CONFERENCE HANDBOOK

EvoStar conferences held in Parma, Italy
4-6 April 2018

SPECIES

Acknowledgements

EvoStar gratefully acknowledges:

Invited speakers

Una-May O'Reilly & Penousal Machado

the **Programme Chairs** and **Programme Committees**

of all EvoStar conferences

Stefano Cagnoni & **Monica Mordonini** from the **Università di Parma** including the local organising team of Laura Sani, Riccardo Pecori, Paolo Fornacciari, Michele Tomaiuolo, Giulio Angiani, Gianfranco Lombardo and Michele Amoretti.

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EvoStar handbook produced by **Anna I Esparcia-Alcázar**, EvoStar Co-coordinator

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Lukas Sekanina, Brno University of Technology, Czech Republic

EuroGP publication chair

Mengjie Zhang Victoria University of Wellington, New Zealand

EvoAPPLICATIONS

21st International Conference on the Applications of Evolutionary Computation

EvoAPPLICATIONS coordinator

Kevin Sim, Edinburgh Napier University, Scotland

EvoAPPLICATIONS publication chair

Paul Kaufmann, Mainz University, Germany

EvoAPPLICATIONS track chairs

EvoBIO - Biology and Medicine

Federico Divina Pablo de Olavide University, Spain
Jaume Bacardit Newcastle University,UK

EvoCOMNET - Communication Networks and other Parallel and Distributed Systems

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Giovanni Iacca RWTH Aachen University, Germany

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Paul Kaufmann Mainz University, Germany
Oliver Kramer University of Oldenburg, Germany

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Alberto Tonda Université Paris-Saclay, INRA, France

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Stefano Cagnoni University of Parma, Italy
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Kevin Sim Edinburgh Napier University, Scotland
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EvoCOP programme chairs
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EvoMUSART

7th International Conference on Computational Intelligence in Music, Sound, Art and Design

EvoMUSART programme chairs
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Antonios Liapis, Institute of Digital Games, University of Malta

EvoMUSART publication chair
Aniko Ekárt, Aston University

EvoStar 2018 Team

EvoStar 2018 local chair
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EvoStar 2018 publicity chair
Pablo García Sánchez, University of Cádiz, Spain

EvoStar 2018 MyReview System coordinator
Marc Schoenauer, INRIA-Saclay, France

EvoStar 2018 coordinators
Jennifer Willies & Anna Esparcia-Alcázar

SPECIES Executive Board

Marc Schoenauer	Anna Esparcia-Alcázar	Wolfgang Banzhaf	Ernesto Costa
J. Ignacio Hidalgo	Penousal Machado	Gabriela Ochoa	Neil Urquhart

Welcome to EvoStar

On behalf of all the EvoStar 2018 organisers, we are pleased to welcome you to Parma for the four co-located EvoStar conferences of EuroGP, EvoAPPs, EvoCOP and EvoMUSART. This is the 21st 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! Many come 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 24 conference sessions plus a general poster session, with 116 papers, short papers and late-breaking abstracts presented over two and a half days. In addition we are pleased to have two eminent invited speakers for the opening and closing talks, Una-May O'Reilly and Penousal Machado. We offer an exciting programme 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 EvoSar2018 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.

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 in Aula B immediately after lunch on Friday 6, at 14:15 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.

Useful information

The EvoStar conference will be held in the historical central building of the **University of Parma at Strada Università 1**, in the historic city center. Strada Università starts from main Piazza Giuseppe Garibaldi on the west side of the square. The University building is accessible through the large doors on the opposite end of Strada dell'Università, approximately 300 meters from Piazza Garibaldi.

Pick up your registration materials when you arrive and be sure to **wear your conference badge visibly at all times** so university staff can recognise you as belonging to the EvoStar conference. This also entitles you to lunches, coffee breaks and the conference reception, so do not lose your badge or leave it at your hotel.

Lunches

Lunches will be held in a café beside the university called **Magnosfera**, turn left outside the main entrance and walk to the next corner (Via Guglielmo Oberdan 7). After showing your conference badge, you will receive a ticket each day valid for a two course lunch including bottled water. Vegetarian options are available. The EvoStar lunch service runs from 13.30 – 14.30 on Wednesday, Thursday and Friday.

Conference Dinner

The Conference Dinner will be held on Thursday, 5 April at Al Cavallino Bianco, approximately 45 minutes outside of Parma and located beside the river Po. On the same site for 100 years, the Spigaroli family has developed Al Cavallino Bianco from its simple ferry crossing origins, and it now offers gastronomic specialties from the local area.

Coaches will depart between 18:00 and 18:30 near the conference venue and will drop you to visit the restaurant cellars where local cheeses and hams are cured. This is a unique opportunity to see and smell the real aging process famous in the Emilia Romagna area. Afterwards a typical dinner of local dishes will be served. If you have indicated any special diets at registration, please make yourself known to conference coordinator Jennifer Willies when you enter the restaurant so you can be identified and served appropriately.

It is important to remember that **YOU MUST BRING YOUR DINNER TICKET WITH YOU TO GET ON THE BUS**. If you cannot attend the dinner, we kindly ask that you return your dinner ticket to the conference desk so that it can be recycled to others wanting to join the dinner; this is greatly appreciated.

Poster session and Conference Reception

The Evostar conference reception will be held in the **MAIN CORRIDOR on the Ground Floor**, on Wednesday evening from 18:30-20:00 in conjunction with the EvoStar poster session. All posters presented will be candidates to the **Best Poster Prize**. Outstanding Students will also candidate to the Best student paper award. Both prizes will be voted by the attendees to the Poster Session
Light refreshments will be served.

Optional local tour on Friday afternoon

For those staying on Friday afternoon, an optional visit to a few famous sites in Parma has been arranged. This includes the not-to-be-missed **Teatro Farnese**, a beautiful 17th century theatre which has seen its share of real

life drama in 400 years (fires, floodings, bombings). Built entirely of wood, it creaks its history as you mount the impressive proscenium stage to imagine performing in front of dukes and princes sitting in the horseshoe shaped double-tiered loggias illuminated by Palladian windows above. The scale, the sounds, the smells - all are impressive.

Then the tour continues to the imposing **Piazza Duomo Parma** standing for 900 years with a wealth of art amassed over centuries. The cupola by Correggio and the freschi by Gambara are among many other great works of art that will leave you in awe.

The walking tour leaves at **approximately 15:15** from the conference venue and is expected to finish **about 17:30** or thereabouts. Tickets are **10 euro** per person, and are available from the conference desk, cash only please.

Laptops and WiFi

WIFI is available at the conference venue. In addition to Eduroam being suitable for many, each participant will be assigned a unique account on the UNIPR network and your username details will be available on the backside of your conference badge.

You are encouraged to bring your own laptop or tablet for your presentation and appropriate adaptors and chargers for your equipment as EvoStar does not provide these. All LCD projectors have a VGA input. Some may provide HDMI, but this is not granted.

Online access to Proceedings

Springer has made online access available for EvoStar participants for the conference proceedings for the week before, and several weeks after, the conference via links at `http://www.evostar.org`

The EvoStar volume numbers are as listed below:

EuroGP 2018: LNCS 10781	EvoCOP 2018: LNCS 10782
EvoMUSART 2018: LNCS 10783	EvoAPPS 2018: LNCS 10784

Instructions to session chairs

You must bear in mind that

- *long* talks take 20 minutes + 5 minutes questions
- *short* talks take 10 minutes, no questions

Please ensure your speakers stick to the allocated times, in order to allow attendants to move between parallel sessions.

Invited speakers

Opening talk on Wednesday, 4 April at 09:45

Una-May O'Reilly

Adversarial Dynamics: Understanding Them Now is Important as Ever

Abstract: The world abounds with adversarial relationships - opponents squaring off in contests and disputes. They are found in nature (predator vs prey) and in human society (gaming, wars, cyber security). They shape important outcomes and influence the character of our existence. I will describe my research agenda on the dynamics of adversarial relationships and understanding how optimization and evolutionary computation comprise a useful lens through which they can be examined.

Una-May O'Reilly leads the AnyScale Learning For All (ALFA) group at MIT. She has expertise in scalable machine learning, evolutionary algorithms, and frameworks for large-scale, automated knowledge mining, prediction and analytics. She educates the forthcoming generation of data scientists, teaching them how develop state of art techniques that address the challenges spanning data integration to knowledge extraction.

Invited speakers

Closing talk on Friday, 6 April at 11:30

Penousal Machado

Evolution, Art and Sex

Abstract: Applying the techniques of Evolutionary Computation to artistic expression in both the visual arts and music over a period of several years has generated a timeline of what might be termed cultural artefacts. This suggested to me that the field - its past and current methodology, its trends and challenges - could be viewed through the prism of archeology. We will focus on one of the most intractable problems in the field: fitness assignment, analysing this challenge from the perspective of a human user interacting with an evolutionary system. How do Machine Learning, Evolutionary Computation and HCI techniques combine to create a Computer Aided Creativity system that responds to the artistic intentions of the user?

Penousal Machado leads the Cognitive and Media Systems group at the University of Coimbra. His research interests include Evolutionary Computation, Computational Creativity, and Evolutionary Machine Learning. In addition to the numerous scientific papers in these areas, his works have been presented in venues such as the National Museum of Contemporary Art (Portugal) and the "Talk to me" exhibition of the Museum of Modern Art, NY (MoMA).

EuroGP Panel debate

Genetic Programming in the Era of Deep Neural Networks

Wednesday, 4 April at 17:40

Description: Artificial intelligence systems based on deep neural networks are now outperforming other computer-based methods or even humans in many domains that are traditionally hard for computers, for example, image recognition, speech recognition and game playing. But what is the role of evolutionary computation (EC), and GP in particular, in this situation? Can GP-based solutions produce the same quality as DNNs in the most challenging benchmarks? Or is EC (GP) more suitable for optimizing and improving DNN-based solutions? What are the best strategies for combining EC with DNNs? How to promote EC in the era of DNNs? The panel is composed of internationally recognized experts working in EC and DNN. The panelists will address these questions and other relevant questions coming from the audience.

Moderator: Wolfgang Banzhaf, Michigan State University (US)

Panelists:

- Una-May O'Reilly, MIT (US)
- Marco Gori, University of Siena (IT)
- Sebastian Risi, IT University of Copenhagen (DK)
- Penousal Machado, University of Coimbra (PT)

Best paper nominations

EuroGP candidates

- **Analyzing Feature Importance for Metabolomics using Genetic Programming**, Ting Hu, Karoliina Oksanen, Weidong Zhang, Edward Randell, Andrew Furey, Guangju Zhai
- **On the Automatic Design of a Representation for Grammar-based Genetic Programming**, Eric Medvet, Alberto Bartoli
- **Scaling Tangled Program Graphs to Visual Reinforcement Learning in ViZDoom**, Robert Smith, Malcolm Heywood
- **Multi-Level Grammar Genetic Programming for Scheduling in Heterogeneous Networks**, Takfarinas Saber, David Fagan, David Lynch, Stepan Kucera, Holger Claussen, Michael O'Neill

EvoAPPLICATIONS candidates

- **Late Acceptance Hill Climbing for Constrained Covering Arrays**, Mosab Bazargani, John H. Drake, Edmund K. Burke
- **Evolving a Repertoire of Controllers for a Multi-Function Swarm**, Sondre A. Engebraten, Jonas Moen, Oleg Yakimenko, Kyrre Glette
- **A Multi-Objective Time-Linkage Approach for Dynamic Optimization Problems with Previous-Solution Displacement Restriction**, Danial Yazdani, Trung Thanh Nguyen, Juergen Branke, Jin Wang
- **A fast metaheuristic for the design of DVB-T2 networks**, Fabio D'Andreagiovanni, Antonella Nardin

EvoCOP candidates

- **Better Runtime Guarantees Via Stochastic Domination**, Benjamin Doerr
- **Worst improvement based iterated local search**, Sara Tari, Matthieu Basseur, Adrien Goëffon

- **A multistart alternating tabu search for commercial districting**, Alex Gliesch, Marcus Ritt, Mayron C.O. Moreira

EvoMUSART candidates

- **Visual art inspired by the collective feeding behavior of sand-bubbler crabs**, Hendrik Richter
- **Generating drums rhythms through data-driven conceptual blending of features and genetic algorithms**, Maximos Kaliakatsos-Papakostas
- **Evotype: Towards the Evolution of Type Stencils**, Tiago Martins, João Correia, Ernesto Costa, Penousal Machado

EvoStar Outstanding Contribution to EC in Europe Award

Each year EvoStar recognises those who have made an outstanding contribution to evolutionary computation in Europe. The award is presented during the conference dinner, this year on **Thursday, 5 April**.

Previous recipients of the award are:

- **2017 - Amsterdam:** Gusz Eiben & James Foster
- **2016 - Porto:** Penousal Machado
- **2015 - Copenhagen:** Anna I Esparcia-Alcázar & Leonardo Vanneschi
- **2014 - Granada:** Terry Fogarty
- **2013 - Vienna:** Una-May O'Reilly & Elena Marchiori
- **2012 - Málaga:** Günter Raidl
- **2011 - Torino:** Julian Miller
- **2010 - Istanbul:** Marco Tomassini
- **2009 - Tübingen:** Stefano Cagnoni & Ernesto Costa
- **2008 - Napoli:** Marc Schoenauer & Bill Langdon
- **2007 - Valencia:** Wolfgang Banzhaf & Riccardo Poli
- **2006 - Budapest:** Jennifer Willies

Students Activities

Welcome Students Reception

This year a welcome reception has been organised for all students attending EvoStar at 6pm on Tuesday 3 April where a one-minute-madness session will take place encouraging students to introduce themselves and their research. It is a great way to meet new people and find others doing work in similar areas. So leave your supervisor at the hotel and come along.

The reception takes place at the T-cafe located on the ground floor of the historic Palazzo Dalla Rosa Prati in the centre of Parma a Strada Duomo 7, 43121, Parma. More info at `https://www.palazzodallarosaprati.it/tcafe/`

Scavenger Hunt

The organisers are also inviting all students to participate in the EvoStar 2018 Student Scavenger Hunt. Students have been placed in small teams to undertake these challenges below.

- Post a picture of your team outdoors in Parma
- Submit the title of a paper that solves a real-world problem.
- Submit the title of a paper that written by someone from Spain.
- Submit the title of a paper that has an application in games.
- Picture yourself with an attendee who has attended more than 10 EvoStar events.
- Post a picture of a member of your team presenting a paper.
- Post a picture of a presentation that covers the MAP Elites algorithm
- Post a picture of your team with a robot
- List the names of the SPECIES board members
- Upload a picture of each team member asking a question at the poster session
- Upload a picture of a team member with some Parma Ham or Parmesan cheese
- Picture your team with a member of the Species board who comes from Portugal
- Take a picture of your team after having seen a **Lucabaza**[1]

To be eligible for prizes, be sure to provide your answers to n.urquhart@napier.ac.uk no later than 10am on Friday the 6th. Winners will be announced and prizes given out at the closing session.

A series of mentoring activities has also been organised, which will be developed further in future years; please send your suggestions to **Neil Urquhart**, `n.urquhart@napier.ac.uk`.

EvoStar is grateful to **Edinburgh Napier University** for their support of these student activities.

[1] Find out what it is first!

Recognition to

Outstanding Students

In EvoStar 2018 we wanted to recognise the good work of our students, who represent the future of our community.

We selected papers that had obtained an overall review score greater than or equal to 5 or that had been nominated for a Best Paper Award, and whose first author was a student registered to attend EvoStar.

Following these rules we came up with a list of 10 Outstanding Students:

- Filipe Assunção, CISUC, University of Coimbra, Portugal
- Mosab Bazargani, Queen Mary University of London, UK
- Alexander Berman, AI_am, Gothenburg, Sweden
- Sondre Engebraten, FFI, Oslo, Norway
- Tiago Martins, CISUC, University of Coimbra, Portugal
- Almuth Meier, University of Oldenburg, Germany
- Rafaela P. Moreira, CEFET-MG, Belo Horizonte, Brazil
- Robert J. Smith, Dalhousie University, Halifax, Canada
- Sara Tari, University of Angers, France
- Sarah Louise Thomson, University of Stirling, Scotland, UK

Please come to the Poster Reception on Wednesday 4th and vote for your favorite for the **Evo* 2018 Best Student Paper award**.

EuroGP Programme

April 04, 2018

11:10-13:20 : *EuroGP 1 - New techniques in GP* Aula A
Chair: Aniko Ekart

A Multiple Expression Alignment Framework for Genetic Programming,
Leonardo Vanneschi, Kristen Scott, Mauro Castelli ***35***

Evolving Graphs by Graph Programming,
Timothy Atkinson, Detlef Plump, Susan Stepney ***35***

Pruning Techniques for Mixed Ensembles of Genetic Programming Models,
Mauro Castelli, Ivo Gonçalves, Luca Manzoni, Leonardo Vanneschi ***36***

Generating Redundant Features with Unsupervised Multi-Tree Genetic Programming,
Andrew Lensen, Bing Xue, Mengjie Zhang ***36***

Towards In Vivo Genetic Programming: Evolving Boolean Networks to Determine Cell States,
Nadia Taou, Michael Lones ***37***

13:20-14:30 : *Lunch* Magnosfera, via Guglielmo Oberdan 7

14:30-16:20 : *EuroGP 2 - GP in machine learning + Short talks* Aula A
Chair: Ting Hu

Evolving the Topology of Large Scale Deep Neural Networks,
Filipe Assunção, Nuno Lourenço, Penousal Machado, Bernardete Ribeiro ***37***

Using GP is NEAT: Evolving Compositional Pattern Production Functions,
Filipe Assunção, Nuno Lourenço, Penousal Machado, Bernardete Ribeiro ***38***

Structurally Layered Representation Learning: Towards Deep Learning through Genetic Programming (Short Talk),
Lino Rodriguez-Coayahuitl, Alicia Morales-Reyes, Hugo Jair Escalante ***38***

Evolving Better RNAfold Structure Prediction (Short Talk),
William B. Langdon, Justyna Petke, Ronny Lorenz ***39***

Genetic Programming Hyper-heuristic with Cooperative Coevolution for Dynamic Flexible Job Shop Scheduling (Short Talk),
Daniel Yska, Yi Mei, Mengjie Zhang ***39***

Geometric Crossover in Syntactic Space (Short Talk),
João Macedo, Carlos Fonseca, Ernesto Costa ***40***

A Comparative Study on Crossover in Cartesian Genetic Programming (Short Talk),
Jakub Husa, Roman Kalkreuth ***40***

16:20-16:40 : *Coffee break* Foyer

16:40-18:15 : *EuroGP 3 - Short talks + Panel: "GP in the Era of Deep Neural Networks"* Aula A
Chair: Mengjie Zhang

Comparing Rule Evaluation Metrics for the Evolutionary Discovery of Multi-Relational Association Rules in the Semantic Web (Short Talk),
Minh Duc Tran, Claudia d'Amato, Binh Thanh Nguyen, Andrea G. B. Tettamanzi ***41***

Investigating a Machine Breakdown Genetic Programming Approach for Dynamic Job Shop Scheduling (Short Talk),
John Park, Yi Mei, Su Nguyen, Gang Chen, Mengjie Zhang ***42***

Multi-Objective Evolution of Ultra-Fast General-Purpose Hash Functions (Short Talk),
David Grochol, Lukas Sekanina ***42***

18:30-20:00 : *EvoStar poster session and conference reception*

April 05, 2018

09:30-11:10 : *EuroGP 4 - Best paper nominations* Aula A
Chair: Mauro Castelli - Lukas Sekanina

Analyzing Feature Importance for Metabolomics using Genetic Programming,
Ting Hu, Karoliina Oksanen, Weidong Zhang, Edward Randell, Andrew Furey, Guangju Zhai ***43***

On the Automatic Design of a Representation for Grammar-based Genetic Programming,
Eric Medvet, Alberto Bartoli ***43***

Scaling Tangled Program Graphs to Visual Reinforcement Learning in ViZDoom,
Robert Smith, Malcolm Heywood ***44***

Multi-Level Grammar Genetic Programming for Scheduling in Heterogeneous Networks,
Takfarinas Saber, David Fagan, David Lynch, Stepan Kucera, Holger Claussen, Michael O'Neill ***44***

EvoAPPLICATIONS Programme

April 04, 2018

09:00-09:30 : *Registrations* Foyer

09:30-09:45 : *Conference opening by SPECIES Society President Marc Schoenauer* Aula dei Filosofi

09:45-10:45 : *Plenary invited talk: Una-May O'Reilly* Aula dei Filosofi "Adversarial Dynamics: Understanding Them Now is Important as ever"

10:45-11:10 : *Coffee break*

11:10-13:20 : ***EvoAPPS 1 (EvoNUM & EvoSET)*** Aula B In parallel with EvoAPPS 2
Chair: Anna I Esparcia-Alcázar

Multi-strategy Differential Evolution,
Anil Yaman, Giovanni Iacca, Matt Coler, George Fletcher, Mykola Pechenizkiy ***45***

A Generic Framework for Incorporating Constraint Handling Techniques into Multi-Objective Evolutionary Algorithms,
Hiroaki Fukumoto, Akira Oyama ***45***

Late Acceptance Hill Climbing for Constrained Covering Arrays,
Mosab Bazargani, John H. Drake, Edmund K. Burke ***46***

Search-Based Temporal Testing in an Embedded Multicore Platform,
Komsan Srivisut, John Clark, Richard Paige ***46***

Investigating the Evolvability of Web Page Load Time (Short Talk),
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11:10-13:20 : ***EvoAPPS 2 (EvoSTOC)*** Aula D In parallel with EvoAPPS 1
Chair: Trung Thanh Nguyen

On the Use of Repair Methods in Differential Evolution for Dynamic Constrained Optimization,
Maria-Yaneli Ameca-Alducin, Maryam Hasani-Shoreh, Frank Neumann ***47***

Prediction with Recurrent Neural Networks in Evolutionary Dynamic Optimization,
Almuth Meier, Oliver Kramer ***48***

A Multi-Objective Time-Linkage Approach for Dynamic Optimization Problems with Previous-Solution Displacement Restriction,
Danial Yazdani, Trung Thanh Nguyen, Juergen Branke, Jin Wang **48**

A Type Detection Based Dynamic Multi-Objective Evolutionary Algorithm,
Shaaban Sahmoud, Haluk Topcuoglu **49**

Robust Evolutionary Optimization Based on Coevolution (Short Talk),
Steffen Limmer, Tobias Rodemann **49**

13:20-14:30 : *Lunch*

14:30-16:20 : ***EvoAPPS 3 - Short talks (EvoBIO, EvoCOMPLEX, EvoCOMNET, EvoENERGY, EvoINDUSTRY, EvoKNOW)*** Aula B In parallel with EvoAPPS 4
Chair: Sanaz Mostaghim

Fitness Functions Evaluation for Segmentation of Lymphoma Histological Images using Genetic Algorithm (Short Talk),
Thaina Tosta, Paulo Faria, Leandro Neves, Marcelo Nascimento **56**

Automatic segmentation of neurons in 3D samples of human brain cortex (Short Talk),
Giacomo Mazzamuto, Irene Costantini, Mattia Neri, Matteo Roffilli, Ludovico Silvestri, Francesco S. Pavone **56**

Analysis of relevance and redundance on Topoisomerase 2b (TOP2B) binding sites: A feature selection approach (Short Talk),
Pedro Manuel Martinez Garcia, Miguel Garcia Torres, Federico Divina, Francisco Antonio Gomez-Vela, Felipe Cortes-Ledesma **57**

Phase-Space Sampling of Energy Ensembles with CMA-ES (Short Talk),
Jörg Bremer, Sebastian Lehnhoff **57**

Improving Multi-Objective Evolutionary Influence Maximization in Social Networks (Short Talk),
Doina Bucur, Giovanni Iacca, Andrea Marcelli, Giovanni Squillero, Alberto Tonda **58**

A Classifier to Identify Soft Skills in a Researcher Textual Description (Short Talk),
Antonia Azzini, Andrea Galimberti, Stefania Marrara, Eva Ratti **58**

Evolving Controllers for Electric Vehicle Charging (Short Talk),
Martin Pilat **59**

Integrating Evolution Strategies into Genetic Algorithms with Fuzzy Inference Evaluation to solve a Steelmaking and Continuous Casting Scheduling Problem (Short Talk),
Eduardo Salazar ***59***

Automatic generation of constructive heuristics for multiple types of combinatorial optimisation problems with grammatical evolution and geometric graphs (Short Talk),
Christopher Stone, Emma Hart, Ben Paechter ***60***

Maximizing the effect of local disturbance in the dynamics of opinion formation (Short Talk),
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Rotation Invariance and Rotated Problems: An Experimental Study on Differential Evolution (Short Talk),
Fabio Caraffini, Ferrante Neri ***61***

14:30-16:20 : ***EvoAPPS 4 - Short talks (EvoGAMES, EvoIASP, EvoROBOT)*** Aula D In parallel with EvoAPPS 3
Chair: Sara Silva

Online-trained Fitness Approximators for Real-world Game Balancing (Short Talk),
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Recomposing the Pokémon Color Palette (Short Talk),
Antonios Liapis ***51***

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Evolving Artificial Neural Networks for Multi-Objective Tasks (Short Talk),
Steven Künzel, Silja Meyer-Nieberg ***55***

HyperNTM: Evolving Scalable Neural Turing Machines through HyperNEAT (Short Talk),
Jakob Merrild, Mikkel Angaju Rasmussen, Sebastian Risi ***55***

16:20-16:40 : *Coffee break*

16:40-18:15 : ***EvoAPPS 5 (EvoPAR & EvoCOMPLEX)*** Aula D
Chair: Francisco Fernández de Vega

A Genetic Algorithm for Community Detection in Attributed Graphs,
Clara Pizzuti, Annalisa Socievole ***61***

Accelerating the Computation of Solutions in Resource Allocation Problems Using an Evolutionary Approach and Multiagent Reinforcement Learning,
Ana Bazzan ***62***

A CPU-GPU parallel Ant Colony Optimization solver for the Vehicle Routing Problem,
Antón Rey-Villaverde, Manuel Prieto, Ignacio Gómez, Christian Tenllado, J. Ignacio Hidalgo ***62***

18:30-20:00 : ***EvoStar poster session and conference reception***

April 05, 2018

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Chair: Alberto Tonda

Mapping Chess Aesthetics onto Procedurally Generated Chess-like Games,
Jakub Kowalski, Antonios Liapis, Lukasz Zarczynski ***63***

Piecemeal Evolution of a First Person Shooter Level,
Antonios Liapis ***63***

Self-Adaptive MCTS for General Video Game Playing,
Chiara F. Sironi, Jialin Liu, Diego Perez-Liebana, Raluca D. Gaina, Ivan Bravi, Simon M. Lucas, Mark H. M. Winands ***64***

Deceptive Games,
Damien Anderson, Matthew Stephenson, Julian Togelius, Christoph Salge, John Levine, Jochen Renz ***64***

09:30-11:10 : ***EvoAPPS 7 (EvoIASP)*** Aula D In parallel with EvoAPPS 6
Chair: Stefano Cagnoni & Mengjie Zhang

11:10-11:30 : *Coffee break*

11:30-13:20 : ***EvoAPPS 8 (EvoBIO & EvoBAFIN)*** Aula D
Chair: Jaume Bacardit

13:20-14:20 : *Lunch*

14:20-16:00 : ***EvoAPPS 9 (EvoROBOT)*** Aula D
Chair: Kyrre Glette

Revolve: A Versatile Simulator for Online Robot Evolution,
Elte Hupkes, Milan Jelisavcic, A. E. Eiben ***70***

Evolving a Repertoire of Controllers for a Multi-Function Swarm,
Sondre A. Engebraten, Jonas Moen, Oleg Yakimenko, Kyrre Glette ***71***

16:00-16:20 : *Coffee break*

16:20-18:00 : ***EvoAPPS 10 (EvoINDUSTRY & General track)*** Aula D
Chair: Kevin Sim & Neil Urquhart

Evaluating the Performance of an Evolutionary Tool for Exploring Solution Fronts,
Neil Urquhart ***71***

Toward the Online Visualisation of Algorithm Performance for Parameter Selection,
David Walker, Matthew Craven ***72***

CardNutri: A software of Weekly Menus Nutritional Elaboration for Schoolar Feeding applying Evolutionary Computation,
Rafaela Moreira, Elizabeth Wanner, Flavio Martins, João Sarubbi ***72***

19:00-21:30 : *Conference dinner*

April 06, 2018

10:00-11:30 : ***EvoAPPS 11 (EvoENERGY)*** Aula B In parallel with EvoAPPS 12
Chair: Paul Kaufmann & Oliver Kramer

Many-objective optimization of mission and hybrid electric power system of an unmanned aircraft,
Teresa Donateo, Claudia Lucia De Pascalis, Antonio Ficarella ***74***

Network Coordinated Evolution: Modeling and Control of Distributed Systems through On-Line Genetic PID-Control Optimization Search,
Holm Smidt, Matsu Thornton, Reza Ghorbani ***75***

Achieving Optimized Decisions on Battery Operating Strategies in Smart Buildings,
Jan Müller, Mischa Ahrens, Ingo Mauser, Hartmut Schmeck ***75***

10:00-11:30 : ***EvoAPPS 12 (EvoCOMNET)*** Aula D In parallel with EvoAPPS 11
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Multimodal Transportation Network Design Using Physarum Polycephalum-Inspired Multi-agent Computation Methods,

Rishi Vanukuru, Nagendra R. Velaga ***73***

Social Relevance Index for Studying Communities in a Facebook Group of Patients,
Laura Sani, Gianfranco Lombardo, Riccardo Pecori, Paolo Fornacciari, Monica Mordonini, Stefano Cagnoni ***73***

A fast metaheuristic for the design of DVB-T2 networks,
Fabio D'Andreagiovanni, Antonella Nardin ***74***

11:30-12:00 : *Coffee break*

12:00-13:00 : *Plenary invited talk: Penousal Machado* Aula dei Filosofi "Evolution, Art and Sex"

13:00-13:30 : *Conference closing, best paper presentations, general announcements including 2019 location*

13:30-14:15 : *Lunch*

14:15-15:15 : *SPECIES society AGM open to all EvoStar participants* Aula B

15:15-18:00 : *Optional afternoon social trip: tour of Parma*

EvoCOP Programme

April 05, 2018

11:30-13:20 : ***EvoCOP 1 - Landscape Analysis and Operators*** Aula A
Chair: Manuel López-Ibáñez

On the Fractal Nature of Local Optima Networks,
Sarah L. Thomson, Sébastien Verel, Gabriela Ochoa, Nadarajen Veerapen, Paul McMenemy ***76***

An Evolutionary Algorithm with Practitioner's-Knowledge-Based Operators for the Inventory Routing Problem,
Piotr Lipinski, Krzysztof Michalak ***77***

How Perturbation Strength Shapes the Global Structure of TSP Fitness Landscapes,
Paul McMenemy, Nadarajen Veerapen, Gabriela Ochoa ***77***

An Ant Colony Approach for the Winner Determination Problem,
Abhishek Ray, Mario Ventresca ***78***

13:20-14:20 : *Lunch*

14:20-16:00 : ***EvoCOP 2 - Hyper-heuristics and Automatic Configuration*** Aula A
Chair: Darrell Whitley

Automatic grammar-based design of heuristic algorithms for unconstrained binary quadratic programming,
Marcelo de Souza, Marcus Ritt ***78***

Data Clustering Using Grouping Hyper-heuristics,
Anas Elhag, Ender Ozcan ***79***

Automatic Algorithm Configuration for the Permutation Flow Shop Scheduling Problem Minimizing Total Completion Time,
Artur Brum, Marcus Ritt ***79***

Reference Point Adaption Method for Genetic Programming Hyper-heuristic in Many-Objective Job Shop Scheduling,
Atiya Masood, Gang Chen, Yi Mei, Mengjie Zhang ***80***

16:00-16:20 : *Coffee break*

16:20-18:00 : ***EvoCOP 3 - Multi-objective + Late-Breaking Abstracts*** Aula A
Chair: Gabriela Ochoa

MOEA/DEP: An Algebraic Decomposition-based Evolutionary Algorithm for the Multi-objective Permutation Flowshop Scheduling Problem,
Marco Baioletti, Alfredo Milani, Valentino Santucci ***80***

The Need to Transform Evolutionary Computation Research (Late Breaking Abstract),
Darrell Whitley ***95***

Ant colony optimization for a multi-criteria generalized job-shop scheduling problem (Late Breaking Abstract),
Fatima Ghedjati ***95***

A distributed multiple Ant Colony algorithm to solve a steel industry scheduling problem (Late Breaking Abstract),
Silvino Fernandez Alzueta, Pablo Valledor Pellicer, Jorge Rodil Martinez, Segundo Álvarez García, Eneko Malatsetxebarria Elizegi ***96***

19:00-21:30 : *Conference dinner*

April 06, 2018

10:00-11:30 : ***EvoCOP 4 - Best paper nominations*** Aula A
Chair: Arnaud Liefooghe

Better Runtime Guarantees Via Stochastic Domination,
Benjamin Doerr ***81***

Worst improvement based iterated local search,
Sara Tari, Matthieu Basseur, Adrien Goëffon ***81***

A multistart alternating tabu search for commercial districting,
Alex Gliesch, Marcus Ritt, Mayron C.O. Moreira ***82***

EvoMUSART Programme

April 04, 2018

16:25-18:15 : ***EvoMusArt 1 - Short talks*** Aula B
Chair: Antonios Liapis

Musical Organisms: a generative approach to growing musical scores (Short Talk),
Anna Lindemann, Eric Lindemann ***83***

Medical art therapy of the future: building an interactive virtual underwater world in a children's hospital (Short Talk),
Ludivine Lechat, Lieven Menschaert, Tom De Smedt, Lucas Nijs, Monica Dhar, Koen Norga, Jaan Toelen ***83***

Dynamical Music with Musical Boolean Networks (Short Talk),
George Gabriel, Susan Stepney ***84***

Adaptive interface for mapping body movements to sounds (Short Talk),
Dimitrije Markovic, Nebojsa Malesevic ***84***

evoExplore: Multiscale Visualization of Evolutionary Histories in Virtual Reality (Short Talk),
Justin Kelly, Christian Jacob ***85***

Towards Partially Automatic Search of Edge Bundling Parameters (Short Talk),
Evgheni Polisciuc, Filipe Assunção, Penousal Machado ***85***

Construction of a repertoire of analog Form-finding techniques as a basis for computational morphological exploration in design and architecture (Short Talk),
Ever Patiño, Jorge Maya ***86***

Generative Solid Modelling Employing Natural Language Understanding and 3D Data (Short Talk),
Marinos Koutsomichalis, Björn Gambäck ***86***

April 05, 2018

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Non-photorealistic Rendering with Cartesian Genetic Programming using Graphics Processing Units,
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Towards a General Framework for Artistic Style Transfer,
Florian Uhde, Sanaz Mostaghim ***87***

The Light Show: Flashing Fireflies Gathering and Flying over Digital Images,
Paulo Urbano ***88***

Deep Interactive Evolution,
Philip Bontrager, Wending Lin, Julian Togelius, Sebastian Risi ***88***

On Collaborator Selection in Creative Agent Societies: An Evolutionary Art Case Study,
Simo Linkola, Otto Hantula ***89***

13:10-14:15 : *Lunch*

14:15-15:55 : ***EvoMusArt 3 - Music & Dance*** Aula B
Chair: Aniko Ekart

Learning as Performance: Autoencoding and Generating Dance Movements in Real Time,
Alexander Berman, Valencia James ***89***

Expressive Piano Music Playing Using a Kalman Filter,
Alexandra Bonnici, Maria Mifsud, Kenneth Camilleri ***90***

Co-Evolving Melodies and Harmonization in Evolutionary Music Composition,
Olav Olseng, Bjoern Gambaeck ***90***

RoboJam: A Musical Mixture Density Network for Collaborative Touchscreen Interaction,
Charles Martin, Jim Torresen ***91***

15:55-16:15 : *Coffee break*

16:15-17:45 : ***EvoMusArt 4 - Best paper nominations*** Aula B
Chair: Antonios Liapis

Visual art inspired by the collective feeding behavior of sand-bubbler crabs,
Hendrik Richter ***91***

Generating drums rhythms through data-driven conceptual blending of features and genetic algorithms,
Maximos Kaliakatsos-Papakostas ***92***

Evotype: Towards the Evolution of Type Stencils,
Tiago Martins, João Correia, Ernesto Costa, Penousal Machado ***92***

Late-breaking Abstracts Programme

April 04, 2018

18:30-20:00 : ***EvoStar Poster Session and conference reception*** Main corridor on ground floor

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José-Ignacio Hidalgo, Carlos Cervigón, David Martínez-Rodríguez, Rafael-Jacinto Villanueva ***93***

MAENERGY: A tool for measuring and analyzing evolutionary algorithms energy consumption in mobile devices. (Late-breaking Abstract),
Francisco Chavez, Borja Rodríguez-Puerta, Francisco Fernández de Vega ***94***

April 05, 2018

16:20-18:00 : ***EvoCOP 3 - Multi-objective + Late-Breaking Abstracts*** Aula A
Chair: Gabriela Ochoa

MOEA/DEP: An Algebraic Decomposition-based Evolutionary Algorithm for the Multi-objective Permutation Flowshop Scheduling Problem (Regular Paper),
Marco Baioletti, Alfredo Milani, Valentino Santucci ***80***

The Need to Transform Evolutionary Computation Research (Late Breaking Abstract),
Darrell Whitley ***95***

Ant colony optimization for a multi-criteria generalized job-shop scheduling problem (Late Breaking Abstract),
Fatima Ghedjati ***95***

A distributed multiple Ant Colony algorithm to solve a steel industry scheduling problem (Late Breaking Abstract),
Silvino Fernandez Alzueta, Pablo Valledor Pellicer, Jorge Rodil Martinez, Segundo Álvarez García, Eneko Malatsetxebarria Elizegi ***96***

List of Abstracts - EuroGP

A Multiple Expression Alignment Framework for Genetic Programming
Leonardo Vanneschi, Kristen Scott, Mauro Castelli
EuroGP 1 - New techniques in GP

Alignment in the error space is a recent idea to exploit semantic awareness in genetic programming. In a previous contribution, the concepts of optimally aligned and optimally coplanar individuals were introduced, and it was shown that given optimally aligned, or optimally coplanar, individuals, it is possible to construct a globally optimal solution analytically. As a consequence, genetic programming methods, aimed at searching for optimally aligned, or optimally coplanar, individuals were introduced. In this paper, we critically discuss those methods, analyzing their major limitations and we propose new genetic programming systems aimed at overcoming those limitations. The presented experimental results, conducted on five real-life symbolic regression problems, show that the proposed algorithms outperform not only the existing methods based on the concept of alignment in the error space, but also geometric semantic genetic programming and standard genetic programming.

Evolving Graphs by Graph Programming
Timothy Atkinson, Detlef Plump, Susan Stepney
EuroGP 1 - New techniques in GP

Rule-based graph programming is a deep and rich topic. We present an approach to exploiting the power of graph programming as a representation and as an execution medium in an evolutionary algorithm (EGGP). We demonstrate this power in comparison with Cartesian Genetic Programming (CGP), showing that it is significantly more efficient in terms of fitness evaluations on some classic benchmark problems. We hypothesise that this is due to its ability to exploit the full graph structure, leading to a richer mutation set, and outline future work to test this hypothesis, and to exploit further the power of graph programming within an EA.

Pruning Techniques for Mixed Ensembles of Genetic Programming Models

Mauro Castelli, Ivo Gonçalves, Luca Manzoni, Leonardo Vanneschi

EuroGP 1 - New techniques in GP

The objective of this paper is to define an effective strategy for building an ensemble of Genetic Programming (GP) models. Ensemble methods are widely used in machine learning due to their features: they average out biases, they reduce the variance and they usually generalize better than single models. Despite these advantages, building ensemble of GP models is not a well-developed topic in the evolutionary computation community. To fill this gap, we propose a strategy that blends individuals produced by standard syntax-based GP and individuals produced by geometric semantic genetic programming, one of the newest semantics-based method developed in GP. In fact, recent literature showed that combining syntactic and semantics could improve the generalization ability of a GP model. Additionally, to improve the diversity of the GP models used to build up the ensemble, we propose different pruning criteria that are based on correlation and entropy, a commonly used measure in information theory. Experimental results, obtained over different complex problems, suggest that the pruning criteria based on correlation and entropy could be effective in improving the generalization ability of the ensemble model and in reducing the computational burden required to build it.

Generating Redundant Features with Unsupervised Multi-Tree Genetic Programming

Andrew Lensen, Bing Xue, Mengjie Zhang

EuroGP 1 - New techniques in GP

Recently, feature selection has become an increasingly important area of research due to the surge in high-dimensional datasets in all areas of modern life. A plethora of feature selection algorithms have been proposed, but it is difficult to truly analyse the quality of a given algorithm. Ideally, an algorithm would be evaluated by measuring how well it removes known bad features. Acquiring datasets with such features is inherently difficult, and so a common technique is to add synthetic bad features to an existing dataset. While adding noisy features is an easy task, it is very difficult to automatically add complex, redundant features. This work proposes one of the first approaches to generating redundant features, using a novel genetic programming approach. Initial experiments show that our proposed method can automatically create difficult, redundant features which have the potential to be used for creating high-quality feature selection benchmark datasets.

Towards In Vivo Genetic Programming: Evolving Boolean Networks to Determine Cell States

Nadia Taou, Michael Lones

EuroGP 1 - New techniques in GP

Within the genetic programming community, there has been growing interest in the use of computational representations motivated by gene regulatory networks (GRNs). It is thought that these representations capture useful biological properties, such as evolvability and robustness, and thereby support the evolution of complex computational behaviours. However, computational evolution of GRNs also opens up opportunities to go in the opposite direction: designing programs that could one day be implemented in biological cells. In this paper, we explore the ability of evolutionary algorithms to design Boolean networks, abstract models of GRNs suitable for refining into synthetic biology implementations, and show how they can be used to control cell states within a range of executable models of biological systems.

Evolving the Topology of Large Scale Deep Neural Networks

Filipe Assunção, Nuno Lourenço, Penousal Machado, Bernardete Ribeiro

EuroGP 2 - GP in machine learning + Short talks

In the recent years Deep Learning has attracted a lot of attention due to its success in difficult tasks such as image recognition and computer vision. Most of the success in these tasks is merit of Convolutional Neural Networks (CNNs), which allow the automatic construction of features. However, designing such networks is not an easy task, which requires expertise and insight. In this paper we introduce DENSER, a novel representation for the evolution of deep neural networks. In concrete we adapt ideas from Genetic Algorithms (GAs) and Grammatical Evolution (GE) to enable the evolution of sequences of layers and their parameters. We test our approach in the well-known image classification CIFAR-10 dataset. The results show that our method: (i) outperforms previous evolutionary approaches to the generations of CNNs; (ii) is able to create CNNs that have state-of-the-art performance while using less prior knowledge (iii) evolves CNNs with novel topologies, unlikely to be designed by hand. For instance, the best performing CNNs obtained during evolution has an unexpected structure using six consecutive dense layers. On the CIFAR-10 the best model reports an average error of 5.87

Using GP is NEAT: Evolving Compositional Pattern Production Functions

Filipe Assunção, Nuno Lourenço, Penousal Machado, Bernardete Ribeiro

EuroGP 2 - GP in machine learning + Short talks

The success of Artificial Neural Networks (ANNs) highly depends on their architecture and on how they are trained. However, making decisions regarding such domain specific issues is not an easy task, and is usually performed by hand, through an exhaustive trial-and-error process. Over the years, researches have developed and proposed methods to automatically train ANNs. One example is the HyperNEAT algorithm, which relies on NeuroEvolution of Augmenting Topologies (NEAT) to create Compositional Pattern Production Networks (CPPNs). CPPNs are networks that encode the mapping between neuron positions and the synaptic weight of the ANNs connection between those neurons. Although this approach has obtained some success, it requires meticulous parameterisation to work properly. In this article we present a comparison of different Evolutionary Computation methods to evolve Compositional Pattern Production Functions: structures that have the same goal as CPPNs, but that are encoded as functions instead of networks. In addition to NEAT three methods are used to evolve such functions: Genetic Programming (GP), Grammatical Evolution, and Dynamic Structured Grammatical Evolution. The results show that GP is able to obtain competitive performance, often surpassing the other methods, without requiring the fine tuning of the parameters.

Structurally Layered Representation Learning: Towards Deep Learning through Genetic Programming

Lino Rodriguez-Coayahuitl, Alicia Morales-Reyes, Hugo Jair Escalante

EuroGP 2 - GP in machine learning + Short talks

We introduce a novel method for representation learning based on genetic programming (GP). Inspired into the way that deep neural networks learn descriptive/discriminative representations from raw data, we propose a structurally layered representation that allows GP to learn a feature space from large scale and high dimensional data sets. Previous efforts from the GP community for feature learning have focused on small data sets with a few input variables, also, most approaches rely on domain expert knowledge to produce useful representations. In this paper, we introduce the structurally layered GP formulation, together with an efficient scheme to explore the search space and show that this framework can be used to learn representations from large data sets of high dimensional raw data. As case of study we describe the implementation and experimental evaluation of an autoencoder developed under the proposed framework. Results evidence the benefits of the proposed framework and pave the way for the development of deep genetic programming.

Evolving Better RNAfold Structure Prediction
William B. Langdon, Justyna Petke, Ronny Lorenz
EuroGP 2 - GP in machine learning + Short talks

Grow and graft genetic programming (GGGP) evolves more than 50000 parameters in a state-of-the-art C program to make functional source code changes which give more accurate predictions of how RNA molecules fold up. Genetic improvement updates 29percent of the dynamic programming free energy model parameters. In most cases (50.3percent) GI gives better predictions on 4655 known secondary structures from RNA_STRAND (29.0percent are worse and 20.7percent are unchanged, p = 0.00000000000000000000000000000000000000000000000000000000000052035 Indeed it also does better than parameters recommended by Andronescu, M., et al.: Bioinformatics 23(13) (2007) i19–i28, p = 0.00000000000000000000000000000000000000000000000000000000001379378

Genetic Programming Hyper-heuristic with Cooperative Coevolution for Dynamic Flexible Job Shop Scheduling
Daniel Yska, Yi Mei, Mengjie Zhang
EuroGP 2 - GP in machine learning + Short talks

Flexible Job Shop Scheduling (FJSS) problem has many real-world applications such as manufacturing and cloud computing, and thus is an important area of study. In real world, the environment is often dynamic, and unpredicted job orders can arrive in real time. Dynamic FJSS consists of challenges of both dynamic optimisation and the FJSS problem. In Dynamic FJSS, two kinds of decisions (so-called routing and sequencing decisions) are to be made in real time. Dispatching rules have been demonstrated to be effective for dynamic scheduling due to their low computational complexity and ability to make real-time decisions. However, it is time consuming and strenuous to design effective dispatching rules manually due to the complex interactions between job shop attributes. Genetic Programming Hyper-heuristic (GPHH) has shown success in automatically designing dispatching rules which are much better than the manually designed ones. Previous works only focused on standard job shop scheduling with only the sequencing decisions. For FJSS, the routing rule is set arbitrarily by intuition. In this paper, we explore the possibility of evolving both routing and sequencing rules together and propose a new GPHH algorithm with Cooperative Co-evolution. Our results show that co-evolving the two rules together can lead to much more promising results than evolving the sequencing rule only.

Geometric Crossover in Syntactic Space
João Macedo, Carlos Fonseca, Ernesto Costa
EuroGP 2 - GP in machine learning + Short talks

This paper presents a geometric crossover operator for Tree-Based Genetic Programming that acts on the syntactic space, where each expression tree is represented in prefix notation. The proposed operator is compared to the standard subtree crossover on a symbolic regression problem, on the Santa Fe Ant Trail and on a classification problem. Statistically validated results show that the individuals produced using this method are significantly smaller than those produced by the subtree crossover, and have similar or better performance in the target tasks.

A Comparative Study on Crossover in Cartesian Genetic Programming
Jakub Husa, Roman Kalkreuth
EuroGP 2 - GP in machine learning + Short talks

Cartesian Genetic Programming is often used with mutation as the sole genetic operator. Compared to the comprehensive and detailed knowledge about the effect and use of mutation in CGP, the use of crossover has been less investigated and studied. In this paper, we present a comparative study of previously proposed crossover techniques for Cartesian Genetic Programming. This work also includes the proposal of a new crossover technique which swaps block of the CGP phenotype between two selected parents. The experiments of our study open a new perspective on comparative studies on crossover in CGP and its challenges. Our results show that it is possible for a crossover operator to outperform the standard (1+lambda) strategy on a limited number of tasks. The question of finding a universal crossover operator in CGP remains open.

Comparing Rule Evaluation Metrics for the Evolutionary Discovery of Multi-Relational Association Rules in the Semantic Web

Minh Duc Tran, Claudia d'Amato, Binh Thanh Nguyen, Andrea G. B. Tettamanzi

EuroGP 3 - Short talks + Panel: "GP in the Era of Deep Neural Networks"

We carry out a comparison of popular asymmetric metrics, originally proposed for scoring association rules, as building blocks for a fitness function for evolutionary inductive programming. In particular, we use them to score candidate multi-relational association rules in an evolutionary approach to the enrichment of populated knowledge bases in the context of the Semantic Web. The evolutionary algorithm searches for hidden knowledge patterns, in the form of SWRL rules, in assertional data, while exploiting the deductive capabilities of ontologies. Our methodology is to compare the number of generated rules and total predictions when the metrics are used to compute the fitness function of the evolutionary algorithm. This comparison, which has been carried out on three publicly available ontologies, is a crucial step towards the selection of suitable metrics to score multi-relational association rules that are generated from ontologies.

Investigating a Machine Breakdown Genetic Programming Approach for Dynamic Job Shop Scheduling

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

EuroGP 3 - Short talks + Panel: "GP in the Era of Deep Neural Networks"

Dynamic job shop scheduling (JSS) problems with dynamic job arrivals have been studied extensively in the literature due to their applicability to real-world manufacturing systems, such as semiconductor manufacturing. In a dynamic JSS problem with dynamic job arrivals, jobs arrive on the shop floor unannounced that need to be processed by the machines on the shop floor. A job has a sequence of operations that can only processed on specific machines, and machines can only process one job at a time. Many effective genetic programming based hyper-heuristic (GP-HH) approaches have been proposed for dynamic JSS problems with dynamic job arrivals, where high quality dispatching rules are automatically evolved by GP to handle the dynamic JSS problem instances. However, research that focus on handling multiple dynamic events simultaneously are limited, such as both dynamic job arrivals and machine breakdowns. A machine breakdown event results in the affected machine being unable to process any jobs during the repair time. It is likely that machine breakdowns can significantly affect the effectiveness of the scheduling procedure unless they are explicitly accounted for. Therefore, this paper develops new machine breakdown terminals for a GP approach and evaluates their effectiveness for a dynamic JSS problem with both dynamic job arrivals and machine breakdowns. The results show that the GP approaches with the machine breakdown terminals do show improvements. The analysis shows that the machine breakdown terminals may indirectly contribute in the evolution of high quality rules, but occur infrequently in the output rules evolved by the machine breakdown GP approaches.

Multi-Objective Evolution of Ultra-Fast General-Purpose Hash Functions

David Grochol, Lukas Sekanina

EuroGP 3 - Short talks + Panel: "GP in the Era of Deep Neural Networks"

Hashing is an important function in many applications such as hash tables, caches and Bloom filters. In past, genetic programming was applied to evolve application-specific as well as general-purpose hash functions, where the main design target was the quality of hashing. As hash functions are frequently called in various time-critical applications, it is important to optimize their implementation with respect to the execution time. In this paper, linear genetic programming is combined with NSGA-II algorithm in order to obtain general-purpose, ultra-fast and high-quality hash functions. Evolved hash functions show highly competitive quality of hashing, but significantly reduced execution time in comparison with the state of the art hash functions available in literature.

Analyzing Feature Importance for Metabolomics using Genetic Programming
Ting Hu, Karoliina Oksanen, Weidong Zhang, Edward Randell, Andrew Furey, Guangju Zhai
EuroGP 4 - Best paper nominations

The emerging and fast-developing field of metabolomics ex- amines the abundance of small-molecule metabolites in body fluids to study the cellular processes related to how the human body responds to genetic and environmental perturbations. Considering the complexity of metabolism, metabolites and their represented cellular processes can correlate and synergistically contribute to a phenotypic status. Genetic programming (GP) provides advanced analytical instruments for the investigation of multifactorial causes of metabolic diseases. In this article, we analyzed a population-based metabolomics dataset on osteoarthritis (OA) and developed a Linear GP (LGP) algorithm to search classification models that can best predict the disease outcome, as well as to identify the most important metabolic markers associated with the dis- ease. The LGP algorithm was able to evolve prediction models with high accuracies especially with a more focused search using a reduced feature set that only includes potentially relevant metabolites. We also identified a set of key metabolic markers that may improve our understanding of the biochemistry and pathogenesis of the disease.

On the Automatic Design of a Representation for Grammar-based Genetic Programming
Eric Medvet, Alberto Bartoli
EuroGP 4 - Best paper nominations

A long-standing problem in Evolutionary Computation consists in how to choose an appropriate representation for the solutions. In this work we investigate the feasibility of synthesizing a representation automatically, for the large class of problems whose solution spaces can be defined by a context-free grammar. We propose a framework based on a form of meta-evolution in which individuals are candidate representations expressed with an ad hoc language that we have developed to this purpose. Individuals compete and evolve according to an evolutionary search aimed at optimizing such representation properties as redundancy, locality, uniformity of redundancy. We assessed experimentally three variants of our framework on established benchmark problems and compared the resulting representations to human-designed representations commonly used (e.g., classical Grammatical Evolution). The results are promising in the sense that the evolved representations indeed exhibit better properties than the human-designed ones. Furthermore, while those improved properties do not result in a systematic improvement of search effectiveness, some of the evolved representations do improve search effectiveness over the human-designed baseline.

Scaling Tangled Program Graphs to Visual Reinforcement Learning in ViZDoom

Robert Smith, Malcolm Heywood

EuroGP 4 - Best paper nominations

A tangled program graph framework (TPG) was recently proposed as an emergent process for decomposing tasks and simultaneously composing solutions by organizing code into graphs of teams of programs. The initial evaluation assessed the ability of TPG to discover agents capable of playing Atari game titles under the Arcade Learning Environment. This is an example of 'visual' reinforcement learning, i.e. agents are evolved directly from the frame buffer without recourse to hand designed features. TPG was able to evolve solutions competitive with state-of-the-art deep reinforcement learning solutions, but at a fraction of the complexity. One simplification assumed was that the visual input could be down sampled from a 210 x 160 resolution to 42 x 32. In this work, we consider the challenging 3D first person shooter environment of ViZDoom and require that agents be evolved at the original visual resolution of 320 x 240 pixels. To do so, we address issues with task scenarios performing fitness evaluation over multiple tasks. The resulting TPG solutions retain all the emergent properties of the original work as well as the computational efficiency. Moreover, solutions appear to generalize across multiple task scenarios, whereas equivalent solutions from deep reinforcement learning have focused on single task scenarios alone.

Multi-Level Grammar Genetic Programming for Scheduling in Heterogeneous Networks

Takfarinas Saber, David Fagan, David Lynch, Stepan Kucera, Holger Claussen, Michael O'Neill

EuroGP 4 - Best paper nominations

Co-ordination of Inter-Cell Interference through scheduling enables telecommunication companies to better exploit their Heterogeneous Networks. However, it requires from these entities to implement an effective scheduling algorithm. The state-of-the-art for the scheduling in Heterogeneous Networks is a Grammar-Guided Genetic Programming algorithm which evolves, from a given grammar, an expression that maps to the scheduling of transmissions. We evaluate in our work the possibility of improving the results obtained by the state-of-the-art using a layered grammar approach. We show that starting with a small restricted grammar and introducing the full functionality after 10 generations outperforms the state-of-the-art, even when varying the algorithm used to generate the initial population and the maximum initial tree depth.

List of Abstracts - EvoAPPS

Multi-strategy Differential Evolution

Anil Yaman, Giovanni Iacca, Matt Coler, George Fletcher, Mykola Pechenizkiy

EvoAPPS 1 (EvoNUM & EvoSET)

We propose the Multi-strategy Differential Evolution (MsDE) algorithm to construct and maintain a self-adaptive ensemble of search strategies while solving an optimization problem. The ensemble of strategies is represented as agents that interact with the candidate solutions to improve their fitness. In the proposed algorithm, the performance of each agent is measured so that successful strategies are promoted within the ensemble. We propose two performance measures, and show their effectiveness in selecting successful strategies. We then present three population adaptation mechanisms, based on sampling, clone-best and clone-multiple adaptation schemes. The MsDE with different performance measures and population adaptation schemes is tested on the CEC2013 benchmark functions and compared with basic DE and with Self-Adaptive DE (SaDE). Our results show that MsDE is capable of efficiently adapting the strategies and parameters of DE and providing competitive results with respect to the state-of-the-art.

A Generic Framework for Incorporating Constraint Handling Techniques into Multi-Objective Evolutionary Algorithms

Hiroaki Fukumoto, Akira Oyama

EvoAPPS 1 (EvoNUM & EvoSET)

This paper proposes a generic framework for incorporating constraint handling techniques (CHTs) into multi-objective evolutionary algorithms (MOEAs). Many of CHTs have been developed for constrained single-objective optimization problems (CSOPs) while there are few CHTs that have been developed for CMOPs. The proposed framework enables it to incorporate CHTs for CSOPs into MOEAs, irrespective to the categories of MOEAs. Performances of combined algorithms of five CHTs and four MOEAs are investigated with the proposed framework. The tested benchmark CMOPs are five constrained DTLZ problems and three engineering constrained optimization problems. The experimental results show that there is no single CHT outperforms on every CMOPs in general. However, constraint-domination principle (CDP), which is widely used CHT, and multiple constraint ranking method (MCR), which is a novel CHT, perform better on relatively complex problems.

Late Acceptance Hill Climbing for Constrained Covering Arrays
Mosab Bazargani, John H. Drake, Edmund K. Burke
EvoAPPS 1 (EvoNUM & EvoSET)

The Late Acceptance Hill-Climbing (LAHC) algorithm is a one-point search meta-heuristic with a single parameter. Like Simulated Annealing (SA) it sometimes accepts worsening moves, however it is far more simple and does not require complex parameter setting. In this paper we study an application of LAHC to the Combinatorial Interaction Testing (CIT) problem. CIT is a cost-effective black-box sampling technique for discovering interaction faults in highly configurable systems. There are several techniques for CIT; one of the most established and well-known is Covering Arrays by Simulated Annealing (CASA). CASA is a layered search framework using SA in its most inner layer. Here we replace SA in CASA with LAHC, proposing a new framework, Coverings Array by Late Acceptance (CALA). Our experimental evaluation demonstrates that LAHC yields better or equal quality solutions compared to SA for all but one of the 35 benchmark instances tested.

Search-Based Temporal Testing in an Embedded Multicore Platform
Komsan Srivisut, John Clark, Richard Paige
EvoAPPS 1 (EvoNUM & EvoSET)

Multicore processors have now become the norm. However, for many embedded real-time systems their use introduces challenges in verification as their shared components are potential channels for interference. Of particular interest is the determination for each task of its worst case (longest) execution time (WCET). In this paper, we investigate the effectiveness of a variety of metaheuristic search algorithms for dynamically finding extreme execution times of tasks executing on a multicore processor. Over finite search spaces, these are shown to perform considerably better than randomly generated test inputs and the work reveals significant performance differences between the various algorithms.

Investigating the Evolvability of Web Page Load Time

Brendan Cody-Kenny, Umberto Manganiello, John Farrelly, Adrian Ronayne, Eoghan Considine, Thomas McGuire, Michael O'Neill

EvoAPPS 1 (EvoNUM & EvoSET)

Client-side Javascript execution environments (browsers) allow anonymous functions and event-based programming concepts such as callbacks. We investigate whether a mutate-and-test approach can be used to optimise web page load time in these environments. First, we characterise a web page load issue in a benchmark web page and derive performance metrics from page load event traces. We parse Javascript source code to an AST and make changes to method calls which appear in a web page load event trace. We present an operator based solely on code deletion and evaluate an existing "community-contributed" performance optimising code transform. By exploring Javascript code changes and exploiting combinations of non-destructive changes, we can optimise page load time by 41

On the Use of Repair Methods in Differential Evolution for Dynamic Constrained Optimization

Maria-Yaneli Ameca-Alducin, Maryam Hasani-Shoreh, Frank Neumann

EvoAPPS 2 (EvoSTOC)

Dynamic constrained optimization problems have received increasing attention in recent years. We study differential evolution which is one of the high performing class of algorithms for constrained continuous optimization in the context of dynamic constrained optimization. The focus of our investigations are repair methods which are crucial when dealing with dynamic constrained problems. Examining recently introduced benchmarks for dynamic constrained continuous optimization, we analyze different repair methods with respect to the obtained offline error and the success rate in dependence of the severity of the dynamic change. Our analysis points out the benefits and drawbacks of the different repair methods and gives guidance to its applicability in dependence on the dynamic changes of the objective function and constraints.

Prediction with Recurrent Neural Networks in Evolutionary Dynamic Optimization

Almuth Meier, Oliver Kramer

EvoAPPS 2 (EvoSTOC)

Evolutionary algorithms (EAs) are a good choice to solve dynamic optimization problems. Objective functions changing over time are challenging because after a change the EA has to adapt its population to find the new optimum. Prediction techniques that estimate the position of the next optimum can be incorporated into the EA. After a change, the predicted optimum can be employed to move the EA's population to a promising region of the solution space in order to accelerate convergence and improve accuracy in tracking the optimum. In this paper we introduce a recurrent neural network-based prediction approach. In an experimental study on the Moving Peaks Benchmark and dynamic variants of the Sphere, Rosenbrock, and Rastrigin functions we compare it to an autoregressive prediction approach and an EA without prediction. The results show the competitiveness of our approach and its suitability especially for repeated optima.

A Multi-Objective Time-Linkage Approach for Dynamic Optimization Problems with Previous-Solution Displacement Restriction

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

EvoAPPS 2 (EvoSTOC)

Dynamic optimization problems (DOPs) are optimization problems that change over time and many real-world problems are classified as DOPs. However, most investigations in this domain are focused on tracking moving optima without considering any other objectives and constrains which creates a gap between real-world problems and academic research in this area. One of the important optimi-zation objectives in many real-world problems is previous-solution displacement restriction (PSDR) in which successive solutions should not be much different. PSDRs can be categorized as multi-objective problem in which the first objective is optimality objective and the second one is minimizing the displacement of con-secutive solutions which also can represents the switching cost. Moreover, PSDRs are counted as dynamic time-linkage problems because the current solu-tion will change the next search space. In this paper, we propose new methods for PSDRs based on their characteristics. The experiments are done on moving peaks benchmark (MPB) and the performance of all methods are investigated on it.

A Type Detection Based Dynamic Multi-Objective Evolutionary Algorithm

Shaaban Sahmoud, Haluk Topcuoglu

EvoAPPS 2 (EvoSTOC)

Characterization of dynamism is an important issue for utilizing or tailoring of several dynamic multi-objective evolutionary algorithms (DMOEAs). One such characterization is the change detection, which is based on proposing explicit schemes to detect the points in time when a change occurs. Additionally, detecting severity of change and incorporating with the DMOEAs is another attempt of characterization, where there is only a few related works presented in the literature. In this paper, we propose a type-detection mechanism for dynamic multi-objective optimization problems, which is one of the first attempts that investigate the significance of type detection on the performance of DMOEAs. Additionally, a hybrid technique is proposed which incorporates our type detection mechanism with a given DOMEA. We present an empirical evaluation by using seven test problems from all four types and five performance metrics, which clearly validate the motivation of type detection as well as significance of our hybrid technique.

Robust Evolutionary Optimization Based on Coevolution

Steffen Limmer, Tobias Rodemann

EvoAPPS 2 (EvoSTOC)

A way to deal with uncertainties in the fitness function of an optimization problem is robust optimization, which optimizes the expected value of the fitness. In the context of evolutionary optimization, it is a common practice to compute the expected value of the fitness approximately with the help of Monte-Carlo simulation. This approach requires a lot of evaluations of the fitness function in order to evaluate an individual and thus it can be very compute-intensive.

In the present paper, we propose a coevolution-based approach for the robust optimization of problems with a fitness function basically depending on discrete random variables, which conditionally depend on the decision variables. Experiments on three benchmark functions show that the approach yields a good trade-off between the number of required fitness function evaluations and the quality of the results.

Online-trained Fitness Approximators for Real-world Game Balancing

Mihail Morosan, Riccardo Poli

EvoAPPS 4 - Short talks (EvoGAMES, EvoIASP, EvoROBOT)

Recent work has shown that genetic algorithms are a good choice for use in game design, particularly for finding improved versions of a game's parameters to better fit a designer's requirements. A significant issue with this approach to game optimisation is the very long time it can take to evaluate fitness, since this requires running the target game many times. In this work we test the use of several different fitness approximators, all used in a similar manner, to greatly reduce the number of times a game has to be played for the purpose of fitness evaluation. The approximators use data generated online by the genetic algorithm to train an underlying model. When the model is ready, it is invoked to provide an estimate of the fitness of each newly created individual. If this is worse than a given threshold, it is taken to be the fitness of the individual. Otherwise, the original fitness function is invoked. We assess this approach on two video games Ms PacMan and TORCS. Results are positive and move us one step closer to the goal of a games balancing tool usable in industry.

Recomposing the Pokémon Color Palette

Antonios Liapis

EvoAPPS 4 - Short talks (EvoGAMES, EvoIASP, EvoROBOT)

In digital games, the visual representation of game assets such as avatars or game levels can hint at their purpose, in-game use and strengths. In the Pokémon games, this is particularly prevalent with the namesake creatures' type and the colors in their sprites. To win these games, players choose Pokémon of the right type to counter their opponents' strengths; this makes the visual identification of type important. In this paper, computational intelligence methods are used to learn a mapping between a Pokémon's type and its in-game sprite, colors and shape. This mapping can be useful for a designer attempting to create new Pokémon of certain types. In this paper, instead, evolutionary algorithms are used to create new Pokémon sprites by using existing color information but recombining it into a new palette. Results show that evolution can be applied to Pokémon sprites on a local or global scale, to exert different degrees of designer control and to achieve different goals.Recomposing the Pokémon Color Palette

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Evolving a TORCS Modular Fuzzy Driver using Genetic Algorithms

Mohammed Salem, Antonio Miguel Mora, Juan Julián Merelo, Pablo García-Sánchez

EvoAPPS 4 - Short talks (EvoGAMES, EvoIASP, EvoROBOT)

This work presents an evolutionary approach to optimize the parameters of a Fuzzy-based autonomous driver for the open simulated car racing game (TORCS). Using evolutionary algorithms, we intend to optimize a modular fuzzy agent designed to determine the optimal target speed as well as the steering angle during the race. The challenge in this kind of fuzzy systems is the design of the membership functions, which is usually done through a trial and error process, but in this paper an adapted real-coded Genetic Algorithm with two different fitness functions - has been applied to find the best values for these parameters, obtaining a robust design for the TORCS controller. The evolved drivers were tested and evaluated competing against other TORCS controllers in practice mode, without rivals, and real races. The optimized fuzzy-controllers yield a very good performance, mainly in tracks that have many turning points, which are, in turn, the most difficult for any autonomous agent. Thus, this is a real enhancement of the baseline fuzzy controllers which had several difficulties to drive in this kind of circuits.

Evolution of Convolutional Highway Networks

Oliver Kramer

EvoAPPS 4 - Short talks (EvoGAMES, EvoIASP, EvoROBOT)

Convolutional highways are based on multiple stacked convolutional layers for feature preprocessing. Like many other convolutional networks convolutional highways are parameterized by numerous hyperparameters that have to be tuned carefully. We introduce an evolutionary algorithm (EA) for optimization of the structure and tuning of hyperparameters of convolutional highways and demonstrate the potential of this optimization setting on the well-known MNIST data set. The EA employs Rechenberg's mutation rate control and a niching mechanism to overcome local optima. An experimental study shows that the EA is capable of evolving convolutional highway networks from scratch with only few evaluations achiving an outstanding accuracy of 99

Improving Evolutionary Algorithm Performance for Feature Selection in High-Dimensional Data

Nicole Cilia, Claudio De Stefano, Francesco Fontanella, Alessandra Scotto di Freca

EvoAPPS 4 - Short talks (EvoGAMES, EvoIASP, EvoROBOT)

In classification and clustering problems, selecting a subset of discriminative features is a challenging problem, especially when hundreds or thousands of features are involved. In this framework, Evolutionary Computation (EC) techniques have received a growing scientific interest in the last years, because they are able to explore large search spaces without requiring any a priori knowledge or assumption on the considered domain. Following this line of thought, we developed a novel strategy to improve the performance of EC-based algorithms for feature selection. The proposed strategy requires to rank the whole set of available features according to a univariate evaluation function; then the search space represented by the first M ranked features is searched using an evolutionary algorithm for finding feature subsets with high discriminative power. Results of comparisons demonstrated the effectiveness of the proposed approach in improving the performance obtainable with three effective and widely used EC-based algorithm for feature selection in high dimensional data problems, namely Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO) and Artificial Bees Colony (ABC).

CGP4Matlab - A Cartesian Genetic Programming MATLAB Toolbox for Audio and Image Processing

Rolando Miragaia, Gustavo Reis, Francisco Fernandez, Tiago Inacio Reis, Carlos Grilo

EvoAPPS 4 - Short talks (EvoGAMES, EvoIASP, EvoROBOT)

This paper presents and describes CGP4Matlab, a powerful toolbox that allows to run Cartesian Genetic Programming within MATLAB. This toolbox is particularly suited for signal processing and image processing problems. The implementation of CGP4Matlab, which can be freely downloaded, is described. Some encouraging results on the problem of pitch estimation of musical piano notes achieved using this toolbox are also presented. Pitch estimation of audio signals is a very hard problem with still no generic and robust solution found. Due to the highly flexibility of CGP4Matlab, we managed to apply a new cartesian genetic programming based approach to the problem of pitch estimation. The obtained results are comparable with the state of the art algorithms.

Can the Relevance Index be Used to Evolve Relevant Feature Sets?
Laura Sani, Riccardo Pecori, Emilio Vicari, Michele Amoretti, Monica Mordonini, Stefano Cagnoni
EvoAPPS 4 - Short talks (EvoGAMES, EvoIASP, EvoROBOT)

The Relevance Index (RI) is an information theory-based measure that was originally defined to detect groups of functionally similar neurons, based on their dynamic behavior. More in general, considering the dynamical analysis of a generic complex system, the larger the RI value associated with a subset of variables, the more those variables are strongly correlated with one another and independent from the other variables describing the system status. We describe some early experiments to evaluate whether such an index can be used to extract relevant feature subsets in binary pattern classification problems. In particular, we used a PSO variant to efficiently explore the RI search space, whose size equals the number of possible variable subsets and find the most relevant and discriminating feature subsets with respect to pattern representation. We then turned such relevant subsets into a new smaller set of richer features, whose values depend on the values of the binary features they include. The paper reports some exploratory results we obtained in a simple character recognition task, comparing the performance of RI-based feature extraction and selection with other classical feature selection/extraction approaches.

Evolvable Deep Features
Jakub Nalepa, Grzegorz Mrukwa, Michal Kawulok
EvoAPPS 4 - Short talks (EvoGAMES, EvoIASP, EvoROBOT)

Feature extraction is the first step in building real-life classification engines—it aims at elaborating features to characterize objects that are to be labeled by a trained model. Time-consuming feature extraction requires domain expertise to effectively design features. Deep neural networks (DNNs) appeared as a remedy in this context—their shallow layers perform representation learning, being an automated discovery of various-level features that robustly represent objects. However, the representations that are being learnt are still extremely difficult to interpret, and DNNs are prone to memorizing small datasets. In this paper, we introduce evolvable deep features (EDFs)—a DNN is used to extract automatic features that undergo genetic feature selection. Such evolved features are fed into a supervised learner. The experiments, backed up with statistical tests, performed on multi- and binary-class sets showed that our approach automatically learns object representations, greatly reduces the number of features without deteriorating the performance of trained models, and can even boost their classification performance.

Evolving Artificial Neural Networks for Multi-Objective Tasks

Steven Künzel, Silja Meyer-Nieberg

EvoAPPS 4 - Short talks (EvoGAMES, EvoIASP, EvoROBOT)

Neuroevolution represents a growing research field in Artificial and Computational Intelligence. The adjustment of the network weights and the topology is usually based on a single performance criterion. Approaches that allow to consider several - potentially conflicting - criteria are only rarely taken into account. This paper develops a novel combination of the NeuroEvolution of Augmenting Topologies (NEAT) algorithm with modern indicator-based evolutionary multi-objective algorithms, which enables the evolution of artificial neural networks for multi-objective tasks including a large number of objectives. Several combinations of evolutionary multi-objective algorithms and NEAT are introduced and discussed. The focus lies on variants with modern indicator-based selection since these are considered as efficient methods for higher dimensional tasks. This paper presents the first combination of these algorithms and NEAT. The experimental analysis shows that the novel algorithms are very promising for multi-objective Neuroevolution.

HyperNTM: Evolving Scalable Neural Turing Machines through HyperNEAT

Jakob Merrild, Mikkel Angaju Rasmussen, Sebastian Risi

EvoAPPS 4 - Short talks (EvoGAMES, EvoIASP, EvoROBOT)

Recent developments in memory-augmented neural networks allowed sequential problems requiring long-term memory to be solved, which were intractable for traditional neural networks. However, current approaches still struggle to scale to large memory sizes and sequence lengths. In this paper we show how access to an external memory component can be encoded geometrically through a novel HyperNEAT-based Neural Turing Machine (HyperNTM). The indirect HyperNEAT encoding allows for training on small memory vectors in a bit vector copy task and then applying the knowledge gained from such training to speed up training on larger size memory vectors. Additionally, we demonstrate that in some instances, networks trained to copy nine bit vectors can be scaled to sizes of 1,000 without further training. While the task in this paper is simple, the HyperNTM approach could now allow memory-augmented neural networks to scale to problems requiring large memory vectors and sequence lengths.

Fitness Functions Evaluation for Segmentation of Lymphoma Histological Images using Genetic Algorithm

Thaina Tosta, Paulo Faria, Leandro Neves, Marcelo Nascimento

EvoAPPS 3 - Short talks (EvoBIO, EvoCOMNET, EvoENERGY, EvoINDUSTRY, EvoKNOW)

For disease monitoring, grade definition and treatments orientation, specialists analyze tissue samples to identify structures of different types of cancer. However, manual analysis is a complex task due to its subjectivity. To help specialists in the identification of regions of interest, segmentation methods are used on histological images obtained by the digitization of tissue samples. Besides, features extracted from these specific regions allow for more objective diagnoses by using classification techniques. In this paper, fitness functions are analyzed for unsupervised segmentation and classification of chronic lymphocytic leukemia and follicular lymphoma images by the identification of their neoplastic cellular nuclei through the genetic algorithm. Qualitative and quantitative analyses allowed the definition of the Rényi entropy as the most adequate for this application. Images classification has reached results of 98.14

Automatic segmentation of neurons in 3D samples of human brain cortex

Giacomo Mazzamuto, Irene Costantini, Mattia Neri, Matteo Roffilli, Ludovico Silvestri, Francesco S. Pavone

EvoAPPS 3 - Short talks (EvoBIO, EvoCOMNET, EvoENERGY, EvoINDUSTRY, EvoKNOW)

Quantitative analysis of brain cytoarchitecture requires effective and efficient segmentation of the raw images. This task is highly demanding from an algorith-mic point of view, because of the inherent variations of contrast and intensity in the different areas of the specimen, and of the very large size of the datasets to be processed. Here, we report a machine vision approach based on Convolutional Neural Networks (CNN) for the near real-time segmentation of neurons in three-dimensional images with high specificity and sensitivity. This instrument, together with high-throughput sample preparation and imaging, can lay the basis for a quantitative revolution in neuroanatomical studies.

Analysis of relevance and redundance on Topoisomerase 2b (TOP2B) binding sites: A feature selection approach

Pedro Manuel Martinez Garcia, Miguel Garcia Torres, Federico Divina, Francisco Antonio Gomez-Vela, Felipe Cortes-Ledesma

EvoAPPS 3 - Short talks (EvoBIO, EvoCOMNET, EvoENERGY, EvoINDUSTRY, EvoKNOW)

Topoisomerases are proteins that regulate the topology of DNA and play a key role in the appropriate repair of DNA damages, as they relax supercoiled DNA and carry out decatenation to solve DNA topological problems. In this paper we focus our attention on Topoisomerase 2 (TOP2), whose abnormal activity is an important factor for the appearance of double-strand DNA breaks whose inefficient repair can seriously compromise genomic stability. It is then important to gain insights on the molecular process involved in the TOP2-DNA binding. In order to do this, we we integrated genomic and epigenomic information from published high-throughput sequencing and tiling array experiments in order to create a database. We then applied feature selection mechanisms in order to both increase the performance of classification and to gain insight on the particular properties that are important in the TOP2-DNA binding process. Results obtained can help in identifying a core set of predictive genomic and/or epigenomic features that can be used in order to explain TOP2 binding.

Phase-Space Sampling of Energy Ensembles with CMA-ES

Jörg Bremer, Sebastian Lehnhoff

EvoAPPS 3 - Short talks (EvoBIO, EvoCOMNET, EvoENERGY, EvoINDUSTRY, EvoKNOW)

Smart grid control demands delegation of liabilities to distributed, small energy resources. Resource independent algorithm design demands abstraction from individual capabilities for integration into a general optimization model. For predictive scheduling with high penetration of renewable energy resources, agent approaches have shown good performance especially when using classifier-based decoders for modeling flexibilities. Such decoder-based methods currently are not able to cope with ensembles of individually acting energy resources. Aggregating training sets that are randomly sampled from phase-spaces of single units results in folded distributions with unfavorable properties for training a decoder. Nevertheless, for integrating e.g. a hotel, a small business, or similar with an ensemble of co-generation, heat pump, solar power, or controllable consumers a combined training set is needed. Thus, we improved the training process. We present an approach using evolution strategies for sampling ensembles that moves new instances to better positions according to spread and coverage of the feasible region. As a test case we use CMA-ES and present preliminary results demonstrating the applicability of the proposed approach.

Improving Multi-Objective Evolutionary Influence Maximization in Social Networks

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

EvoAPPS 3 - Short talks (EvoBIO, EvoCOMNET, EvoENERGY, EvoINDUSTRY, EvoKNOW)

In the context of social networks, maximizing influence amounts to contacting the largest possible number of nodes, starting from a small set of seed nodes, and assuming a model for influence propagation. The real-world applications of influence maximization are of uttermost importance, and range from social studies to marketing campaigns. Building on our previous work on multi-objective evolutionary influence maximization, we propose improvements that not only speed up the optimization process considerably, but also deliver higher-quality results. State-of-the-art heuristics are run for different sizes of the seed sets, and the results are then used to seed the initial population of a multi-objective evolutionary algorithm. The algorithm is then able to find better and better solutions, with a much faster convergence when compared to the same algorithm started from scratch. As the most computationally expensive part of the evaluation is the simulation of influence spread, we also consider the possibility of exploiting influence spread approximations found in literature. The proposed approaches are tested on several real-world networks taken from established repositories.

A Classifier to Identify Soft Skills in a Researcher Textual Description

Antonia Azzini, Andrea Galimberti, Stefania Marrara, Eva Ratti

EvoAPPS 3 - Short talks (EvoBIO, EvoCOMNET, EvoENERGY, EvoINDUSTRY, EvoKNOW)

Find Your Doctor (FYD) aims at becoming the first Jobplacement agency in Italy dedicated to PhDs who are undergoing the transition outside Academia. To support the FYD Human Resources team we started a research project aimed at extracting, from texts (questionnaires) provided by a person telling his/her experience, a set of well defined soft skills. The final aim of the project is to produce a list of researchers ranked w.r.t. their degree of soft skills ownership. In the context of this project, this paper presents an approach employing machine learning techniques aimed at classifying the researchers questionnaires w.r.t. a pre-defined soft skills taxonomy. This paper also presents some preliminary results obtained in the "communication" area of the taxonomy, which are promising and worth of further research in this direction.

Evolving Controllers for Electric Vehicle Charging

Martin Pilat

EvoAPPS 3 - Short talks (EvoBIO, EvoCOMNET, EvoENERGY, EvoINDUSTRY, EvoKNOW)

We describe an algorithm to design controllers for the charging of electric vehicles. The controller is represented as a neural network, whose weights are set by an evolutionary algorithm in order to minimize the changes in the overall electrical consumption. The presented algorithm provides de-centralized controllers that also respect the privacy of the owner of electric vehicles, i.e. the controller does not share the information about charging with any third party. The presented controllers also require only a very small amount of memory and computational resources and are thus suitable for implementation in embedded systems.

Integrating Evolution Strategies into Genetic Algorithms with Fuzzy Inference Evaluation to solve a Steelmaking and Continuous Casting Scheduling Problem.

Eduardo Salazar

EvoAPPS 3 - Short talks (EvoBIO, EvoCOMNET, EvoENERGY, EvoINDUSTRY, EvoKNOW)

This contribution presents a metaheuristic approach that integrates evolution strat-egies into genetic algorithms using a fuzzy rule based inference system to evalu-ate schedules in a generalized steelmaking and continuous casting production sys-tem. The genetic algorithm controls the job sequences assigned to the machines while the setting of jobs initial processing dates at the converter are optimize by means of evolution strategies. The fuzzy inference system gives an overall eval-uation of the schedule quality by controlling discontinuities and transit times with different degrees of acceptance throughout the evolution process. This approach integrates an embedded search procedure to overcome one of the weaknesses of metaheuristic scheduling methods of setting initial dates for task processing and is especially suited for highly nonlinear objective functions as in this case. A gen-eral structure of the steelmaking and continuous casting production system is consider with an arbitrary number of machines at each stage, with production of several steel grades and types (e.g. slabs and billets). Technological constraints such as continuous casting between jobs (batches) and in process time of liquid steel are included. For illustration purposes, a real sized problem is solve.

Automatic generation of constructive heuristics for multiple types of combinatorial optimisation problems with grammatical evolution and geometric graphs

Christopher Stone, Emma Hart, Ben Paechter

EvoAPPS 3 - Short talks (EvoBIO, EvoCOMNET, EvoENERGY, EvoINDUSTRY, EvoKNOW)

In many industrial problem domains, when faced with a combinatorial optimisation problem, a "good enough, quick enough" solution to a problem is often required. Simple heuristics often suffice in this case. However, for many domains, a simple heuristic may not be available, and designing one can require considerable expertise. Noting that a wide variety of problems can be represented as graphs, we describe a system for the automatic generation of constructive heuristics in the form of Python programs by mean of grammatical evolution. The system can be applied seamlessly to different graph-based problem domains, only requiring modification of the fitness function. We demonstrate its effectiveness by generating heuristics for the Travelling Salesman and Multi-Dimensional Knapsack problems. The system is shown to be better or comparable to human-designed heuristics in each domain. The generated heuristics can be used 'out-of-the-box' to provide a solution, or to augment existing hyper-heuristic algorithms with new low-level heuristics.

Maximizing the effect of local disturbance in the dynamics of opinion formation

Long Him Cheung, Ka Wai Cheung, Kwok Yip Szeto

EvoAPPS 3 - Short talks (EvoBIO, EvoCOMNET, EvoENERGY, EvoINDUSTRY, EvoKNOW)

The dynamics of opinion formation process in a social network is of great interest for many non-equilibrium systems, such as election, competition of market share in advertising etc.. By introducing local disturbance in the social network, such as the implantation of an agent, we can use numerical simulation to measure the effect of this agent on the result of the election, which has a deadline. By extending the statistical physics of damage spreading in spin models on lattice to social network, we investigate the effect of one agent on a two-party election on the time to dominance as a function of the given time to the deadline of the election. We find that certain rewiring mechanism of the social network will enhance the speed to dominance by the party that implant the agent. Using genetic algorithm, we also find good methods of rewiring that can greatly increase the efficiency of the agent. Our model used is the Ising model and the network used is Watts-Strogatz network. We perform Monte Carlo simulations on the effect of interaction and use a genetic algorithm with a mutation matrix to find the best way of rewiring to amplify the effect of the agent in influencing the result of the election. We also discuss the general topological feature of an optimal rewiring condition in maximizing the effect of the local disturbance in opinion formation.

Rotation Invariance and Rotated Problems: An Experimental Study on Differential Evolution

Fabio Caraffini, Ferrante Neri

EvoAPPS 3 - Short talks (EvoBIO, EvoCOMNET, EvoENERGY, EvoINDUSTRY, EvoKNOW)

This paper presents an experimental study on the efficacy of a rotation-invariant Differential Evolution (based on current-to-rand mutation) on a benchmark of test problems in its non-rotated and rotated version. Numerical results show that standard Differential Evolution outperforms rotation-invariant Differential Evolution on the benchmark under consideration for both non-rotated and rotated problems. In other words, the rotation-invariant Differential Evolution does not seem to be more efficient than its standard counterpart to address rotated problems. According to our interpretation, these experimental results show that rotated problems are simply different problems with respect to the non-rotated problems. Furthermore, rotation-invariant Differential Evolution is characterised by its moving operator: it generates an offspring by perturbing all the design variables of a candidate solution at the same time. This logic does not appear to guarantee a better performance on rotated problems.

A Genetic Algorithm for Community Detection in Attributed Graphs

Clara Pizzuti, Annalisa Socievole

EvoAPPS 5 (EvoPAR & EvoCOMPLEX)

A genetic algorithm for detecting a community structure in attributed graphs is proposed. The method optimizes a fitness function that combines node similarity and structural connectivity. The communities obtained by the method are composed by nodes having both similar attributes and high link density. Experiments on synthetic networks and a comparison with five state-of-the-art methods show that the genetic approach is very competitive and obtains network divisions more accurate than those obtained by the considered methods.

Accelerating the Computation of Solutions in Resource Allocation Problems Using an Evolutionary Approach and Multiagent Reinforcement Learning

Ana Bazzan

EvoAPPS 5 (EvoPAR & EvoCOMPLEX)

In systems composed by a high number of highly coupled components, aligning the optimum of the system with the optimum of those individual components can be conflicting, especially in situations in which resources are scarce. In order to deal with this, many authors have proposed forms of biasing the optimization process. However, mostly, this works for cooperative scenarios. When resources are scarce, the components compete for them, thus those solutions are not necessarily appropriate. In this paper a new approach is proposed, in which there is a synergy between: (i) a global optimization process in which the system authority employs metaheuristics, and (ii) reinforcement learning processes that run at each component or agent. Both the agents and the system authority exchange solutions that are incorporated by the other party. The contributions are twofold: we propose a general scheme for such synergy and show its benefits in scenarios related to congestion games.

A CPU-GPU parallel Ant Colony Optimization solver for the Vehicle Routing Problem

Antón Rey-Villaverde, Manuel Prieto, Ignacio Gómez, Christian Tenllado, J. Ignacio Hidalgo

EvoAPPS 5 (EvoPAR & EvoCOMPLEX)

This paper shows a new hybrid approach based on Ant Colony Optimization algorithms, a route-first cluster-second method and some local search procedures which generates high quality solutions for the Capacited Vehicle Routing Problem. This method uses the parallel computing power of modern general purpose GPUs and multicore CPU, and it outperforms the current ACO-based VRP solvers both on quality and convergence time, while it also shows to be a competitive approach comparing to current best known metaheuristics.

Mapping Chess Aesthetics onto Procedurally Generated Chess-like Games
Jakub Kowalski, Antonios Liapis, Lukasz Zarczynski
EvoAPPS 6 (EvoGAMES)

Variants of chess have been generated in many forms and for several reasons, such as testbeds for artificial intelligence research in general game playing. This paper uses the visual properties of chess pieces as inspiration to generate new shapes for other chess-like games, targeting specific visual properties which allude to the pieces' in-game function. The proposed method uses similarity measures in terms of pieces' strategic role and movement in a game to identify the new pieces' closest representatives in chess. Evolution then attempts to minimize the distance from chess pieces' visual properties, resulting in new shapes which combine one or more chess pieces' visual identities. While experiments in this paper focus on two chess-like games from previous publications, the method can be used for broader generation of game visuals based on functional similarities of components to known, popular games.

Piecemeal Evolution of a First Person Shooter Level
Antonios Liapis
EvoAPPS 6 (EvoGAMES)

This paper describes an iterative process for generating multi-story shooter game levels by means of interlocking rooms evolved individually. The process is highly controllable by a human designer who can specify the entrances to this room as well as its size, its distribution of game objects and its architectural patterns. The small size of each room allows for computationally fast evaluations of several level qualities, but these rooms can be combined into a much larger shooter game level. Each room has two floors and is generated iteratively, with two stages of evolution and two stages of constructive post-processing. Experiments in generating an arena-based level for two teams spawning in different rooms demonstrate that the placement and allocation of entrances on each floor have a strong effect on the patterns of the final level.

Self-Adaptive MCTS for General Video Game Playing

Chiara F. Sironi, Jialin Liu, Diego Perez-Liebana, Raluca D. Gaina, Ivan Bravi, Simon M. Lucas, Mark H. M. Winands

EvoAPPS 6 (EvoGAMES)

Monte Carlo Tree Search (MCTS) has shown particular success in General Game Playing (GGP) and General Video Game Playing (GVGP) and many enhancements and variants have been developed. Recently, an on-line adaptive parameters tuning mechanism for MCTS agents has been proposed that almost achieves the same performance as off-line tuning in GGP. In this paper we apply the same approach to GVGP and use the popular General Video Game AI (GVGAI) framework, in which the time allowed to make a decision is only 40ms. We design three Self-Adaptive MCTS (SA-MCTS) agents that optimize on-line the parameters of a standard non-Self-Adaptive MCTS agent of GVGAI. The three agents select the parameter values using Naive Monte-Carlo, an Evolutionary Algorithm and an N-Tuple Bandit Evolutionary Algorithm respectively, and are tested on 20 single-player games of GVGAI. The SA-MCTS agents achieve more robust results on the tested games. With the same time setting, they perform similarly to the baseline standard MCTS agent in the games for which the baseline agent performs well, and significantly improve the win rate in the games for which the baseline agent performs poorly. As validation, we also test the performance of non-Self-Adaptive MCTS instances that use the most sampled parameter settings during the on-line tuning of each of the three SA-MCTS agents for each game. Results show that these parameter settings improve the win rate on the games Wait for Breakfast and Escape by 4 times and 150 times, respectively.

Deceptive Games

Damien Anderson, Matthew Stephenson, Julian Togelius, Christoph Salge, John Levine, Jochen Renz

EvoAPPS 6 (EvoGAMES)

Deceptive games are games where the reward structure or other aspects of the game are designed to lead the agent away from a globally optimal policy. While many games are already deceptive to some extent, we designed a series of Video Game Description Language games following specific deception types, classified by the cognitive biases they exploit. The games are implemented in the General Video Game Artificial Intelligence Framework, making it possible to test a variety of existing AI agents that have been submitted to the GVGAI Competition on these deceptive games. Our results show that all tested agents are vulnerable to several kinds of deception, but that different agents have different weaknesses. This suggests that we can use deception to understand the capabilities of a game-playing algorithm, and game-playing algorithms to characterize the deception displayed by a game.

Adapting Bagging and Boosting to Learning Classifier Systems

Yi Liu, Xue Bing, Will N. Browne

EvoAPPS 7 (EvoIASP)

Learning Classifier Systems (LCSs) have demonstrated their classification capability by employing a population of polymorphic rules in addressing numerous benchmark problems. However, although the produced solution is often accurate, the alternative ways to represent the data in a single population obscure the underlying patterns of a problem. Moreover, once a population is dominated by over-general rules, the system will sink into the local optimal trap. To grant a problem's patterns more transparency, the redundant rules and optimal rules need to be distinguished. Therefore, the bagging method is introduced to LCSs with the aim to reduce the variance associated with redundant rules. A novel rule reduction method is proposed to reduce the rules' polymorphism in a problem. This is tested with complex binary problems with typical epistatic, over-lapping niches, niche-imbalance, and specific-addiction properties at various scales. The results show the successful highlighting of the patterns for all the tested problems, which have been addressed successfully. Moreover, by combining the boosting method with LCSs, the hybrid system could adjust previously defective solutions such that they now represent the correct classification of data. Keywords: Learning classifier systems, Multiple domain learning, Ensemble learning

Towards Evolutionary Super-Resolution

Michal Kawulok, Pawel Benecki, Daniel Kostrzewa, Lukasz Skonieczny

EvoAPPS 7 (EvoIASP)

Super-resolution reconstruction (SRR) allows for producing a high-resolution (HR) image from a set of low-resolution (LR) observations. The majority of existing methods require tuning a number of hyper-parameters which control the reconstruction process and configure the imaging model that is supposed to reflect the relation between high and low resolution. In this paper, we demonstrate that the reconstruction process is very sensitive to the actual relation between LR and HR images, and we argue that this is a substantial obstacle in deploying SRR in practice. We propose to search the hyper-parameter space using a genetic algorithm (GA), thus adapting to the actual relation between LR and HR, which has not been reported in the literature so far. The results of our extensive experimental study clearly indicate that our GA improves the capacities of SRR. Importantly, the GA converges to different values of the hyper-parameters depending on the applied degradation procedure, which is confirmed using statistical tests.

Estimation of the 3D pose of an object using correlation filters and CMA-ES

Juan Carlos Dibene, Kenia Picos, Victor Diaz-Ramirez, Leonardo Trujillo

EvoAPPS 7 (EvoIASP)

Object recognition is a widely studied problem in computer vision. Template matching with correlation filters is one of the most accurate strategies for target recognition. However, it is computationally expensive, particularly when there is no restriction in the pose of the object of interest and an exhaustive search is implemented. This work proposes the use of a Covariance Matrix Adaptation Evolution Strategy (CMA-ES) for post-processing template matched filters. The proposed strategy searches for the best template matching guided by the discrimination capability of a correlation-based filter, considering a vast set of filters. CMA-ES is used to find the best match and determine the correct pose or orientation parameters of a target object. The proposed method demonstrates that CMA-ES is effective for multidimensional problems in a huge search space, which makes it a suitable candidate for target recognition in unconstrained applications. Experimental results show high efficiency in terms of the number of function evaluations and locating the correct pose parameters based on the DC measure.

An Automatic Feature Extraction Approach to Image Classification Using Genetic Programming

Ying Bi, Bing Xue, Mengjie Zhang

EvoAPPS 7 (EvoIASP)

Feature extraction is an essential process for image data dimensionality reduction and classification. However, feature extraction is very difficult and often requires human intervention. Genetic Programming (GP) can achieve automatic feature extraction and image classification but the majority of existing methods extract low-level features from raw images without any image-related operations. Furthermore, the work on the combination of image-related operators/descriptors in GP for feature extraction and image classification is limited. This paper proposes a multi-layer GP approach (MLGP) to performing automatic high-level feature extraction and classification. A new program structure, a new function set including a number of image operators/descriptors and two region detectors, and a new terminal set are designed in this approach. The performance of the proposed method is examined on six different data sets of varying difficulty and compared with five GP based methods and 42 traditional image classification methods. Experimental results show that the proposed method achieves better or comparable performance than these baseline methods. Further analysis on the example programs evolved by the proposed MLGP method reveals the good interpretability of MLGP and gives insight into how this method can effectively extract high-level features for image classification.

Task Classification using Topological Graph Features for Functional M/EEG Brain Connectomics

Javier Del Ser, Eneko Osaba, Miren Nekane Bilbao

EvoAPPS 8 (EvoBIO & EvoBAFIN)

In the last few years the research community has striven to achieve a thorough understanding of the brain activity when the subject under analysis undertakes both mechanical tasks and purely mental exercises. One of the most avant-garde approaches in this regard is the discovery of connectivity patterns among different parts of the human brain unveiled by very diverse sources of information (e.g. magneto- or electro-encephalography – M/EEG, functional and structural Magnetic Resonance Imaging – fMRI and sMRI, or positron emission tomography – PET), coining the so-called brain connectomics discipline. Surprisingly, even though contributions related to the brain connectome abound in the literature, far too little attention has been paid to the exploitation of such complex spatial-temporal patterns to classify the task performed by the subject while brain signals are being registered. This manuscript covers this research niche by elaborating on the extraction of topological features from the graph modeling the brain connectivity under different tasks. By resorting to public information from the Human Connectome Project, the work will show that a selected subset of topological predictors from M/EEG connectomes suffice for accurately predicting (with average accuracy scores of up to 95

Mutual Information Iterated Local Search: A Wrapper-Filter Hybrid for Feature Selection in Brain Computer Interfaces

Jason Adair, Alexander Brownlee, Gabriela Ochoa

EvoAPPS 8 (EvoBIO & EvoBAFIN)

Brain Computer Interfaces provide a very challenging classification task due to small numbers of instances, large numbers of features, non-stationary problems, and low signal-to-noise ratios. Feature selection (FS) is a promising solution to help mitigate these effects. Wrapper FS methods are typically found to outperform filter FS methods, but reliance on cross-validation accuracies can be misleading due to overfitting. This paper proposes a filter-wrapper hybrid based on Iterated Local Search and Mutual Information, and shows that it can provide more reliable solutions, where the solutions are more able to generalise to unseen data. This study further contributes comparisons over multiple datasets, something that has been uncommon in the literature.

Feature Selection for Detecting Gene-gene Interactions in Genome-wide Association Studies

Faramarz Dorani, Ting Hu

EvoAPPS 8 (EvoBIO & EvoBAFIN)

Disease association studies aim at finding the genetic variations underlying complex human diseases in order to better understand the etiology of the disease and to provide better diagnoses, treatment, and even prevention. The non-linear interactions among multiple genetic factors play an important role in finding those genetic variations, but have not always been taken fully into account. This is due to the fact that searching combinations of interacting genetic factors becomes inhibitive as its complexity grows exponentially with the size of data. It is especially challenging for genome-wide association studies (GWAS) where typically more than a million single-nucleotide polymorphisms (SNPs) are under consideration. Dimensionality reduction is thus needed to allow us to investigate only a subset of genetic attributes that most likely have interaction effects. In this article, we conduct a comprehensive study by examining six widely used feature selection methods in machine learning for filtering interacting SNPs rather than the ones with strong individual main effects. Those six feature selection methods include chi-square, logistic regression, odds ratio, and three Relief-based algorithms. By applying all six feature selection methods to both a simulated and a real GWAS datasets, we report that Relief-based methods perform the best in filtering SNPs associated with a disease in terms of strong interaction effects.

Multi-objective Cooperative Coevolutionary Algorithm with Dynamic Species-Size Strategy

Karoon Suksonghong, Kittipong Boonlong

EvoAPPS 8 (EvoBIO & EvoBAFIN)

Although numbers of heuristic algorithms are successfully developed for solving portfolio optimization problems, this is not for all cases of the large scale ones. A large-scale portfolio optimization involves dealing with the large search space and dense variance-covariance matrix associated with the problem. This paper proposed a new multi-objective algorithm for solving a large-scale optimization problem based upon the notion of cooperative coevolutionary algorithms (CCA). The new problem decomposition scheme was designed by allowing the species-size to be dynamically adjusted as the runs progress. This scheme enhances capability of traditional CCA in dealing with non-separable optimization problem. The collaborator selection method was modified to allow the proposed CCA to perform in a multi-objective (MO) optimization framework. Additionally, the proposed algorithm, named as DMOCCA, was implemented for solving large-scale portfolio optimization problem with cardinality constraint using the real-world data set having scale up to 2196 dimensions. Moreover, its performances were benchmarked with those of the SPEA-II and MOPSO.

Combining MAP-Elites and Incremental Evolution to Generate Gaits for a Mammalian Quadruped Robot

Jørgen Nordmoen, Kai Olav Ellefsen, Kyrre Glette

EvoAPPS 9 (EvoROBOT)

Four-legged mammals are capable of showing a great variety of movement patterns, ranging from a simple walk to more complex movement such as trots and gallops. Imbuing this diversity to quadruped robots is of interest in order to improve both mobility and reach. Within the field of Evolutionary Robotics, Quality Diversity techniques have shown a remarkable ability to produce not only effective, but also highly diverse solutions. When applying this approach to four-legged robots an initial problem is to create viable movement patterns that do not fall. This difficulty stems from the challenging fitness gradient due to the mammalian morphology. In this paper we propose a solution to overcome this problem by implementing incremental evolution within the Quality Diversity framework. This allows us to evolve controllers that become more complex while at the same time utilizing the diversity produced by Quality Diversity. We show that our approach is able to generate high fitness solutions early in the search process, keep these solutions and perform a more open-ended search towards the end of evolution.

Search Space Analysis of Evolvable Robot Morphologies
Karine Miras, Evert Haasdijk, Kyrre Glette, A. E. Eiben
EvoAPPS 9 (EvoROBOT)

We present a study on morphological traits of evolved modular robots. We note that the evolutionary search space –the set of obtainable morphologies– depends on the given representation and reproduction operators and we propose a framework to assess morphological traits in this search space regardless of a specific environment and/or task. To this end, we present eight quantifiable morphological descriptors and a generic novelty search algorithm to produce a diverse set of morphologies for any given representation. With this machinery, we perform a comparison between a direct encoding and a generative encoding. The results demonstrate that our framework permits to find a very diverse set of bodies, allowing a morphological diversity investigation. Furthermore, the analysis showed that despite the high levels of diversity, a bias to certain traits in the population was detected. Surprisingly, the two encoding methods showed no significant difference in the diversity levels of the evolved morphologies or their morphological traits.

Revolve: A Versatile Simulator for Online Robot Evolution
Elte Hupkes, Milan Jelisavcic, A. E. Eiben
EvoAPPS 9 (EvoROBOT)

Developing robotic systems that can evolve in real-time and real-space is a long term objective with technological as well as algorithmic milestones on the road. Technological prerequisites include advanced 3D-printing, automated assembly, and robust sensors and actuators. The necessary evolutionary mechanisms need not wait for these, they can be developed and investigated in simulations. In this paper, we present a system to simulate online evolution of constructible robots, where 1) the population members (robots) concurrently exist and evolve their morphologies and controllers, 2) all robots can be physically constructed. Experiments with this simulator provide us with insights into differences of using online and offline evolutionary setups.

Evolving a Repertoire of Controllers for a Multi-Function Swarm

Sondre A. Engebraten, Jonas Moen, Oleg Yakimenko, Kyrre Glette

EvoAPPS 9 (EvoROBOT)

Automated design of swarm behaviors with a top-down approach is a challenging research question that has not yet been fully addressed in the robotic swarm literature. This paper seeks to explore the possibility of using an evolutionary algorithm to evolve, rather than hand code, a wide repertoire of behavior primitives enabling more effective control of a large group or swarm of unmanned systems. We use the MAP-Elites algorithm to generate a repertoire of controllers with varying abilities and behaviors allowing the swarm to adapt to user-defined preferences by selection of a new appropriate controller. To test the proposed method we examine two example applications: perimeter surveillance and network creation. Perimeter surveillance require agents to explore, while network creation requires them to disperse without losing connectivity. These are distinct applications that have drastically different requirements on agent behavior, and are a good benchmark for our swarm controller optimization framework. We show a performance comparison between a simple weighted controller and a parametric controller. Finally, evolving controllers allows for specifying desired behaviors top-down, in terms of objectives to solve, rather than bottom-up.

Evaluating the Performance of an Evolutionary Tool for Exploring Solution Fronts

Neil Urquhart

EvoAPPS 10 (EvoINDUSTRY & General track)

EvoFilter is an evolutionary algorithm based tool for searching through large non-dominated fronts in order to find a subset of solutions that are of interest to the user. EvoFilter is designed to take the output of existing Multi Objective Evolutionary Algorithms and act as a decision support tool for users. Currently EvoFilter is available for all to use on-line [**?**]. This paper evaluates the performance of EvoFilter by creating a large number of randomised filter specifications which are then applied using EvoFilter and a simple filter to a range of non-dominated fronts created by a portfolio of Multi Objective Genetic Algorithms (MOGAs). The results show that EvoFilter is capable of finding sets of solutions that meet the users' requirements more closely than those found using the simple filter. EvoFilter increases performance on some objectives by including relevant solutions event if these solutions slightly lessen performance on other objectives. The filter discussed in this paper may be accessed online.

Toward the Online Visualisation of Algorithm Performance for Parameter Selection

David Walker, Matthew Craven

EvoAPPS 10 (EvoINDUSTRY & General track)

A visualisation method is presented that is intended to assist evolutionary algorithm users with the parametrisation of their algorithms. The visualisation method presents the convergence and diversity properties such that different parametrisations can be easily compared, and poor performing parameter sets can be easily identified and discarded. The efficacy of the visualisation is presented using a set of benchmark optimisation problems from the literature, as well as a benchmark water distribution network design problem. Results show that it is possible to observe the different performance caused by different parametrisations. Future work discusses the potential of this visualisation within an online tool that will enable a user to discard poor parametrisations as they execute to free up resources for better ones.

CardNutri: A software of Weekly Menus Nutritional Elaboration for Schoolar Feeding applying Evolutionary Computation

Rafaela Moreira, Elizabeth Wanner, Flavio Martins, Joao Sarubbi

EvoAPPS 10 (EvoINDUSTRY & General track)

This paper aims to present and evaluate a software that uses an evolutionary strategy to design weekly nutritional menus for School Feeding. The software ensures the nutritional needs of students and also minimizes the total cost of the menu. We based our nutritional needs on the Brazilian National School Feeding Programme (PNAE). This program takes into account: (i) the age of the student; (ii) some preparations issues as color, consistency and, variety; and also (iii) the maximum amount to be paid per meal. Our software generates, in less than five minutes, a set of menus, and the nutritionist can choose the menu that suits his/her best. We evaluate our algorithm using the weighted-sum approach, and our results show that the obtained 5-days menus using the proposed methodology not only comply with the restrictions imposed by the authorities but also produce inexpensive and healthy menus. We also appraise the software itself using an opinion pool among nine nutritionists. The professionals considered our software above expectations.

Multimodal Transportation Network Design Using Physarum Polycephalum-Inspired Multi-agent Computation Methods

Rishi Vanukuru, Nagendra R. Velaga

EvoAPPS 12 (EvoCOMNET)

In this paper, a new approach towards P. Polycephalum inspired computational efforts is proposed, with specific application to the problem of Multimodal transportation network design for planned cities of the future. Working with a multi-agent model of the Physarum Polycephalum, parallels are drawn between agent properties and mode characteristics, and agents are allowed to dynamically change from one mode to another. A mechanism to compare the performance of resultant multimodal networks against single mode networks involving the same component modes is demonstrated. The observations point to the potential applicability of the new approach in city planning and design.

Social Relevance Index for Studying Communities in a Facebook Group of Patients

Laura Sani, Gianfranco Lombardo, Riccardo Pecori, Paolo Fornacciari, Monica Mordonini, Stefano Cagnoni

EvoAPPS 12 (EvoCOMNET)

Identifying Relevant Sets, i.e., variable subsets that exhibit a coordinated behavior, in complex systems is a very interesting and studied topic. Systems that exhibit complex dynamics are, for example, social networks, since they are characterized by complex and dynamic relationships among users. A challenging topic in this context regards the identification of communities or subsets of users, both within the whole network and within specific groups. We applied the Relevance Index method, which has been shown to be effective in many situations, to the study of communities of users in the Facebook group of the Italian association of patients affected by Hidradenitis Suppurativa. Since the need for computing the Relevance Index for each possible variable subset of users makes the exhaustive computation unfeasible, we resorted to the help of an efficient niching evolutionary metaheuristic, hybridized with local searches. The communities detected through the aforementioned method have been studied to search similarities in terms of number of posts, sentiments, number of contacts, roles, behaviors, etc. The results demonstrate that it is possible to detect such subsets of users in the particular Facebook group we analyzed.

A fast metaheuristic for the design of DVB-T2 networks

Fabio D'Andreagiovanni, Antonella Nardin

EvoAPPS 12 (EvoCOMNET)

In order to better exploit scarce radio spectrum resources, the second generation of the Digital Video Broadcasting - Terrestrial standard (DVB-T2) has been developed and is under adoption in many countries, especially in Europe, for providing digital television services. The switch from the first to the second generation of DVB-T will require new DVB-T2 operators to design their new networks and old DVB operators to reconfigure their existing networks to better adapt to the features and opportunities of the new services. In this work, we propose an optimization model and a fast metaheuristic for the design of DVB-T2 networks. The metaheuristic is based on combining a probabilistic variable fixing procedure with an exact large neighborhood search and is developed to tackle the unsatisfying performance of state-of-the-art optimization solvers when adopted to solve realistic instances. Computational tests on realistic instances show that our metaheuristic can find solutions of much better quality than those identified by a state-of-the-art optimization solver.

Many-objective optimization of mission and hybrid electric power system of an unmanned aircraft

Teresa Donateo, Claudia Lucia De Pascalis, Antonio Ficarella

EvoAPPS 11 (EvoENERGY)

This work aims at comparing different many-objective techniques for the optimization of a hybrid electric power system for aircraft. In particular, this works considers, as input of the optimization, the specification of the flight mission, the size of the main components and the energy management strategy for a Medium Altitude Long Endurance Unmanned Aerial Vehicle (MALE-UAV). The goals of the optimization are maximization of electric endurance, minimization of overall fuel consumption, improvement of take-off performance and minimization of the additional volume of the hybrid electric solution with respect to the initial conventional powertrain. The optimization methods considered in this study are those included in the ModeFRONTIER optimization environment: NSGA-II, MOGA-II, MOSA and Evolutionary Strategy. Initially, appropriate metrics are used to compare the proposed methods in a simplified problem with only two objective functions. Then a complete optimization is performed, in order to underline the degradation of the proposed optimization methods as the size of the problem increases and to define the best method according to the number of objective functions.

Network Coordinated Evolution: Modeling and Control of Distributed Systems through On-Line Genetic PID-Control Optimization Search

Holm Smidt, Matsu Thornton, Reza Ghorbani

EvoAPPS 11 (EvoENERGY)

The evolution of the modern power grid has evident challenges as increasing renewable distributed energy resources are outpacing grid adaptation. With increasing availability and access to real-time sensors and actuators for equipment, distributed control and optimization mechanisms are coming within technical and economic reach. Applying these now feasible mechanisms to known and existing technologies in-place brings rise to new opportunities for the integration of distributed energy resources. This work demonstrated the use of evolutionary computation in finding optimal control parameters of refrigeration systems whose dynamics are unknown and difficult to estimate. By networking evolutionary processes through administrative layers in the form of cyber-physical graph database models, controllers can be deployed at scale and then configured through genetic search algorithms and network interfaces. The premise and direction of this work focuses on leveraging relational information inferred from the graph database to improve the efficiency of the evolutionary process.

Achieving Optimized Decisions on Battery Operating Strategies in Smart Buildings

Jan Müller, Mischa Ahrens, Ingo Mauser, Hartmut Schmeck

EvoAPPS 11 (EvoENERGY)

Battery energy storage systems are a key to the utilization of renewable energies, allowing for short-term storage of electricity and balancing of energy generation and consumption. However, the optimal operation of these systems is still an area of research. This paper presents operating strategies and their optimization with respect to total operational energy costs in buildings that are equipped with automated building energy management systems. The presented approach uses an evolutionary algorithm to set the parameters of the battery system controller for a rolling horizon. The combination of scheduling and control is chosen to aim at robustness against deviations of local loads from predictions. Scenarios comprising different electricity tariffs and the optimization of three operating strategies are simulated and evaluated. The results show that the operating strategies and their optimization lead to significantly different results, reflecting their ability to cope with uncertainty of future consumption and generation.

List of Abstracts - EvoCOP

On the Fractal Nature of Local Optima Networks

Sarah L. Thomson, Sébastien Verel, Gabriela Ochoa, Nadarajen Veerapen, Paul McMenemy

EvoCOP 1 - Landscape Analysis and Operators

A Local Optima Network represents fitness landscape connectivity within the space of local optima as a mathematical graph. In certain other complex networks or graphs there have been recent observations made about inherent self-similarity. An object is said to be self-similar if it shows the same patterns when measured at different scales; another word used to convey self-similarity is fractal. The fractal dimension of an object captures how the detail observed changes with the scale at which it is measured, with a high fractal dimension being associated with complexity. We conduct a detailed study on the fractal nature of the local optima networks of a benchmark combinatorial optimisation problem (NK Landscapes). The results draw connections between fractal characteristics and performance by three prominent metaheuristics: Iterated Local Search, Simulated Annealing, and Tabu Search.

An Evolutionary Algorithm with Practitioner's-Knowledge-Based Operators for the Inventory Routing Problem

Piotr Lipinski, Krzysztof Michalak

EvoCOP 1 - Landscape Analysis and Operators

This paper concerns the Inventory Routing Problem (IRP) which is an optimization problem addressing the optimization of transportation routes and the inventory levels at the same time. The IRP is notable for its difficulty - even finding feasible initial solutions poses a significant problem. In this paper an evolutionary algorithm is proposed that uses approaches to solution construction and modification utilized by practitioners in the field. The population for the EA is initialized starting from a base solution which in this paper is generated by a heuristic, but can as well be a solution provided by a domain expert. Subsequently, feasibility-preserving moves are used to generate the initial population. In the paper dedicated recombination and mutation operators are proposed which aim at generating new solutions without lofeasibility. In order to reduce the search space, solutions in the presented EA are encoded as lists of routes with the quantities to be delivered determined by a supplying policy. The presented work is a step towards utilizing domain knowledge in evolutionary computation. The EA presented in this paper employs mechanisms of solution initialization capable of generating a set of feasible initial solutions of the IRP in a reasonable time. Presented operators generate new feasible solutions effectively without requiring a repair mechanism.

How Perturbation Strength Shapes the Global Structure of TSP Fitness Landscapes

Paul McMenemy, Nadarajen Veerapen, Gabriela Ochoa

EvoCOP 1 - Landscape Analysis and Operators

Local optima networks are a valuable tool used to analyse and visualise the global structure of combinatorial search spaces; in particular, the existence and distribution of multiple funnels in the landscape. We extract and analyse the networks induced by Chained-LK, a powerful iterated local search for the TSP, on a large set of randomly generated (Uniform and Clustered) instances. Results indicate that increasing the perturbation strength employed by Chained-LK modifies the landscape's global structure, with the effect being markedly different for the two classes of instances. Our quantitative analysis shows that several funnel metrics have stronger correlations with Chained-LK success rate than the number of local optima, indicating that global structure clearly impacts search performance.

An Ant Colony Approach for the Winner Determination Problem

Abhishek Ray, Mario Ventresca

EvoCOP 1 - Landscape Analysis and Operators

Combinatorial auctions are those where bidders can bid on bundles of items. These auctions can lead to more economically efficient allocations, but determining the winners is an NP-complete problem. In this paper, we propose an ant colony technique for approximating solutions to hard instances of this problem. Hard instances are those that are unsolvable within 601 second by CPLEX and have more than 1000 bids on 500 or more unique items. Such instances occur in real world applications such as 4th Party Logistics auctions, online resource time sharing auctions and the sale of spectrum licenses by the Federal Communications Commission. We perform experiments on 10 such instances to show and compare the performance of the proposed approach to CPLEX (Branch-and-Bound), stochastic greedy search, random walk and memetic algorithm. Results indicate that in a given runtime, CPLEX results lie within the third quartile of the values generated using our approach for 3 of 10 of the instances. In addition, CPLEX results are on average 0.24% lower than best values reported using our approach for 5 of 10 instances. Further, our approach performs statistically significantly better than other heuristics on all instances.

Automatic grammar-based design of heuristic algorithms for unconstrained binary quadratic programming

Marcelo de Souza, Marcus Ritt

EvoCOP 2 - Hyper-heuristics and Automatic Configuration

Automatic methods have been applied to find good heuristic algorithms to combinatorial optimization problems. These methods aim at reducing human efforts in the trial-and-error search for promising heuristic strategies. We propose a grammar-based approach to the automatic design of heuristics and apply it to binary quadratic programming. The grammar represents the search space of algorithms and parameter values. A solution is represented as a sequence of categorical choices, which encode the decisions taken in the grammar to generate a complete algorithm. We use an iterated F-race to evolve solutions and tune parameter values. Experiments show that our approach can find algorithms which perform better than or comparable to state-of-the-art methods, and can even find new best solutions for some instances of standard benchmark sets.

Data Clustering Using Grouping Hyper-heuristics

Anas Elhag, Ender Ozcan

EvoCOP 2 - Hyper-heuristics and Automatic Configuration

Grouping problems represent a class of computationally hard to solve problems requiring optimal partitioning of a given set of items with respect to multiple criteria varying dependent on the domain. A recent work proposed a general-purpose selection hyper-heuristic search framework with reusable components, designed for rapid development of grouping hyper-heuristics to solve grouping problems. The framework was tested only on the graph colouring problem domain. Extending the previous work, this study compares the performance of selection hyper-heuristics implemented using the framework, pairing up various heuristic/operator selection and move acceptance methods for data clustering. The selection hyper-heuristic performs the search processing a single solution at any decision point and controls a fixed set of generic low level heuristics specifically designed for the grouping problems based on a bi-objective formulation. An archive of high quality solutions, capturing the trade-off between the number of clusters and overall error of clustering, is maintained during the search process. The empirical results verify the effectiveness of a successful selection hyper-heuristic, winner of a recent hyper-heuristic challenge for data clustering on a set of benchmark problem instances.

Automatic Algorithm Configuration for the Permutation Flow Shop Scheduling Problem Minimizing Total Completion Time

Artur Brum, Marcus Ritt

EvoCOP 2 - Hyper-heuristics and Automatic Configuration

Automatic algorithm configuration aims to automate the often time-consuming task of designing and evaluating search methods. We address the permutation flow shop scheduling problem minimizing total completion time with a context-free grammar that defines how algorithmic components can be combined to form a full heuristic search method. We implement components from various works from the literature, including several local search procedures. The search space defined by the grammar is explored with a racing-based strategy and the algorithms obtained are compared to the state of the art.

Reference Point Adaption Method for Genetic Programming Hyper-heuristic in Many-Objective Job Shop Scheduling

Atiya Masood, Gang Chen, Yi Mei, Mengjie Zhang

EvoCOP 2 - Hyper-heuristics and Automatic Configuration

Job Shop Scheduling (JSS) is considered to be one of the most significant combinatorial optimization problems in practice. It is widely evidenced in the literature that JSS usually contains many (four or more) potentially conflicting objectives. One of the promising and successful approaches to solve the JSS problem is Genetic Programming Hyper-Heuristic (GP-HH). This approach automatically evolves dispatching rules for solving JSS problems. This paper aims to evolve a set of effective dispatching rules for many-objective JSS with genetic programming and NSGA-III. NSGA-III originally defines uniformly distributed reference points in the objective space. Thus, there will be few reference points with no Pareto optimal solutions associated with them; especially, in the cases with discrete and non-uniform Pareto front, resulting in many useless reference points during evolution. In other words, these useless reference points adversely affect the performance of NSGA-III and genetic programming. To address the above issue, in this paper a new reference point adaptation mechanism is proposed based on the distribution of the candidate solutions. We evaluated the performance of the proposed mechanism on many-objective benchmark JSS instances. Our results clearly show that the proposed strategy is promising in adapting reference points and outperforms the existing state-of-the-art algorithms for many-objective JSS

MOEA/DEP: An Algebraic Decomposition-based Evolutionary Algorithm for the Multi-objective Permutation Flowshop Scheduling Problem

Marco Baioletti, Alfredo Milani, Valentino Santucci

EvoCOP 3 - Multi-objective + Late-Breaking Abstracts

Algebraic evolutionary algorithms are an emerging class of meta-heuristics for combinatorial optimization based on strong mathematical foundations. In this paper we introduce a decomposition-based algebraic evolutionary algorithm, namely MOEA/DEP, in order to deal with multiobjective permutation-based optimization problems. As a case of study, MOEA/DEP has been experimentally validated on a multiobjective permutation flowshop scheduling problem (MoPFSP). In particular, the makespan and total flowtime objectives have been investigated. Experiments have been held on a widely used benchmark suite, and the obtained results have been compared with respect to the state-of-the-art Pareto fronts for MoPFSP. The experimental results have been analyzed by means of two commonly used performance metrics for multiobjective optimization. The analysis clearly shows that MOEA/DEP reaches new state-of-the-art results for the considered benchmark.

Better Runtime Guarantees Via Stochastic Domination

Benjamin Doerr

EvoCOP 4 - Best paper nominations

Apart from few exceptions, the mathematical runtime analysis of evolutionary algorithms is mostly concerned with expected runtimes. In this work, we argue that stochastic domination is a notion that should be used more frequently in this area. Stochastic domination allows to formulate much more informative performance guarantees than the expectation alone, it allows to decouple the algorithm analysis into the true algorithmic part of detecting a domination statement and probability theoretic part of deriving the desired probabilistic guarantees from this statement, and it allows simpler and more natural proofs. As particular results, we prove a fitness level theorem which shows that the runtime is dominated by a sum of independent geometric random variables, we prove tail bounds for several classic problems, and we give a short and natural proof for Witt's result that the runtime of any (μ, p) mutation-based algorithm on any function with unique optimum is subdominated by the runtime of a variant of the (1+1) EA on the onemax function.

Worst improvement based iterated local search

Sara Tari, Matthieu Basseur, Adrien Goëffon

EvoCOP 4 - Best paper nominations

To solve combinatorial optimization problems, many metaheuristics use first or best improvement hill-climbing as intensification mechanism in order to find local optima. In particular, first improvement offers a good tradeoff between computation cost and quality of reached local optima. In this paper, we investigate a worst improvement-based moving strategy, never considered in the literature. Such a strategy is able to reach good local optima despite requiring a significant additional computation cost. Here, we investigate if such a pivoting rule can be efficient when considered within metaheuristics, and especially within iterated local search (ILS). In our experiments, we compare an ILS using a first improvement pivoting rule to an ILS using an approximated version of worst improvement pivoting rule. Both methods are launched with the same number of evaluations on bit-string based fitness landscapes. Results are analyzed using some landscapes' features in order to determine if the worst improvement principle should be considered as a moving strategy in some cases.

A multistart alternating tabu search for commercial districting

Alex Gliesch, Marcus Ritt, Mayron C.O. Moreira

EvoCOP 4 - Best paper nominations

In this paper we address a class of commercial districting problems that arises in the context of the distribution of goods. The problem aims at partitioning an area of distribution, which is modeled as an embedded planar graph, into connected components, called districts. Districts are required to be mutually balanced with respect to node attributes, such as number of customers, expected demand, and service cost, and as geometrically-compact as possible, by minimizing their Euclidean diameters. To solve this problem, we propose a multistart algorithm that repeatedly constructs solutions greedily and improves them by two alternating tabu searches, one aiming at achieving feasibility through balancing and the other at maximizing district compactness. Computational experiments confirm the effectiveness of the different components of our method and show that it significantly outperforms the current state of the art, improving known upper bounds in almost all instances.

List of Abstracts - EvoMUSART

Musical Organisms: a generative approach to growing musical scores

Anna Lindemann, Eric Lindemann

EvoMusArt 1 - Short talks

In this paper, we describe the creation of Musical Organisms using a novel generative music composition approach modeled on biological evolutionary and developmental (Evo Devo) processes. We are interested in using the Evo Devo processes that generate biological organisms with diverse and interesting structures—structures that exhibit modularity, repetition, and hierarchy—in order to create diverse music compositions that exhibit these same structural properties. The current focus of our work has been on Musical Organism development. Our Musical Organisms are musical scores that develop from a single musical note, just as a biological organism develops from a single cell. We describe the musical genome and the non-linear dynamical processes that drive the development of the Musical Organism from single note to complex musical score. While the evolution of Musical Organisms has not been our central focus, we describe how evolution can act upon genomic variation within populations of Musical Organisms to create new Musical Organism species with diverse and complex structures. And we introduce the concept of genome embedding as a unique method for generating genetic variation in a population, and developing structural modularity in Musical Organisms.

Medical art therapy of the future: building an interactive virtual underwater world in a children's hospital

Ludivine Lechat, Lieven Menschaert, Tom De Smedt, Lucas Nijs, Monica Dhar, Koen Norga, Jaan Toelen

EvoMusArt 1 - Short talks

We are developing an interactive virtual underwater world with the aim to reduce stress and boredom in hospitalised children, to improve their quality of life, by employing an evidence-based design process and by using techniques from Artificial Life and Human-Computer Interaction. A 3D motion sensing camera tracks the activity of children in front of a wall projection. As they wave their hands, colorful sea creatures paddle closer to say hi and interact with the children.

Dynamical Music with Musical Boolean Networks

George Gabriel, Susan Stepney

EvoMusArt 1 - Short talks

An extended Boolean network model is investigated as a possible medium in which a human composer can write music. A Boolean network is a simple discrete-time dynamical system whose state is characterised by the states of its constituent Boolean-valued vertices. The evolution of the system is predetermined by an initial state and the properties of the activation functions associated with each vertex. By associating musical events with the states of the system, its trajectory from a particular start state can be interpreted as a piece of tonal music. The primary source of interest in composing music using a deterministic dynamical system is the dependence of the musical result on the initial conditions. This paper explores the possibility of producing musically interesting variations on a given melodic phrase by changing the initial conditions from which the generating dynamical system is started.

Adaptive interface for mapping body movements to sounds

Dimitrije Markovic, Nebojsa Malesevic

EvoMusArt 1 - Short talks

Contemporary digital musical instruments allow an abundance of means to generate sound. Although superior to traditional instruments in terms of producing a unique audio-visual act, there is still an unmet need for digital instruments that allow performers to generate sounds through movements in an intuitive manner. One of the key factors for an authentic digital music act is a low latency between movements (user commands) and corresponding sounds. Here we present such a low-latency interface that maps the user's kinematic actions into sound samples. The interface relies on wireless sensor nodes equipped with inertial measurement units and a real-time algorithm dedicated to the early detection and classification of a variety of movements/gestures performed by a user. The core algorithm is based on the approximate inference of a hierarchical generative model with piecewise-linear dynamical components. Importantly, the model's structure is derived from a set of motion gestures. The performance of the Bayesian algorithm was compared against the k-nearest neighbors (k-NN) algorithm, which showed the highest classification accuracy, in a pre-testing phase, among several existing state-of-the-art algorithms. In almost all of the evaluation metrics the proposed probabilistic algorithm outperformed the k-NN algorithm.

evoExplore: Multiscale Visualization of Evolutionary Histories in Virtual Reality

Justin Kelly, Christian Jacob

EvoMusArt 1 - Short talks

evoExplore is a system built for virtual reality (VR) and designed to assist evolutionary design projects. Built with the Unity 3D game engine and designed with future development and expansion in mind, evoExplore allows the user to review and visualize data collected from evolutionary design experiments. Expanding upon existing work, evoExplore provides the tools needed to breed your own evolving populations of designs, save the results from such evolutionary experiments and then visualize the recorded data as an interactive VR experience. evoExplore allows the user to dynamically explore their own evolutionary experiments, as well as those produced by other users. In this document we describe the features of evoExplore, its use of virtual reality and how it supports future development and expansion.

Towards Partially Automatic Search of Edge Bundling Parameters

Evgheni Polisciuc, Filipe Assunção, Penousal Machado

EvoMusArt 1 - Short talks

Edge bundling methods are used in flow maps and graphs to reduce the visual clutter, which is generated when representing complex and heterogeneous data. Nowadays, there are many edge bundling algorithms that have been successfully applied to a wide range of problems in graph representation. However, the majority of these methods are still difficult to use and apply on real world problems by the experts from other areas. This is due to the complexity of the algorithms and concepts behind them, as well as a strong dependence on their parametrization. In addition, the majority of edge bundling methods need to be fine-tuned when applied on different datasets. This paper presents a new approach that helps finding near-optimal parameters for solving such issues in edge bundling algorithms, regardless of the configuration of the input graph. Our method is based on evolutionary computation, allowing the users to find edge bundling solutions for their needs. In order to understand the effectiveness of the evolutionary algorithm in such kind of tasks, we performed experiments with automatic fitness functions, as well as with partially user-guided evolution. We tested our approach in the optimization of the parameters of two different edge bundling algorithms. Results are compared using objective criteria and a critical discussion of the obtained graphical solutions.

Construction of a repertoire of analog Form-finding techniques as a basis for computational morphological exploration in design and architecture

Ever Patiño, Jorge Maya

EvoMusArt 1 - Short talks

The article describes the process of constructing a repertoire of form-finding analog techniques, which can be used in evolutionary computation to (i) compare the techniques among them and select the most suitable for a project, (ii) to explore forms or shapes in an analogue and/or manual way, (iii) as a basis for the development of algorithms in specialized software, (iv) or to understand the physical processes and mathematical procedures of the techniques. To our knowledge no one has built a repertoire of this nature, since all the techniques are in sources of diverse disciplines. Methodologically, the construction process was based on a systematic review of the literature, allowing us to identify 33 techniques where the principles of bio inspiration and self-organization are evident, characteristics both of form-finding strategies. As a result, we present the repertoire structure, composed of five groups of techniques sharing similar physical processes: inflate, group, de-construct, stress, solidify and fold. Subsequently, the repertoire's conceptual, mathematical, and graphical analysis categories are presented. Finally, conclusions of potential applications and research trends of the subject are presented.

Generative Solid Modelling Employing Natural Language Understanding and 3D Data

Marinos Koutsomichalis, Björn Gambäck

EvoMusArt 1 - Short talks

The paper describes an experimental system for generating 3D-printable models inspired by arbitrary textual input. Utilizing a transliteration pipeline, the system pivots on Natural Language Understanding technologies and 3D data available via online repositories to result in a bag of retrieved 3D models that are then concatenated in order to produce original designs. Such artefacts celebrate a post-digital kind of objecthood, as they are concretely physical while, at the same time, incorporate the cybernetic encodings of their own making. Twelve individuals were asked to reflect on some of the 3D-printed, physical artefacts. Their responses suggest that the created artefacts succeed in triggering imagination, and in accelerating moods and narratives of various sorts.

Non-photorealistic Rendering with Cartesian Genetic Programming using Graphics Processing Units

Illya Bakurov, Brian Ross

EvoMusArt 2 - Visual arts

A non-photorealistic rendering system implemented with Cartesian genetic programming (CGP) is discussed. The system is based on Baniasadi's NPR system using tree-based GP. The CGP implementation uses a more economical representation of rendering expressions compared to the tree-based system. The system borrows their many-objective fitness evaluation scheme, which uses a model of aesthetics, colour testing, and image matching. GPU acceleration of the paint stroke application results in up to 6 times faster rendering times compared to CPU-based renderings. The convergence dynamics of CGP's mu+lambda evolutionary strategy was more unstable than conventional GP runs with large populations. One possible reason may be the sensitivity of the smaller mu+lambda population to the many-objective ranking scheme, especially when objectives are in conflict with each other. This instability is arguably an advantage as an exploratory tool, especially when considering the subjectivity inherent in evolutionary art.

Towards a General Framework for Artistic Style Transfer

Florian Uhde, Sanaz Mostaghim

EvoMusArt 2 - Visual arts

In recent times, artificial intelligence has become more sophisticated when it comes to the creation of fine arts. Especially in the area of painting, artificial methods reached a new level of maturity in the process of replicating perceptual quality. These systems are able to separate style and content of given images, enabling them to recombine and mutate the facets to create novel content. This work defines a general framework for conducting artistic style transfer. This allows recombination and structured modification of state of the art algorithms for further investigation and profiling of artistic style transfer.

The Light Show: Flashing Fireflies Gathering and Flying over Digital Images

Paulo Urbano

EvoMusArt 2 - Visual arts

Computational Generative Art has been inspired by complex collective tasks made by social insects like the ants, which are able to coordinate through local interactions and simple stochastic behavior. In this paper we present the Light Show, an application of the mechanism of flash synchronization exhibited by some species of fireflies. The virtual fireflies form The Light Show gather and fly over digital readymades, self-choreographing the rhythm of illumination of their artistic habitats. We present a standard model with some design parameters able to control synchronization and also a variation able to exhibit clusters of synch at different phases that grow, fight, disappear or win, illuminating different parts of a digital image in an animated process.

Deep Interactive Evolution

Philip Bontrager, Wending Lin, Julian Togelius, Sebastian Risi

EvoMusArt 2 - Visual arts

This paper describes an approach that combines generative adversarial networks (GANs) with interactive evolutionary computation (IEC). While GANs can be trained to produce lifelike images, they are normally sampled randomly from the learned distribution, providing limited control over the resulting output. On the other hand, interactive evolution has shown promise in creating various artifacts such as images, music and 3D objects, but traditionally relies on a hand-designed evolvable representation of the target domain. The main insight in this paper is that a GAN trained on a specific target domain can act as a compact and robust genotype-to-phenotype mapping (i.e. most produced phenotypes do resemble valid domain artifacts). Once such a GAN is trained, the latent vector given as input to the GAN's generator network can be put under evolutionary control, allowing controllable and high-quality image generation. In this paper, we demonstrate the advantage of this novel approach through a user study in which participants were able to evolve images that strongly resemble specific target images.

On Collaborator Selection in Creative Agent Societies: An Evolutionary Art Case Study

Simo Linkola, Otto Hantula

EvoMusArt 2 - Visual arts

We study how artistically creative agents may learn to select favorable collaboration partners. We consider a society of creative agents with varying skills and aesthetic preferences able to interact with each other by exchanging artifacts or through collaboration. The agents exhibit interaction awareness by modeling their peers and make decisions about collaboration based on the learned peer models. To test the peer models, we devise an experimental collaboration process for evolutionary art, where two agents create an artifact by evolving the same artifact set in turns. In an empirical evaluation, we focus on how effective peer models are in selecting collaboration partners and compare the results to a baseline where agents select collaboration partners randomly. We observe that peer models guide the agents to more beneficial collaborations.

Learning as Performance: Autoencoding and Generating Dance Movements in Real Time

Alexander Berman, Valencia James

EvoMusArt 3 - Music & Dance

This paper describes the technology behind a performance where human dancers interact with an "artificial" performer projected on a screen. The system learns movement patterns from the human dancers in real time. It can also generate novel movement sequences that go beyond what it has been taught, thereby serving as a source of inspiration for the human dancers, challenging their habits and normal boundaries and enabling a mutual exchange of movement ideas. It is central to the performance concept that the system's learning process is perceivable for the audience. To this end, an autoencoder neural network is trained in real time with motion data captured live on stage. As training proceeds, a "pose map" emerges that the system explores in a kind of improvisational state. The paper shows how this method is applied in the performance, and shares observations and lessons made in the process.

Expressive Piano Music Playing Using a Kalman Filter

Alexandra Bonnici, Maria Mifsud, Kenneth Camilleri

EvoMusArt 3 - Music & Dance

In this paper, we present an algorithm that uses the Kalman filter to combine simple phrase structure models with observed differences in pitch within the phrase to refine the phrase model and hence adjust the loudness level and tempo of qualities of the melody line. We show how similar adjustments may be made to the accompaniment to introduce expressive attributes to a midi file representation of a score. In the paper, we show that the subjects had some difficulty in distinguishing between the resulting expressive renderings and human performances of the same score.

Co-Evolving Melodies and Harmonization in Evolutionary Music Composition

Olav Olseng, Bjoern Gambaeck

EvoMusArt 3 - Music & Dance

The paper describes a novel multi-objective evolutionary algorithm implementation that generates short musical ideas consisting of a melody and abstract harmonization, developed in tandem. The system is capable of creating these ideas based on provided material or autonomously. Three automated fitness features were adapted to the model to evaluate the generated music during evolution, and a fourth was developed to ensure harmonic progression. Four rhythmical pattern matching features were also developed. 21 pieces of music, produced by the system under various configurations, were evaluated in a user study. The results indicate that the system is capable of composing musical ideas that are subjectively interesting and pleasant, but not consistently.

RoboJam: A Musical Mixture Density Network for Collaborative Touchscreen Interaction

Charles Martin, Jim Torresen

EvoMusArt 3 - Music & Dance

RoboJam is a machine-learning system for generating music that assists users of a touchscreen music app by performing responses to their short improvisations. This system uses a recurrent artificial neural network to generate sequences of touchscreen interactions and absolute timings, rather than high-level musical notes. To accomplish this, RoboJam's network uses a mixture density layer to predict appropriate touch interaction locations in space and time. In this paper, we describe the design and implementation of RoboJam's network and how it has been integrated into a touchscreen music app. A preliminary evaluation analyses the system in terms of training, musical generation and user interaction.

Visual art inspired by the collective feeding behavior of sand-bubbler crabs

Hendrik Richter

EvoMusArt 4 - Best paper nominations

Sand-bubblers are crabs of the genera Dotilla and Scopimera which are known to produce remarkable patterns and structures at tropical beaches. From these pattern-making abilities, we may draw inspiration for digital visual art. A simple mathematical model of sand- bubbler patterns is proposed and an algorithm is designed that may create such patterns artificially. In addition, design parameters to modify the patterns are identified and analyzed by computational aesthetic measures. Finally, an extension of the algorithm is discussed that may enable controlling and guiding generative evolution of the art-making process.

Generating drums rhythms through data-driven conceptual blending of features and genetic algorithms

Maximos Kaliakatsos-Papakostas

EvoMusArt 4 - Best paper nominations

Conceptual blending allows the emergence of new conceptual spaces by blending two input spaces. Using conceptual blending for inventing new concepts has been proven a promising technique for computational creativity. Especially in music, recent work has shown that proper representations of the input spaces allows the generation of consistent and sometimes surprising blends. The paper at hand proposes a novel approach to conceptual blending through the combination of higher-level features extracted from data; the field of application is drums rhythms. Through this methodology, the input rhythms are represented by 32 extracted features. After their generic space of similar features is computed, a simple amalgam-based methodology creates a blended set of an as equally as possible divided number of the most salient features from each input. This blended set of features acts as the target vector for a Genetic Algorithm that outputs the rhythm that best captures the blended features; this rhythm is called the blended rhythm. The salience of each feature in each rhythm in the database of input rhythms is computed from data and reflects the uniqueness of features. Preliminary results shed some light on how feature blending works on the generation of drums rhythms and new possible research directions for data-driven feature blending are proposed.

Evotype: Towards the Evolution of Type Stencils

Tiago Martins, João Correia, Ernesto Costa, Penousal Machado

EvoMusArt 4 - Best paper nominations

Typefaces are an essential resource employed by graphic designers. The increasing demand for innovative type design work increases the need for good technological means to assist the designer in the creation of a typeface. We present an evolutionary computation approach for the generation of type stencils to draw coherent glyphs for different characters. The proposed system employs a Genetic Algorithm to evolve populations of type stencils. The evaluation of each candidate stencil uses a hill climbing algorithm to search the best configurations to draw the target glyphs. We study the interplay between legibility, coherence and expressiveness, and show how our framework can be used in practice.

Late-breaking Abstracts

Selecting an optimal number of particles to fit large network computational models with random PSO

José-Ignacio Hidalgo, Carlos Cervigón, David Martínez-Rodríguez, Rafael-Jacinto Villanueva

EvoStar Poster Session and conference reception

In the recent times, we have been presented several works studying the transmission dynamics of the Human Papillomavirus (HPV). To do so, we have designed and implemented a computational model where the contagion of the HPV is described on a network of lifetime sexual partners. Having the model is not enough, since we need to find the model parameters that best fit the model to available data of prevalence of HPV in women. To fit the model we implemented a rPSO algorithm in previous works. The implementation is computationally expensive since, in order to evaluate a single particle we need to run a simulation of the model (with networks of 250 thousands nodes or more) for around 65 minutes. Hence, the number of particles to be used in rPSO should be decided carefully looking for a compromise between quality of the solutions and computation time. Here, we investigate the configuration of the distributed rPSO in order to get the best algorithm performance in terms not only of the quality of the solutions, but also of the computation time. Our results shows that a configuration with 30 particles, for the available machine, obtains a similar or even better quality as 64 particles. As each particle is run on a single processor, reducing the number of particles allows us to free 29-34 processors for other computational tasks.

MAENERGY: A tool for measuring and analyzing evolutionary algorithms energy consumption in mobile devices.

Francisco Chavez, Borja Rodriguez-Puerta, Francisco Fernandez de Vega

EvoStar Poster Session and conference reception

Energy consumption is a growing concern in our society. In the field of computing has been a problem studied since the appearance of large computing infrastructures. Nowadays, the energy study has also been transferred to smaller devices, such as smartphones or tablets. Among other advances improvements are being made in the algorithms that are executed in mobile devices that allow a better energy efficiency.

In this work we have focused on the study of Evolutionary Algorithms and how they can be improved to be more efficient from the point of view of energy savings. For this, we have focused on the use of genetic algorithms in mobile devices, thanks to their high capacities that they begin to incorporate, making it possible to execute more complex systems every time.

For a correct execution of this type of algorithms in mobile devices, we must know the energy consumption they perform, to adapt the tasks to the particular capabilities of the device where they are executed, hence the need to have a tool to measure this consumption of energy. In this document we present the first version of a tool that allows us to measure the consumption that a genetic algorithm performs when it is executed on a mobile device.

The Need to Transform Evolutionary Computation Research

Darrell Whitley

EvoCOP 3 - Multi-objective + Late-Breaking Abstracts

It is almost an article of faith that all evolutionary algorithms utilize random mutation. This level of randomness might have some justification in natural evolution in a dynamically changing environment. However when solving combinatorial optimization problems, random mutation is often unnecessary and unproductive.

Another recent trend is to characterize all evolutionary algorithms as “Black Box Optimizers" where nothing is known about the objective function. Unfortunately, “Black Box Optimizers" are subject to the restrictions of No Free Lunch theorems. More recent No Free Lunch proofs hold over finite and tractable sets of functions, making this a serious concern.

Black box optimizers using random operators are doom to fail in any competition with more intelligent forms of search. Today, all competitive MAXSAT and Graph Coloring heuristic search methods deterministically compute the location of improving moves in constant time. New proofs show that these same methods hold over all k-bounded pseudo Boolean functions. Just as all SAT problems can be reduced to a MAX-3SAT instance, all problems that have a bit representation can be transformed into a k-bounded pseudo Boolean function. This raises an important challenge to all researchers working in evolutionary computation. Why does the field ignore these advances and continue to use random and blind black box operators?

In domains such as MAXSAT and the Traveling Salesman Problem, we can also prove that new deterministic forms of recombination can offer new performance guarantees. If the parents are known to be local optima, all of the offspring are proven to also be locally optimal in largest hyperplane subspace that contains both parents.

We argue that the only way for evolutionary algorithms to be competitive is to abandon “black box optimization" and adopt more intelligent search methods. The result is a form of Gray Box Optimization where knowledge about problem structure is actively and explicitly exploited.

Ant colony optimization for a multi-criteria generalized job-shop scheduling problem

Fatima Ghedjati

EvoCOP 3 - Multi-objective + Late-Breaking Abstracts

We provide interesting results for a multi-criteria generalized job-shop scheduling problem using Ant Colony Optimization.

A distributed multiple Ant Colony algorithm to solve a steel industry scheduling problem

Silvino Fernandez Alzueta, Pablo Valledor Pellicer, Jorge Rodil Martínez, Segundo Álvarez García, Eneko Malatsetxebarria Elizegi

EvoCOP 3 - Multi-objective + Late-Breaking Abstracts

The production of steel is a very complex process, with several stages involved in its transformation from coal and iron ore to many potential steel formats. Within current digitalization initiatives, there is a wide range of combinatorial problems alongside the process where optimization techniques, and particularly metaheuristics, have proven its importance to enhance daily results. These solutions provide several advantages such as objective criteria to optimize the operations independently of subjective human opinion, fast reaction under sudden incidents, avoid human errors, and powerful computation capacities to explore solutions.

In the industry, disruptions are unfortunately common events, such as arrivals of urgent orders or machine breakdowns, making recalculations imperative, while foremen wait for new instructions to operate. Hence, it is mandatory to exploit as much as possible the anytime behavior of metaheuristics, to find good solutions faster. Parallelization is a powerful tool to achieve this objective and is an inherent property of metaheuristics, opening a wide range of possibilities to accelerate the calculations, reducing computation time and assuring a good solution to face incidents.

In this study, we present preliminary results on the application of a distributed architecture of multiple ant colonies on a real-word problem with the aim of optimizing the schedule of orders in a production facility. The different colonies share their best solutions to improve efficiency while reducing the computing time. The proposed algorithm is compared to the single-colony solution that is currently in operation proving better results in the problem instances evaluated.

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