Urquhart

Meta-heuristically Seeded Genetic Algorithm for Independent Job Scheduling in Grid Computing

Muhanad Younis, Shengxiang Yang, Benjamin Passow

Grid computing is an infrastructure which connects geographically distributed computers owned by various organizations allowing their resources, such as computational power and storage capabilities, to be shared, selected, and aggregated. Job scheduling problem is one of the most difficult tasks in grid computing systems. To solve this problem efficiently, new methods are required. In this paper, a seeded genetic algorithm is proposed which uses a meta-heuristic algorithm to generate its initial population. To evaluate the performance of the proposed method in terms of minimizing the makespan, the Expected Time to Compute (ETC) simulation model is used to carry out a number of experiments. The results show that the proposed algorithm performs better than other selected techniques.

Analysis of Average Communicability in Complex Networks

Qi Bu, Kwok Yip Szeto

The average communicability of a complex network is an important measure of the efficiency of information exchange in the entire network. The optimization of average communicability is a significant problem in network design for various applications in science and engineering. Since the search of the topology that achieves the highest average communicability is a very difficult problem due to the enormous size of the solution space, genetic algorithm is a good choice for search. From numerical simulation, we discover a positive correlation between the variance of the degree distribution with the average communicability of the network. This correlation is then proven mathematically, with applications to the comparison for the average communicability of two networks with the same number of nodes and links using the largest eigenvalues of their adjacency matrices.

Lamarckian and Lifelong Memetic Search in Agent-based Computing

Wojciech Korczynski, Marek Kisiel-Dorohinicki, Aleksander Byrski

Memetic algorithms when used with care can help in balancing exploitation and exploration of the metaheuristics, without the overhead measured by the rapidly increased number of function fitness calls. The paper tackles such balancing of use of metaheuristics in an agent-oriented setting. In particular, application of local search during a computing agent's life is researched. The results shown for selected benchmark functions are presented along with necessary statistic testing.

Meta-Heuristics for Improved RF Emitter Localization

Sondre Andreas Engebraaten, Jonas Moen, Kyrre Glette

Locating RF emitters can be done with a number of methods, but cheap and widely available sensors make the Power Difference of Arrival (PDOA) technique a prominent choice. Predicting the location of an unknown RF emitter can be seen as a continuous optimization problem, minimizing the error w.r.t. the sensor measurements gathered. Most instances of this problem feature multi-modality, making these challenging to solve. This paper presents an analysis of the performance of evolutionary computation and other meta-heuristic methods on this real-world problem. We applied the Nelder-Mead method, Genetic Algorith, Covariance Matrix Adaptation Evolutionary Strategies, Particle Swarm Optimization and Differential Evolution. The use of meta-heuristics solved the minimization problem more efficiently and precisely, compared to brute force search, potentially allowing for a more widespread use of the PDOA method. To compare algorithms two different metrics were proposed: average distance miss and median distance miss, giving insight into the algorithms' performance. Finally, the use of an adaptive mutation step proved important.

Evolutionary Art using the Fly Algorithm

Zainab Abbood, Othman Amlal, Franck Vidal

This study is about Evolutionary art such as digital mosaics.The most common techniques to generate a digital mosaic effect heavily rely on Centroidal Voronoi diagrams. Our method generates artistic images as an optimisation problem without the introduction of any a priori knowledge or constraint other than the input image. We adapt a cooperative co-evolution strategy based on the Parisian evolution approach, the Fly algorithm, to produce artistic visual effects from an input image (e.g. a photograph). The primary usage of the Fly algorithm is in computer vision, especially stereo-vision in robotics. It has also been used in image

cont

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reconstruction for tomography. Until now the individuals correspond to simplistic primitives: Infinitely small 3-D points. In this paper, the individuals have a much more complex representation and represent tiles in a mosaic. They have their own position, size, colour, and rotation angle. We take advantage of graphics processing units (GPUs) to generate the images using the modern OpenGL Shading Language. Different types of tiles are implemented, some with transparency, to generate different visual effects, such as digital mosaic and spray paint. A user study has been conducted to evaluate some of our results. We also compare results with those obtained with GIMP, an open-source software for image manipulation.

Container Vessel Stowage Planning System using Genetic Algorithm
Miri Weiss Cohen, Vitor N. Coelho, Adi Dahan, Itzzik Kaspi
This paper deals with the container stowage planning problem, an important and a complex problem in maritime logistic optimization. The variant tackled in this work involves several constraints, inspired by real-life problems and application found in the literature. Given the complexity of the problem, which belongs to the class of NP hard problems, a novel evolutionary metaheuristic algorithm is developed and designed considering the ability and flexibility of Genetic Algorithm (GA). The approach is based on a two-phase procedure, one for master planning and the other for allocation of the containers into slots. GA parameters are analyzed to achieve practical and best results.The system offers stowage allocation solutions for both phases, thus offering flexibility for a wide variety of vessels and route combinations.

Presenting the ECO: Evolutionary Computation Ontology
Anil Yaman, Ahmed Hallawa, Matt Coler, Giovanni Iacca
A well-established notion in Evolutionary Computation (EC) is the importance of the balance between exploration and exploitation. Data structures (e.g. for solution encoding), evolutionary operators, selection and fitness evaluation facilitate this balance. Furthermore, the ability of an Evolutionary Algorithm (EA) to provide efficient solutions typically depends on the specific type of problem. In order to obtain the most efficient search, it is often needed to incorporate any available knowledge (both at algorithmic and domain level) into the EA. In this work, we develop an ontology to formally represent knowledge in EAs. Our approach makes use of knowledge in the EC literature, and can be used for suggesting efficient strategies for solving problems by means of EC. We call our ontology "Evolutionary Computation Ontology" (ECO). In this contribution, we show one possible use of it, i.e. to establish a link between algorithm settings and problem types. We also show that the ECO can be used as an alternative to the available parameter selection methods and as a supporting tool for algorithmic design.

Evolutionary Adaptation to Social Information Use without Learning
James M. Borg, Alastair Channon
Social information can provide information about the presence, state and intentions of other agents; therefore it follows that the use of social information may be of some adaptive benefit. As with all information, social information must be interpretable and relatively accurate given the situation in which it is derived. In both nature and robotics, agents learn which social information is relevant and under which circumstances it may be relied upon to provide useful information about the current environmental state. However, it is not clear to what extent social information alone is beneficial when decoupled from a within-lifetime learning process, leaving evolution to determine whether social information provides any long term adaptive benefits. In this work we assess this question of the adaptive value of social information when it is not accompanied by a within-lifetime learning process. The aim here is to begin to understand when social information, here expressed as a form of public information, is adaptive; the rationale being that any social information that is adaptive without learning will be a good base to allow the learning processes associated with social information to evolve and develop later. Here we show, using grounded neuroevolutionary artificial life simulations incorporating simulated agents, that social information can in certain circumstances provide an adaptive advantage to agents, and that social information that more accurately indicates success confers more reliable information to agents leading to improved success over less reliable sources of social information.

EvoAPPS session 6 : Applications of Evolutionary Computation

Wednesday 19 April 1625-1815

Room 3

chair : Neil Urquhart

Evolution and Morphogenesis of Simulated Modular Robots: A Comparison Between a Direct and Generative Encoding

Frank Veenstra, Andres Faina, Sebastian Risi, Kasper Stoy

Modular robots offer an important benefit in evolutionary robotics, which is to quickly evaluate evolved morphologies and control systems in reality. However, artificial evolution of simulated modular robotics is a difficult and time consuming task requiring significant computational power. While artificial evolution in virtual creatures has made use of powerful generative encodings, here we investigate how a generative encoding and direct encoding compare for the evolution of locomotion in modular robots when the number of robotic modules changes. Simulating less modules would decrease the size of the genome of a direct encoding while the size of the genome of the implemented generative encoding stays the same. We found that the generative encoding is significantly more efficient in creating robot phenotypes in the initial stages of evolution when simulating a maximum of 5, 10, and 20 modules. This not only confirms that generative encodings lead to decent performance more quickly, but also that when simulating just a few modules a generative encoding is more powerful than a direct encoding for creating robotic structures. Over longer evolutionary time, the difference between the encodings no longer becomes statistically significant. This leads us to speculate that a combined approach -- starting with a generative encoding and later implementing a direct encoding -- can lead to more efficient evolved designs.

Overcoming Initial Convergence in Multi-Objective Evolution of Robot Control and Morphology Using a Two-Phase Approach

Tønnes F. Nygaard, Eivind Samuelsen, Kyrre Glette

Co-evolution of robot morphologies and control systems is a new and interesting approach for robotic design. However, the increased size and ruggedness of the search space becomes a challenge, often leading to early convergence with sub-optimal morphology-controller combinations. Further, mutations in the robot morphologies tend to cause large perturbations in the search, effectively changing the environment, from the controller's perspective. In this paper, we present a two-stage approach to tackle the early convergence in morphology-controller co-evolution. In the first phase, we allow free evolution of morphologies and controllers simultaneously, while in the second phase we re-evolve the controllers while locking the morphology. The feasibility of the approach is demonstrated in physics simulations, and later verified on three different real-world instances of the robot morphologies. The results demonstrate that by introducing the two-phase approach, the search produces solutions which outperform the single co-evolutionary run by over 10%.

Interactive Evolution of Complex Behaviours through Skill Encapsulation

Pablo González de Prado Salas, Sebastian Risi

Human-based computation (HBC) is an emerging research area in which humans and machines collaborate to solve tasks that neither one can solve in isolation. In evolutionary computation, HBC is often realized through interactive evolutionary computation (IEC), in which a user guides evolution by iteratively selecting the parents for the next generation. IEC has shown promise in a variety of different domains, but evolving more complex or hierarchically composed behaviours remains challenging with the traditional IEC approach. To overcome this challenge, this paper combines the recently introduced ESP algorithm with IEC to allow users to intuitively break complex challenges into smaller pieces and preserve, reuse and combine interactively evolved sub-skills. The combination of ESP principles with IEC provides a new way in which human insights can be leveraged in evolutionary computation and, as the results in this paper show, IEC-ESP is able to solve complex control problems that are challenging for a traditional fitness-based approach.

Automated Design of Genetic Programming Classification Algorithms using a Genetic Algorithm

Thambo Nyathi, Nelishia Pillay

There is a large scale initiative by the machine learning community to automate the design of machine learning techniques to remove reliance on the human expert, providing out of the box software that can be used by novices. In this study the automated design of genetic programming classification algorithms is proposed. A number of design decisions have to be considered by algorithm designers during the design process and this is usually a time consuming task. Our automated design approach uses a genetic algorithm to automatically configure a genetic programming classification algorithm. The genetic algorithm determines parameter values and sets the flow control for the classification algorithm. The proposed system is tested on real world problems and the results indicate that induced classifiers perform better than manually designed classifiers.

Notes

EvoAPPS session 7 : Bio-inspired Algorithms & Complex Systems

Thursday 20 April 0930-1110

Room 3

chair : Carlos Cotta

The Two Regimes of Neutral Evolution: Localization on Hubs and Delocalized Diffusion

David Shorten, Geoff Nitschke

It has been argued that much of evolution takes place in the absence of fitness gradients. Such periods of evolution can be analysed by examining the mutational network formed by sequences of equal fitness, that is the neutral network. It has been demonstrated that, in large populations under a high mutation rate, the population distribution over the neutral network and average mutational robustness are given by the principle eigenvector and eigenvalue, respectively, of the network‚Äôs adjacency matrix. However, little progress has been made towards understanding the manner in which the topology of the neutral network influences the resulting population distribution and robustness. In this work, we build on recent results from spectral graph theory and utilize numerical methods to demonstrate that there exist two regimes of behaviour: convergence on hubs and diffusion over the network. We also derive approximations for the population‚Äôs behaviour under these regimes. This challenges the widespread assumption that neutral evolution always leads to exploration of the neutral network and elucidates the conditions which result in the evolution of robust organisms.

Two-phase strategy managing insensitivity in global optimization

Jakub Sawicki, Maciej Smo\l{}ka, Marcin \L{}o\'s, Robert Schaefer, Piotr Faliszewski

Solving ill-posed continuous, global optimization problems remains challenging. For example, there are no well-established methods for handling objective insensitivity in the neighborhood of solutions, which appears in many important applications, e.g., in non-invasive tumor tissue diagnosis or geophysical exploration. The paper presents a~complex metaheuristic that identifies regions of objective function's insensitivity (plateaus). The strategy is composed of a~multi-deme hierarchic memetic strategy coupled with random sample clustering, cluster integration, and special kind of multiwinner selection that allows to breed the demes and cover each plateau separately. We test the method on benchmarks with multiple non-convex plateaus and evaluate how well the plateaus are covered.

Local Misfit Approximation in Memetic Solving of Ill-posed Inverse Problems

Marcin Łoś, Robert Schaefer, Jakub Sawicki, Maciej Smołka

The approximation of the objective function is a well known method of speeding up optimization process, especially if the objective evaluation is costly. This is the case of inverse parametric problems formulated as global optimization ones, in which we recover partial differential equation parameters by minimizing the misfit between its measured and simulated solutions. Typically, the approximation used to build the surrogate objective is rough but globally applicable in the whole admissible domain. The authors try to carry out a different task of detailed misfit approximation in the regions of low sensitivity (plateaus). The proposed complex method consists of independent C0 Lagrange approximation of the misfit and its gradient, based on the nodes obtained during the dedicated memetic process, and the subsequent projection of the obtained components (single or both) on the space of B-splines. The resulting approximation is globally C1, which allows us to use fast gradient-based local optimization methods. Another goal attained in this way is the estimation of the shape of plateau as an appropriate level set of the approximated objective. The proposed strategy can be applied for solving ill-conditioned real world inverse problems, e.g., appearing in the oil deposit investigation. We show the results of preliminary tests of the method on two benchmarks featuring convex and non-convex U-shaped plateaus.

Avenues for the Use of Multi–State Cellular Automata

Laura Diosan, Anca Andreica, Irina Voiculescu, Imre Boros

The majority of Cellular Automata (CA) described in the literature are binary or three--state. While several abstractions are possible to generalise to more than three states, only a negligible number of multi--state CA rules exist with concrete practical applications. This paper proposes a generic rule for multi--state CA. The rule allows for any number of states, and allows for the states are semantically related. The rule is illustrated on the concrete example of image segmentation, where the CA agents are pixels in an image, and their states are the pixels' greyscale values. We investigate in detail the proposed rule and some of its variations, and we also compare its effectiveness against its closest relative, the existing GH automaton. We apply the proposed methods to both synthetic and real--world images, evaluating the results with a variety of measures. The experimental results demonstrate that our proposed method can segment images accurately and effectively.

EvoAPPS session 8 : Software Testing & Real World Applications

Thursday 20 April 1130-1310

Room 3

chair : Anna I Esparcia-Alcázar

Polytypic Genetic Programming

Jerry Swan, Krzysztof Krawiec, Neil Ghani

The application of search-based techniques (e.g. Genetic Programming (GP) or Genetic Improvement (GI)) to programs often requires a great deal of `boilerplate' code to adapt the application APIs to the search mechanism. In addition, the majority of existing approaches are not type-safe: i.e. they can fail at runtime because the search mechanisms lack strict type information often available to the compiler. This is clearly an obstacle to widespread acceptance for dynamically optimized programs --- one of the stated aims of contemporary research in Search-Based Software Engineering (SBSE). In this article, we describe Polytope, a Scala framework that uses polytypic programming, a relatively recent advance in program abstraction. Polytope requires a minimum of boilerplate code and supports a form of strong-typing in which type rules are automatically enforced by the compiler, even for search operations such as mutation which are applied at runtime. By operating directly on language-native expressions, it provides an embeddable optimization procedure for existing code. It can therefore be seen as occupying an intermediate position between GP and (online) GI, with the potential to ease the path to adoption of Genetic Improvement. We give a tutorial example of our specific polytypic approach and compare both runtime efficiency and required lines of code against the well-known EpochX GP framework, showing comparable performance in the former and the complete elimination of boilerplate for the latter.

Evolving rules for action selection in automated testing via genetic programming - a first approach

Anna I Esparcia-Alcázar, Francisco Almenar, Urko Rueda, Tanja E.J. Vos

Tools that perform automated software testing via the user interface rely on an action selection mechanism that at each step of the testing process decides what to do next. This mechanism is often based on random choice, a practice commonly referred to as monkey testing. In this work we evaluate a first approach to genetic programming (GP) for action selection that involves evolving IF-THEN-ELSE rules; we carry out experiments and compare the results with those obtained by random selection and also by Q-learning, a reinforcement learning technique. Three applications are used as Software Under Test (SUT) in the experiments, two of which are proprietary desktop applications and the other one an open source web-based application.

Focusing Learning-based Testing away from Known Weaknesses

Christian Fleischer, Jörg Denzinger

We present an extension to learning-based testing of systems for adversary-induced weaknesses that addresses the problem of repeated generation of known weaknesses. Our approach adds to the normally used fitness measure a component that computes the similarity of a test to known tests that revealed a weakness and uses this similarity to penalize new tests. We instantiated this idea to the testing of ad-hoc wireless networks using the IACL approach, more precisely to applications in precision agriculture, and our experiments show that our modification results in finding substantially different tests from the test(s) that we want to avoid.

EvoAPPS session 8 : Software Testing & Real World Applications

Thursday 20 April 1130-1310

Room 3

chair : Anna I Esparcia-Alcázar

Adaptive Batteries Exploiting On-line Steady-State Evolution Strategy

Edoardo Fadda, Guido Perboli, Giovanni Squillero

In energy distribution systems, uncertainty is the major single cause of power outages. In this paper, we consider the usage of electric batteries in order to mitigate it. We describe an intelligent battery able to maximize its own lifetime while guaranteeing to satisfy all the electric demand peaks. The battery exploits a customized steady-state evolution strategy to dynamically adapt its recharge strategy to changing environments. Experimental results on both synthetic and real data demonstrate the efficacy of the proposed solution.

Brain Programming and the Random Search in Object Categorization

Gustavo Olague, Eddie Clemente, Daniel E. Hernandez, Aaron Barrera

Computational neuroscience lays the foundations of intelligent behavior through the application of machine learning approaches. Brain programming, which derives from such approaches, is emerging as a new evolutionary computing paradigm for solving computer vision and pattern recognition problems. Primate brains have several distinctive features that are obtained by a complex arrangement of highly interconnected and numerous cortical visual areas. This paper describes a virtual system that mimics the complex structure of primate brains composed of an artificial dorsal pathway -- or ``where" stream -- and an artificial ventral pathway -- or ``what" stream -- that are fused to recreate an artificial visual cortex. The goal is to show that brain programming is able to discover numerous heterogeneous functions that are applied within a hierarchical structure of our virtual brain. Thus, the proposal applies two key ideas: first, object recognition can be achieved by a hierarchical structure in combination with the concept of function composition; second, the functions can be discovered through multiple random runs of the search process. This last point is important since is the first step in any evolutionary algorithm; in this way, enhancing the possibilities for solving hard optimization problems.

EvoAPPS session 9 : Evolutionary Feature Selection

Thursday 20 April 1415-1555

Room 3

chair : Mengjie Zhang

Using Particle Swarm Optimisation and the Silhouette Metric to Estimate the Number of Clusters, Select Features, and Perform Clustering

Andrew Lensen, Bing Xue, Mengjie Zhang

One of the most difficult problems in clustering, the task of grouping similar instances in a dataset, is automatically determining the number of clusters that should be created. When a dataset has a large number of attributes (features), this task becomes even more difficult due to the relationship between the number of features and the number of clusters produced. One method of addressing this is feature selection, the process of selecting a subset of features to be used. Evolutionary computation techniques have been used very effectively for solving clustering problems, but have seen little use for simultaneously performing the three tasks of clustering, feature selection, and determining the number of clusters. Furthermore, only a small number of existing methods exist, but they have a number of limitations that affect their performance and scalability. In this work, we introduce a number of novel techniques for improving the performance of these three tasks using particle swarm optimisation and statistical techniques. We conduct a series of experiments across a range of datasets with clustering problems of varying difficulty. The results show our proposed methods achieve significantly better clustering performance than existing methods, while only using a small number of features and automatically determining the number of clusters more accurately.

Bagging and Feature Selection for Classification with Incomplete Data

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

Missing values are an unavoidable issue of many real-world datasets. Dealing with missing values is an essential requirement in classification problem, because inadequate treatment with missing values often leads to large classification errors. Some classifiers can directly work with incomplete data, but they often result in big classification errors and generate complex models. Feature selection and bagging have been successfully used to improve classification, but they are mainly applied to complete data. This paper proposes a combination of bagging and feature selection to improve classification with incomplete data. To achieve this purpose, a wrapper-based feature selection which can directly work with incomplete data is used to select suitable feature subsets for bagging. The experiments on eight incomplete datasets were designed to compare the proposed method with three other popular methods that are able to deal with incomplete data using C4.5/REPTree as classifiers and using Particle Swam Optimisation as a search technique in feature selection. Results show that the combination of bagging and feature selection can not only achieve better classification accuracy than the other methods but also generate less complex models compared to the bagging method.

Surrogate-model based Particle Swarm Optimisation with Local Search for Feature Selection in Classification

Bach Nguyen, Bing Xue, Peter Andreae

Evolutionary computation (EC) techniques have been applied widely to many problems because of their powerful search ability. However, EC based algorithms are usually computationally intensive, especially with an expensive fitness function. In order to solve this issue, many surrogate models have been proposed to reduce the computation time by approxi- mating the fitness function, but they are hardly applied to EC based fea- ture selection. This paper develops a surrogate model for particle swarm optimisation based wrapper feature selection by selecting a small number of instances to create a surrogate training set. Furthermore, based on the surrogate model, we propose a sampling local search, which improves the current best solution by utilising information from the previous evolution- ary iterations. Experiments on 10 datasets show that the surrogate training set can reduce the computation time without affecting the classification performance. Meanwhile the sampling local search results in a significantly smaller number of features, especially on large datasets. The combination of the two proposed ideas successfully reduces the number of features and achieves better performance than using all features, a recent sequential fea- ture selection algorithm, original PSO, and PSO with one of them only on most datasets.

Feature Selection in High Dimensional Data by a Filter-Based Genetic Algorithm

Claudio De Stefano, Franecsco Fontanella, Alessandra Scotto di Freca

In classification and clustering problems, feature selection techniques can be used to reduce the dimensionality of the data and increase the performances. However, feature selection is a challenging task, especially when hundred or thousands of features are involved. In this framework, we present a new approach for improving the performance of a filter-based genetic algorithm. The proposed approach consists of two steps: first, the available features are ranked according to a univariate evaluation function; then the search space represented by the first M features in the ranking is searched using a filter-based genetic algorithm for finding feature subsets with a high discriminative power.Experimental results demonstrated the effectiveness of our approach in dealing with high dimensional data, both in terms of recognition rate and feature number reduction.

EvoAPPS session 10 : Machine Learning Apps for Real World Problems

Thursday 20 April 1615-1745

Room 3

chair : Michael Kampouridis

Pricing Rainfall Based Futures Using Genetic Programming

Sam Cramer, Michael Kampouridis, Alex Freitas, Antonis Alexandridis

Rainfall derivatives are in their infancy since starting trading on the Chicago Mercentile Exchange (CME) since 2011. Being a relatively new class of financial instruments there is no generally recognised pricing framework used within the literature. In this paper, we propose a novel framework for pricing contracts using Genetic Programming (GP). Our novel framework requires generating a risk-neutral density of our rainfall predictions generated by GP supported by Markov chain Monte Carlo and Esscher transform. Moreover, instead of having a single rainfall model for all contracts, we propose having a separate rainfall model for each contract. We compare our novel framework with and without our proposed contract-specific models for pricing against the pricing performance of the two most commonly used methods, namely Markov chain extended with rainfall prediction (MCRP), and burn analysis (BA) across contracts available on the CME. Our goal is twofold, (i) to show that by improving the predictive accuracy of the rainfall process, the accuracy of pricing also increases. (ii) contract-specific models can further improve the pricing accuracy. Results show that both of the above goals are met, as GP is capable of pricing rainfall futures contracts closer to the CME than MCRP and BA. This shows that our novel framework for using GP is successful, which is a significant step forward in pricing rainfall derivatives.

Minimization of Systemic Risk for Directed Network Using Genetic Algorithm

Wenshuo Guo, Kwok Yip Szeto

In directed networks, flow dynamics may lead to cascade failures due to node and link removal. The systemic risk in financial systems follows similar mechanism, where banks are connected by interbank linkages with money transfers. A mathematical model of the banking network is used to investigate the relationships between the cascade dynamics and key parameters determining the banking network structure, including the connectivity, the bank‚Äôs capitalization, and the size of interbank exposure, based on analytical calculation and numerical simulation. To optimize the network topology for the minimization of systemic risk, genetic algorithm is applied to evolve the network. It is observed that the systemic risk of financial system could be decreased by increasing the degree variance of the associated network. This could be useful for financial risk management, with possible applications to other physical systems such as ecological web, where the network stability is also an important issue.

Dynamic Portfolio Optimization in Ultra-High Frequency Environment

Patryk Filipiak, Piotr Lipinski

This paper concerns the problem of portfolio optimization in the context of ultra-high frequency environment with dynamic and frequent changes in statistics of financial assets. It aims at providing Pareto fronts of optimal portfolios and updating them when estimated return rates or risks of financial assets change. The problem is defined in terms of dynamic optimization and solved online with a proposed evolutionary algorithm. Experiments concern ultra-high frequency time series coming from the London Stock Exchange Rebuilt Order Book database and the FTSE100 index.

Continual and One-Shot Learning through Neural Networks with Dynamic External Memory

Benno Lüders, Mikkel Schläger, Aleksandra Korach, Sebastian Risi

Training neural networks to quickly learn new skills without forgetting previously learned skills is an important open challenge in machine learning. A common problem for adaptive networks that can learn during their lifetime is that the weights encoding a particular task are often overridden when a new task is learned. This paper takes a step in overcoming this limitation by building on the recently proposed Evolving Neural Turing Machine (ENTM) approach. In the ENTM, neural networks are augmented with an external memory component that they can write to and read from, which allows them to store associations quickly and over long periods of time. The results in this paper demonstrate that the ENTM is able to perform one-shot learning in reinforcement learning tasks without catastrophic forgetting of previously stored associations. Additionally, we introduce a new ENTM default jump mechanism that makes it easier to find unused memory location and therefor facilitates the evolution of continual learning networks. Our results suggest that augmenting evolving networks with an external memory component is not only a viable mechanism for adaptive behaviors in neuroevolution but also allows these networks to perform continual and one-shot learning at the same time.

EvoAPPS session 11 : Comms Networks & other Parallel & Distributed Systems

Friday 21 April 0945-1115

Room 2

chair : Fabio D'Andreagiovanni

Configuring Dynamic Heterogeneous Wireless Communications Networks using a Customised Genetic Algorithm

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

Wireless traffic is surging due to the prevalence of smart devices, rising demand for multimedia content and the advent of the "Internet of Things". Network operators are deploying Small Cells alongside existing Macro Cells in order to satisfy demand during this era of exponential growth. Such Heterogeneous Networks (HetNets) are highly spectrally efficient because both cell tiers transmit using the same scarce and expensive bandwidth. However, load balancing and cross-tier interference issues constrain cell-edge rates in co-channel operation. Capacity can be increased by intelligently configuring Small Cell powers and biases, and the muting cycles of Macro Cells. This paper presents a customised Genetic Algorithm (GA) for reconfiguring HetNets. The GA converges within minutes so tailored settings can be pushed to cells in real time. The proposed GA lifts cell-edge (2.5'th percentile) rates by 32% over a non-adaptive baseline that is used in practice. HetNets are highly dynamic environments. However, customers tend to cluster in hotspots which arise at predictable locations over the course of a typical day. An explicit memory of previously evolved solutions is maintained and used to seed fresh runs. System level simulations show that the 2.5'th percentile rates are boosted to 36% over baseline when prior knowledge is utilised.

Multi-Objective Evolutionary Algorithms for Influence Maximization in Social Networks

Doina Bucur, Giovanni Iacca, Andrea Marcelli, Giovanni Squillero, Alberto Tonda

As the pervasiveness of social networks increases, new NP-hard related problems become interesting for the optimization community. The objective of \emph{influence maximization} is to contact the largest possible number of nodes in a network, starting from a small set of seed nodes, and assuming a model for information propagation. This problem is of utmost practical importance for applications ranging from social studies to marketing. The influence maximization problem is typically formulated assuming that the number of the seed nodes is a parameter. Differently, in this paper, we choose to formulate it in a multi-objective fashion, considering the minimization of the number of seed nodes among the goals, and we tackle it with an evolutionary approach. As a result, we are able to identify sets of seed nodes of different size that spread influence the best, providing factual data to trade-off costs with quality of the result. The methodology is tested on two real-world case studies, using two different influence propagation models, and compared against state-of-the-art heuristic algorithms. The results show that the proposed approach is almost always able to outperform the heuristics.

A fast ILP-based Heuristic for the robust design of Body Wireless Sensor Networks

Fabio D'Andreagiovanni, Antonella Nardin, Enrico Natalizio

We consider the problem of optimally designing a body wireless sensor network, while taking into account the uncertainty of data generation of biosensors. Since the related min-max robustness Integer Linear Programming (ILP) problem can be difficult to solve even for state-of-the-art commercial optimization solvers, we propose an original heuristic for its solution. The heuristic combines deterministic and probabilistic variable fixing strategies, guided by the information coming from strengthened linear relaxations of the ILP robust model, and includes a very large neighborhood search for reparation and improvement of generated solutions, formulated as an ILP problem solved exactly. Computational tests on realistic instances show that our heuristic finds solutions of much higher quality than a state-of-the-art solver and than an effective benchmark heuristic.

Hybrid Multi-Ensemble Scheduling

Joerg Bremer, Sebastian Lehnhoff

A steadily increasing pervasion of the electrical distribution grid with rather small renewable energy resources imposes fluctuating and hardly predictable feed-in, a partly reverse load flow and demands new predictive load planning strategies. For predictive scheduling with high penetration of renewable energy resources, agent-based approaches using classifier-based decoders for modeling individual flexibilities have shown good performance. On the other hand, such decoder-based methods are currently designed for single entities and not able to cope with ensembles of energy resources. Combining training sets sampled from individually modeled energy units, results in folded distributions with unfavorable properties for training a decoder. Nevertheless, this happens to be a quite frequent use case, e.g. when a hotel, a small business, a school or similar with an ensemble of co-generation, heat pump, solar power, and controllable consumers wants to take part in decentralized predictive scheduling. In this paper, we propose an extension to an established agent approach for scheduling individual single energy units by extending the agents' decision routine with a covariance matrix adaption evolution strategy that is hybridized with decoders. In this way, locally managed ensembles of energy units can be included. We show the applicability of our approach by conducting several simulation studies.

EvoAPPS session 12 : Knowledge Incorporation in Evolutionary Computation

Friday 21 April 0945-1115

Room 3

chair : Giovanni Iacca

A New Evolutionary Algorithm for Synchronization

Jakub Kowalski, Adam Roman

A synchronizing word brings all states of a finite automaton to the one particular state. From practical reasons the synchronizing words should be as short as possible. Unfortunately, the decision version of the problem is NP-complete. In this paper we present a new evolutionary approach for finding possibly short synchronizing words for a given automaton. As the optimization problem has two contradicting goals (the word's length and the word's rank) we use a 2 population feasible-infeasible approach. It is based on the knowledge on words' ranks of all prefixes of a given word. This knowledge makes the genetic operators more efficient than in case of the standard letter-based operators.

A Framework for Knowledge Integrated Evolutionary Algorithms

Ahmed Hallawa, Anil Yaman, Giovanni Iacca, Gerd Ascheid

One of the main reasons for the success of Evolutionary Algorithms (EAs) is their general-purposeness, i.e. the fact that they can be applied in a straight forward manner to a broad range of optimization problems, without any specific prior knowledge. On the other hand, it has been shown that incorporating a priori knowledge, such as expert knowledge or empirical findings, can significantly improve the performance of an EA. However, integrating knowledge in EAs poses numerous challenges. It is often the case that the features of the search space are unknown, hence any knowledge associated with the search space properties can be hardly used. In addition, a priori knowledge is typically problem-specific and hard to generalize. In this paper, we propose a framework, called Knowledge Integrated Evolutionary Algorithm (KIEA), which facilitates the integration of existing knowledge into EAs. Notably, the KIEA framework is EA-agnostic, i.e. it works with any evolutionary algorithm, problem-independent, i.e. it is not dedicated to a specific type of problems and expandable, i.e. its knowledge base can grow over time. Furthermore, the framework integrates knowledge while the EA is running, thus optimizing the consumption of computational power. In the preliminary experiments shown here, we observe that the KIEA framework produces in the worst case an 80\% improvement on the converge time, w.r.t. the corresponding ``knowledge-free'' EA counterpart.

Large Scale Problems in Practice: The effect of dimensionality on the interaction among variables

Fabio Caraffini, Ferrante Neri, Giovanni Iacca

This article performs a study on correlation between pairs of variables in dependence on the problem dimensionality. Two tests, based on Pearson and Spearman coefficients, have been designed and used in this work. In total, 86 test problems ranging between 10 and 1000 variables have been studied. If the most commonly used experimental conditions are used, the correlation between pairs of variables appears, from the perspective of the search algorithm, to consistently decrease. This effect is not due to the fact that the dimensionality modifies the nature of the problem but is a consequence of the experimental conditions: the computational feasibility of the experiments imposes an extremely shallow search in case of high dimensions. An exponential increase of budget and population with the dimensionality is still practically impossible. Nonetheless, since real-world application may require that large scale problems are tackled despite of the limited budget, an algorithm can quickly improve upon initial guesses if it integrates the knowledge that an apparent weak correlation between pairs of variables occurs, regardless the nature of the problem.

DICE: A New Family of Bivariate Estimation of Distribution Algorithms based on Dichotomised Multivariate Gaussian Distributions

Fergal Lane, R. Muhammad Atif Azad, Conor Ryan

A new family of \emph{Estimation of Distribution Algorithms} (EDAs) for discrete search spaces is presented. The proposed algorithms, which we label DICE (\emph{D}iscrete \emph{C}orrelated \emph{E}stimation of distribution algorithms) are based, like previous bivariate EDAs such as MIMIC and BMDA, on bivariate marginal distribution models. However, bivariate models previously used in similar discrete EDAs were only able to exploit an $O(d)$ subset of all the $O(d^{2})$ bivariate variable dependencies between d variables. We introduce, and utilize in DICE, a model based on \emph{dichotomised multivariate Gaussian distributions}. These models are able to capture and make use of all $O(d^{2})$ bivariate variable interactions in binary and multary search spaces. This paper tests the performances of these new EDA models and algorithms on a suite of challenging combinatorial optimization problems, and compares their performances to previously used discrete-space bivariate EDA models. EDAs utitilzing these new \emph{dichotomised Gaussian} (DG) models exhibit significantly superior optimization performances, with the performance gap becoming more marked with increasing dimensionality.

EvoStar Participants

Zainab	Abbood	Bangor University	UK
Margareta	Ackerman	San Jose State University	USA
Anca	Andreica	Babes-Bolyai University	Romania
Dilek	Arikan	Istanbul Technical University	Turkey
Gerd	Ascheid	RWTH Aachen University	Germany
Hamna	Aslam	Innopolis University	Russian Federation
Raja M Atif	Azad	Birmingham City University	UK
Jaume	Bacardit	Newcastle University	UK
Wolfgang	Banzhaf	Michigan State University	USA
Aarón	Barrera Román	CICESE	México
Anton	Bassin	ITMO University	Russia
Jochem	Berndsen	Sioux Embedded Eindhoven	The Netherlands
Benjamin	Biesinger	AIT Austrian Institute of Technology	Austria
Iwo	Błądek	Poznan University of Technology	Poland
Christian	Blum	Artificial Intelligence Research Inst	Spain
James M.	Borg	Keele University	UK
Dimitrios	Bountouridis	Utrecht University	Netherlands
Ivan	Bravi	Politecnico di Milano	Italy
Aidan	Breen	National Univ of Ireland, Galway	Ireland
Jörg	Bremer	University of Oldenburg	Germany
Qi	Bu	Hong Kong Univ of Science & Tech	China
Doina	Bucur	University of Twente	Netherlands
Aleksander	Byrski	AGH University of Science & Tech	Poland
Stefano	Cagnoni	University of Parma	Italy
Fabio	Caraffini	De Montfort University	UK
Mauro	Castelli	NOVA IMS, Univ Nova de Lisboa	Portugal
Francisco	Chicano	University of Malaga	Spain
Vic	Ciesielski	RMIT University	Australia
Brian	Cole	University of Pennsylvania	USA
Florian	Colombo	EPFL SV IC LCN	Switzerland
João	Correia	CISUC-DEI	Portugal
Ernesto	Costa	University of Coimbra	Portugal
Carlos	Cotta	Universidad de Malaga	Spain
Sam	Cramer	University of Kent	UK
Fabio	D'Andreagiovanni	CNRS, Sorbonne University	France
Fabio	Daolio	University of Stirling	UK
White	David R	University College London	UK
Kenneth	De Jong	George Mason University	USA
Ignacio	Decia	Universidad de la República	Uruguay
Bilel	Derbel	INRIA	France
Federico	Divina	Pablo de Olavide University	Spain
John	Drake	Queen Mary University of London	UK
Malachy	Eaton	University of Limerick	Ireland
Marc	Ebner	Ernst Moritz Arndt Universität Greifswald	Germany
Gusz	Eiben	VU University Amsterdam	Netherlands
Aniko	Ekart	Aston University	UK

EvoStar Participants

Sondre	Engebraaten	FFI	Norway
Juan José	Escobar	University of Granada	Spain
Anna	Esparcia-Alcázar	Universidad Politecnica de Valencia	Spain
Edoardo	Fadda	Politecnico di Torino	Italy
Andres	Faiña	IT University of Copenhagen	Denmark
Francisco	Fernández de Vega	University of Extremadura	Spain
Christian	Fleischer	University of Calgary	Canada
Francesco	Fontanella	Univ di Cassino e del Lazio meridionale	Italy
Stefan	Forstenlechner	University College Dublin	Ireland
James	Foster	University of Idaho	USA
Alex	G. C. de Sá	Univ Federal de Minas Gerais (UFMG)	Brazil
Raluca	Gaina	University of Essex	UK
Jose	Garcia Valdez	Tecnológico Nacional de México	México
Kyrre	Glette	University of Oslo	Norway
Pablo	González de Prado	IT University of Copenhagen	Denmark
Erik	Goodman	BEACON Center, Michigan State Univ	USA
Thomas D.	Griffiths	Aston University	UK
Fabio	Guigou	Université de Strasbourg	France
Wenshuo	Guo	Hong Kong Univ of Science & Tech	China
Evert	Haasdijk	Vrije Universiteit Amsterdam	Netherlands
Ahmed	Hallawa	RWTH Aachen	Germany
Hayfa	Hammami	Université Libre de Bruxelles	Belgium
Saemundur O.	Haraldsson	University of Stirling	UK
Emma	Hart	Edinburgh Napier University	UK
Jacqueline	Heinerman	VU University Amsterdam	Netherlands
Ignacio	Hidalgo	Universidad Complutense de Madrid	Spain
Bin	Hu	AIT Austrian Institute of Technology	Austria
Patrick	Hutchings	Monash University	Australia
Giovanni	Iacca	Phoenix Project	Netherlands
Dario	Izzo	European Space Agency	Netherlands
Mohammad Ali	Javaheri Javid	Goldsmiths, University of London	UK
Baozhu	Jia	Ernst-Moritz-Arndt Universität Greifswald	Germany
Leonid	Joffe	University College London	UK
Daniel D.	Johnson	Harvey Mudd College	USA
Colin	Johnson	University of Kent	UK
Julia	Jordan	Hochschule Karlsruhe	Germany
Roman	Kalkreuth	TU Dortmund University	Germany
Michael	Kampouridis	University of Kent	UK
Paul	Kaufmann	Paderborn University	Germany
Stephen	Kelly	Dalhousie University	Canada
Christian	Kloimüllner	TU Wien	Austria
Daniel	Kneipp de Sá Vieira	UFMG	Brazil
Arthur	Kordon	Kordon Consulting LLC	USA
Jakub	Kowalski	University of Wrocław	Poland
Oliver	Kramer	University of Oldenburg	Germany
Krzysztof	Krawiec	Poznan University of Technology	Poland

EvoStar Participants

William	La Cava	University of Pennsylvania	USA
Maarten	Lamers	Leiden University	Netherlands
Fergal	Lane	University of Limerick	Ireland
William	Langdon	University College London	UK
Paul	Lapok	Edinburgh Napier University	UK
Pierrick	Legrand	IMB/Universite de Bordeaux	France
Antonios	Liapis	University of Malta	Malta
Piotr	Lipinski	University of Wroclaw	Poland
Uriel	Lopez	Instituto Tecnológico de Tijuana	México
Manuel	López-Ibáñez	University of Manchester	UK
Róisín	Loughran	University College Dublin	Ireland
Nuno	Lourenço	University of Coimbra	Portugal
David	Lynch	University College Dublin	Ireland
Penousal	Machado	University of Coimbra	Portugal
Broos	Maenhout	Ghent University	Belgium
Stephen	Majercik	Bowdoin College	USA
Eneko	Malatsetxebarria	ArcelorMittal	Spain
Marcus	Märtens	Delft University of Technology	Netherlands
Michalis	Mavrovouniotis	Nottingham Trent University	UK
Jon	McCormack	Monash University	Australia
James	McDermott	University College Dublin	Ireland
Nicola	McDonnell	National University of Ireland, Galway	Ireland
Eric	Medvet	DIA, University of Trieste	Italy
Juan-Julián	Merelo	Universidad de Granada	Spain
Alessio	Mereta	European Space Agency	Netherlands
Krzysztof	Michalak	Wroclaw University of Economics	Poland
Milos	Minarik	Brno University of Technology	Czech Republic
Mohamed Wiem	Mkaouer	Rochester Institute of Technology	USA
Mihail	Morosan	University of Essex	UK
Masaharu	Munetomo	Hokkaido University	Japan
Jakub	Nalepa	Silesian University of Technology	Poland
Frank	Neumann	University of Adelaide	Australia
Aneta	Neumann	University of Adelaide	Australia
Michelle	Neumann	Student Intern	Australia
Trung Thanh	Nguyen	Livepool John Moores University	UK
Ronan	Nugent	Springer-Verlag	Germany
Tønnes	Nygaard	University of Oslo	Norway
Gabriela	Ochoa	University of Stirling	UK
Fabian	Ostermann	TU Dortmund	Germany
Ben	Paechter	Edinburgh Napier University	UK
Tomasz	Pawlak	Poznan University of Technology	Poland
Diego	Perez-Liebana	University of Essex	UK
Chiara	Picardi	University of York	UK
Elizabeth	Piette	University of Pennsylvania	USA
Nelishia	Pillay	University of KwaZulu-Natal	South Africa
Elias	Reichensdoerfer	BMW Group & Technical Univ Munich	Germany

EvoStar Participants

Sebastian	Risi	IT University of Copenhagen	Denmark
Barrie	Robison	University of Idaho	USA
Michael	Saint-Guillain	UCLouvain	Belgium
Jakub	Sawicki	AGH Univ of Science & Technology	Poland
Robert	Schaefer	AGH Univ of Science & Technology	Poland
Martin	Schlueter	Hokkaido University	Japan
Marc	Schoenauer	INRIA	France
Lukas	Sekanina	Brno University of Technology	Czech Republic
David	Shorten	University of Cape Town	South Africa
Sara	Silva	Universidade de Lisboa	Portugal
Kevin	Sim	Edinburgh Napier University	UK
Luís F.	Simões	Vrije Universiteit Amsterdam	Netherlands
Benjamin	Smith	Indiana University-Purdue University	USA
Andy	Song	RMIT University	Australia
Terence	Soule	University of Idaho	USA
Giovanni	Squillero	Politecnico di Torino - DAUIN	Italy
Ranjan	Srivastava	University of Connecticut	USA
Rolf	Steinbuch	Reutlingen University	Germany
Gizem	Sungu	Marmara University	Turkey
Jerry	Swan	University of York	UK
Gelareh	Taghizadeh	Vienna University of Technology	Austria
Marco	Tomassini	University of Lausanne	Switzerland
Alberto	Tonda	INRA	France
Christian	Ullerich	DB AG - DB Analytics (DS.V)	Germany
Neil	Urquhart	Edinburgh Napier University	UK
Peter	van der Putten	Leiden University	The Netherlands
Mario	Vanhoucke	Universiteit Gent	Belgium
Leonardo	Vanneschi	NOVA IMS, Universidade Nova de Lisboa	Portugal
Igor	Vatolkin	TU Dortmund	Germany
Frank	Veenstra	IT University of Copenhagen	Denmark
Nadarajen	Veerapen	University of Stirling	UK
Sam	Verkoelen	Leiden University	Netherlands
Luiz Otavio	Vilas Boas Oliveira	Universidade Federal de Minas Gerais	Brazil
miri	weiss cohen	braude college of engineering	israel
Darrell	Whitley	Colorado State University	USA
Jennifer	Willies	EvoStar Coordinator	UK
Rachel	Willis	Queens University Belfast	UK
Bing	Xue	Victoria University of Wellington	New Zealand
Anil	Yaman	Eindhoven University of Technology	Netherlands
Muhanad	Younis	De Montfort University	UK
Lauren	Yu	Williams College	USA
Rocco	Zaccagnino	University of Salerno	Italy
Mengjie	Zhang	Victoria University of Wellington	New Zealand

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