EVOSTAR CONFERENCE HANDBOOK

EvoStar conferences held in Copenhagen
8-10 April 2015

Overview Programme

Wednesday 8 April				
0845-0930	Registrations			
0930-0945	Conference opening			
0945-1045	Plenary invited talk: Pierre-Yves Oudeyer : *Open-Source Baby Robots for Science, Education & Art*			
1045-1120	Coffee break			
		room 1	room 2	room 3
1120-1300		EuroGP 1	EvoMusArt 1	EvoApplications 1
1300-1415	Lunch			
1415-1555		EuroGP 2	EvoMusArt 2	EvoApplications 2
1555-1620	Coffee break			
1620-1800		EuroGP 3	EvoMusArt 3	EvoApplications 3
1815-1945	EvoStar poster session in conjunction with conference reception			
		EuroGP posters	EvoMusArt posters	EvoAPPLICATIONS posters

Thursday 9 April				
		room 1	room 2	room 3
0930-1110		EuroGP 4	EvoCOP 1	EvoApplications 4
1110-1135	Coffee break			
1135-1315		EvoApplications 5	EvoCOP 2	EvoApplications 6
1315-1430	Lunch			
1430-1610		EvoApplications 7	EvoCOP 3	EvoApplications 8
1610-1630	Coffee break			
1630-1810		EvoApplications 9	EvoCOP 4	EvoApplications 10
1830-1930	Boat tour			
1930-2200	Conference dinner			

Friday 10 April				
		room 1	room 2	room 3
0930-1110		EvoApplications 11	EvoCOP 5 best papers	EvoApplications 12
1110-1130	Coffee break			
1130-1230	Plenary invited talk: Paulien Hogeweg : *Non-random random mutations: Evolution of Genotype-Phenoptype mapping*			
1230-1300	Conference closing, best paper presentations, general announcements incl 2016 location			
1300-1345	Lunch			
1400-1700	Optional afternoon walking tour of old Copenhagen plus Tivoli Gardens or other attractions			

Acknowledgements

EvoStar is grateful for the support from the following :

Invited speakers **Pierre-Yves Oudeyer**, from INRIA Paris and
Paulien Hogeweg from Utrecht University in the Netherlands

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

The **National Museum of Denmark** at Copenhagen
especially Dorthe Langkilde and Pernille Strandby

Aalborg University Copenhagen for hosting the conference dinner

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Sebastian Risi (IT University of Copenhagen)

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for EvoStar coordination and financial administration

EvoStar Handbook prepared by **Jennifer Willies**, EvoStar Coordinator
EvoStar logo design by **Mauro Castelli**

Contents

EvoStar 2015 Organisers

EuroGP

18th European Conference on Genetic Programming

EuroGP programme chairs :
Malcolm Heywood, Dalhousie University, Canada
Penousal Machado, University of Coimbra, Portugal

EuroGP publication chair :
James McDermott University College Dublin, Ireland

EvoCOP

15th European Conference on Evolutionary Computation in Combinatorial Optimisation

EvoCOP programme chairs :
Gabriela Ochoa, University of Stirling, UK
Francisco Chicano, University of Malaga, Spain

EvoMUSART

4th International Conference on Evolutionary and Biologically Inspired Music, Sound, Art and Design

EvoMUSART programme chairs :
Colin Johnson, University of Kent, UK
Adrián Carballal, University of A Coruña, Spain

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

EvoAPPLICATIONS

17th European Conference on the Applications of Evolutionary Computation

EvoApplications coordinator :
Antonio Mora, University of Granada, Spain

EvoAPPS publication chair :
Giovanni Squillero, Politecnico di Torino, Italy

Track chairs :
EvoBIO : Evolutionary Computation, Machine Learning and Data Mining in Computational Biology
William S. Bush, Case Western Reserve, USA
Federico Divina, Universidad Pablo de Olavide, Sevilla, Spain

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

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

EvoStar 2015 Organisers

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

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

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

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

EvoNUM : Bio-inspired algorithms for continuous parameter optimization
Anna I Esparcia-Alcázar, S2 Grupo, Spain

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

EvoRISK : Computational Intelligence for Risk Management, Security and Defence Applications
Anna I Esparcia-Alcázar, S2 Grupo, Spain

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

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

EvoStar 2015 publicity chairs
Pablo García Sánchez, University of Granada, Spain
Mauro Castelli, ISEGI; Universidade Nova de Lisboa, Portugal

EvoStar 2015 local chairs
Paolo Burelli, Aalborg University, Copenhagen, Denmark
Sebastian Risi, IT University of Copenhagen, Denmark

EvoStar coordinator
Jennifer Willies, Edinburgh Napier University, UK

Welcome to Copenhagen

On behalf of all the EvoStar 2015 organisers, we are pleased to see you in Copenhagen for the four co-located EvoStar conferences of EuroGP, EvoCOP, EvoMUSART and EvoAPPLICATIONS. We are presenting a total of 27 conference sessions with 132 papers presented over two and a half days. EvoStar is now in its 18th year and it arose out of workshops originally developed by EvoNet, the Network of Excellence in Evolutionary Computing, established by the Information Societies Technology Programme of the European Commission These events represent a continuity of research collaboration stretching back over 20 years.

Again this year we have an exciting program with many high-quality contributions from the diverse fields within bio-inspired computation. The EvoStar events provide excellent opportunities to meet friends and establish new working relationships within comfortable social settings. We are pleased to include two great invited talks from Pierre-Yves Oudeyer and Paulien Hogeweg in the programme.

This year's EvoStar will be held at the National Museum of Denmark in the centre of Copenhagen and you are free to visit museum exhibits during the breaks. The conference reception will be held on Wednesday evening in conjunction with the poster session and the conference dinner will be held at Aalborg University on Thursday evening. We shall travel there by boat and more details are available on page 83.

Copenhagen has a lot to offer so please do enjoy the city centre, and for those staying on Friday afternoon, we have organized a short walking tour of the old town followed by a visit to the famous Tivoli Gardens. Other suggestions for local visits are on page 84 and you are bound to find others EvoStar participants going to these places too.

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

Local Organisers : Paoli Burelli
& Sebastian Risi

EvoStar Coordinator : Jennifer Willies

Getting around Copenhagen

WHICH TICKET?

Copenhagen has great public transport but you need to spend a few minutes to work out the ticketing system. Your transport ticket will work on the trains, metro and buses and includes the waterbus too (a great way to see Copenhagen). Public transport areas are divided into zones, but if staying and moving around the city, a central 1-4 zone day pass is easiest and should suffice. It will also encourage you to do and see more, and you can also use to and from the airport. A 24 hour pass costs 80 DKK. These are also available as a 72- hour pass for zones 1-4 too at a cost of 200DKK.

Single trip tickets are also available but you will need to work out how many zones will be travelled to reach your destination. A two-zone ticket costs 24 DKK valid for one hour.

To make matters more complicated, the Copenhagen Card offers unlimited travel on buses, trains, metro and water bus in all zones plus gives free or discounted entrance to many attractions, museums etc plus discounts in restaurants. This might be worth considering if you are staying on Friday afternoon after the conference finishes. A 24 hour card costs 48 EUR, 48 hour card costs 65 EUR.

Tickets can be bought from station machines and should be purchased before boarding, though bus tickets can be bought from the driver with small change. Or you can buy tickets online at www.dsb.dk/en/

HOW TO GET THERE?

All journeys can be routed via the online planner at www.rejseplanen.dk

Bus lines 12, 26, 33, 40, 1A, 2A, 9A all stop near the EvoStar venue of the National Museum. The closest metro stop is Nørreport and the closest train station is the Central Station (Hovedbanegård). Both stations are connected by local, national and international trains, and from each, you can travel to the airport by direct journey taking about 20 minutes.

BICYCLING THROUGH COPENHAGEN

The centre of Copenhagen is pleasant to walk through as access to cars is limited though you need to be careful of cyclists. Walking through the city helps you appreciate more, but riding a bike gets you there quicker. There are more than 300KM of cycle ways and you can zoom around the city like a native. Bike rental information at www.visitcopenhagen.com/copenhagen/transportation/copenhagen-bike-rentals

Invited speakers

Opening Talk Wednesday, 8 April at 0945

Pierre-Yves Oudeyer

"Open-Source Baby Robots for Science, Education and Art"

What can baby robots tell us about ourselves? Mysteries of human cognition, like the mechanisms of curiosity or the origins of languages, are starting to be unveiled through experiments with robots that can learn by themselves. In this talk, I will present several examples of such research projects, with models of curiosity-driven learning or language formation. I will emphasize the importance of understanding and experimenting the role of the body in cognition, and in this context introduce the Poppy open-source 3D printed humanoid robot. I will illustrate how Poppy allows rapid experimentation of varied robotic morphologies. I will also explain how this platform, born inside a scientific project, also opens stimulating opportunities in the world of education, for the integrated and interdisciplinary learning of mechanics, 3D printing, electronics, computer science, artificial intelligence and design. I wil also give examples of projects exploring how it can be used in the artistic domain.

Dr. Pierre-Yves Oudeyer is Research Director at Inria and head of the Inria and Ensta-ParisTech FLOWERS team (France). Before, he has been a permanent researcher in Sony Computer Science Laboratory for 8 years (1999-2007). After working on computational models of language evolution, he is now working on developmental and social robotics, focusing on sensorimotor development, language acquisition and life-long learning in robots. Strongly inspired by infant development, the mechanisms he studies include artificial curiosity, intrinsic motivation, the role of morphology in learning motor control, human-robot interfaces, joint attention and joint intentional understanding, and imitation learning. He has published a book, more than 80 papers in international journals and conferences, holds 8 patents, gave several invited keynote lectures in international conferences, and received several prizes for his work in developmental robotics and on the origins of language. In particular, he is laureate of the ERC Starting Grant EXPLORERS. He is editor of the IEEE CIS Newsletter on Autonomous Mental Development, and associate editor of IEEE Transactions on Autonomous Mental Development, Frontiers in Neurorobotics, and of the International Journal of Social Robotics. He is also working actively for the diffusion of science towards the general public, through the writing of popular science articles and participation to radio and TV programs as well as science exhibitions. Web: http://www.pyoudeyer.com and http://flowers.inria.fr

Invited speakers

Closing Talk Friday, 10 April at 11:30

Paulien Hogeweg

"Non-random random mutations: Evolution of Genotype-Phenotype mapping"

Darwinian evolution, i.e. random mutations and selection, not only leads to adaptation to the environment, but more importantly, to the complex multilayered genotype-phenotype mapping, and therewith the mutational neighbourhood. In evolutionary models with enough degrees of freedom, information integration over evolutionary time will shape the mutational neighbourhood sothat (the effect of) random mutations is not random but biased to be beneficial. I will show that the structuring of the mutational neighbourbood, may serve as an alternative to more well known processes like regulation and speciation to cope with temporal and spatial heterogeneous environments.

Paulien Hogeweg is a Dutch theoretical biologist and complex systems researcher studying biological systems as dynamic information processing systems at many interconnected levels. Together with Ben Hesper he coined the term "bioinformatics" in the 70's, as the study of informatics processes in biotic systems, including both data analysis and modelling. Currently her main interest is studying "multilevel evolution": how new levels of selection emerge, and how complex genotype-phenotype transitions evolve.

Best paper nominations

Best paper prizes are presented during the EvoStar closing ceremony on Friday, 10 April at 12:30

EuroGP candidates

Cartesian GP in Optimization of Combinational Circuits with Hundreds of Inputs and Thousands of Gates
Zdenek Vasicek

On the Generalization Ability of Geometric Semantic Genetic Programming
Ivo Gonçalves, Sara Silva, Carlos M. Fonseca

Attributed Grammatical Evolution using Shared Memory Spaces and Dynamically Typed Semantic Function Specification
James Vincent Patten and Conor Ryan

The Effect of Distinct Geometric Semantic Crossover Operators in Regression Problems
Julio Albinati, Gisele Lobo Pappa, Luiz Otavio V.B. Oliveira, Fernando Otero

EvoCOP candidates

Hyper-heuristic Operator Selection and Acceptance Criteria
Richard Marshall, Mark Johnston, Mengjie Zhang

On the Complexity of Searching the Linear Ordering Problem Neighborhoods
Benjamin Correal, Philippe Galinier

Upper and Lower Bounds on Unrestricted Black-Box Complexity of $\text{Jump}_{n,l}$
Maxim Buzdalov, Mikhail Kever, Benjamin Doerr

EvoMUSART candidates

Interior Illumination Design Using Genetic Programming
Kelly Moylan, Brian Ross

Moody Music Generator: Characterising Control Parameters Using Crowdsourcing
Marco Scirea, Julian Togelius, Mark Nelson

Evotype: Evolutionary Type Design
Tiago Martins, João Correia, Ernesto Costa, Penousal Machado

Lichtsuchende: Exploring the Emergence of a Cybernetic Society
Dave Murray-Rust, Rocio von Jungenfeld

Best paper nominations

EvoCOMNET candidates

A Novel Grouping Genetic Algorithm for Assigning Resources to Users in WCDMA Networks
Lucas Cuadra, Sancho Salcedo-Sanz, Antonio D. Carnicer, Miguel A. Del Arco, Jose A. Portilla-Figueras

A Swarm Intelligence Approach to 3D Distance-based Indoor Localization
Stefania Monica, Gianluigi Ferrari

Parallel Extremal Optimization with Guided State Changes applied to Load Balancing
Eryk Laskowski, Marek Tudruj, Umberto Scafuri, Richard Olejnik, Ivanoe De Falco, Ernesto Tarantino

EvoIASP candidates

Alternating Optimization of Unsupervised Regression with Evolutionary Embeddings
Oliver Kramer, Daniel Lückehe

Gaussian Transformation based Representation in Particle Swarm Optimisation for Feature Selection
Hoai Bach Nguyen, Bing Xue, Ivy Liu, Peter Andreae, Mengjie Zhang

Genetic Programming with Alternative Search Drivers for Detection of Retinal Blood Vessels
Krzysztof Krawiec, Mikołaj Pawlak

EvoROBOT sponsored by frontiers

On the Tradeoff between Hardware Protection and Optimization Success: A Case Study in Onboard Evolutionary Robotics for Autonomous Parallel Parking
Mostafa Wahby, Heiko Hamann

Real-World Reproduction of Evolved Robot Morphologies: Automated Categorization and Evaluation
Eivind Samuelsen, Kyrre Glette

Evolving Generalised Maze Solvers
David Shorten, Geoff Nitschke

Evolving Robot Controllers for Structured Environments through Environment Decomposition
Rodrigo Moreno, Andres Faina, Kasper Stoy

Autonomous Learning of Procedural Knowledge in an Evolutionary Cognitive Architecture for Robots
Rodrigo Salgado, Francisco Bellas, Richard J. Duro

EvoStar posters

The EvoStar poster session is held in conjunction with the conference reception on Wednesday 8 April at 18:15 – 19:45 in the foyer area of the National Museum. These papers will be presented:

Studying the Geographical Cluster Paging with delay constraint in Registration Areas with the Algorithm NSGAII
Victor Berrocal-Plaza, Miguel A. Vega-Rodriguez, Juan M. Sanchez-Perez

Genetic Programming for Feature Selection and Question-Answer Ranking in IBM Watson
Urvesh Bhowan, D. J. McCloskey

A Benchmark For Virtual Camera Control
Paolo Burelli, Georgios Yannakakis

Feature Discovery by Deep Learning for Aesthetic Analysis of Evolved Abstract Images
Allan Campbell, Vic Ciesielski, A. K. Qin

Automatic Evolution of Parallel Recursive Programs
Gopinath Chennupati, Muhammad R. Atif Azad, Conor Ryan

Object Detection in Natural Images using the Brain Programming Paradigm with a Multi-Objective Approach
Eddie Clemente, Gustavo Olague, Daniel E. Hernández, Jose L. Briseño, Jose Mercado

FuXi: a Fish-Driven Instrument for Real-Time Music Performance
Joao Cordeiro

A Multiobjective Evolutionary Algorithm for Personalized Tours in Street Networks
Ivanoe De Falco, Umberto Scafuri, Ernesto Tarantino

Chorale Music Splicing System: an algorithmic music composer inspired by molecular splicing
Clelia De Felice, Roberto De Prisco, Delfina Malandrino, Gianluca Zaccagnino, Rocco Zaccagnino, Rosalba Zizza

Fair Resource Allocation Using Multi-Population Evolutionary Algorithm
Tohid Erfani, Rasool Erfani

How the world was MADE: parametrization of evolved agent-based models for backstory generation
Rubén Héctor García Ortega, Pablo García Sánchez, Juan Julián Merelo Guervós, Maribel García Arenas, Pedro A. Castillo Valdivieso, Antonio Mora García

Investigating Fitness Measures for the Automatic Construction of Graph Models
Kyle Harrison, Mario Ventresca, Beatrice Ombuki-Berman

A Genetic Programming Approach to Generating Musical Compositions
David M. Hofmann

Heat Map Based Feature Selection: A Case Study for Ovarian Cancer
Carlos Huertas, Reyes Juárez-Ramírez

Parallel cooperation for large-scale multiobjective optimization on feature selection problems
Dragi Kimovski, Julio Ortega, Andrés Ortiz, Raúl Baños

Echo
Christoph Klemmt, Rajat Sodhi

Planning the Deployment of Indoor Wireless Sensor Networks through Multiobjective Evolutionary Techniques
J. M. Lanza-Gutierrez, J. A. Gomez-Pulido, S. Priem-Mendes, M. Ferreira, J. S. Pereira

Collaborative Diffusion on the GPU for Path-finding in Games
Craig McMillan, Emma Hart, Kevin Chalmers

EvoStar posters

Automatic Generation of Chord Progressions with an Arti cial Immune System
Maria Navarro, Leandro Nunes de Castro, Marcelo Caetano, Gilberto Bernandes, Juan Manuel Corchado

A Novel Multi-Objectivisation Approach for Optimising the Protein Inverse Folding Problem
Sune S. Nielsen, Grégoire Danoy, Wiktor Jurkowski, Juan Luis Jiménez Laredo, Reinhard Schneider, El-Ghazali Talbi, Pascal Bouvry

Analysis of Diversity Methods for Evolutionary Multi-Objective Ensemble Classifiers
Stefan Oehmcke, Justin Heinermann, Oliver Kramer

Proposal and Preliminary Investigation of a Fitness Function for Partial Differential Models
Igor S. Peretta, Keiji Yamanaka, Paul Bourgine, Pierre Collet

Evolutionary Methods for the Construction of Cryptographic Boolean Functions
Stjepan Picek, Domagoj Jakobovic, Julian F. Miller, Elena Marchiori, Lejla Batina

A Concept for Real-Valued Multi-Objective Landscape Analysis Realized on Biochemcial Optimization Problems
Susanne Rosenthal, Bernd Freisleben, Markus Borschbach

Evolutionary Training of Robotised Architectural Elements
Claudio Rossi, Pablo Gil, William Coral

A Projection-Based Approach for Real-time Assessment and Playability Check for Physics-Based Games
Mohammad Shaker, Noor Shaker, Mohamed Abou-Zleikha, Julian Togelius

Schemographe: Application for a New Representation Technique and Methodology of Analysis in Tonal Harmony
Anna Shvets, Myriam Desainte-Cathérine

Chromatic Selection -- an Oversimplified Approach to Multi-Objective Optimization
Giovanni Squillero

Templar - a Framework for Template-Method Hyper-Heuristics
Jerry Swan, Nathan Burles

Biological Content Generation: Evolving Game Terrains through Living Organisms
Wim van Eck, Maarten Lamers

Circuit Approximation Using Single- and Multi-Objective Cartesian GP
Zdenek Vasicek, Lukas Sekanina

Interpretability of Music Classification as a Criterion for Evolutionary Multi-Objective Feature Selection
Igor Vatolkin, Guenter Rudolph, Claus Weihs

On the Stylistic Evolution of a Society of Virtual Melody Composers
Valerio Velardo, Mauro Vallati

PowerSurge: A Serious Game on Power Transmission Networks
Sebastian von Mammen, Fabian Hertwig, Florain Obermayer, Patrick Lehner

Evolving Controllers for Programmable Robots to Influence Non-Programmable Lifeforms: A Casy Study
Payam Zahadat, Thomas Schmickl

DrawCompileEvolve: Sparking Interactive Evolutionary Art with Human Creations
Jinhong Zhang, Rasmus Taarnby, Antonios Liapis, Sebastian Risi

European projects posters

SWARM-ORGAN : www.swarm-organ.eu

The Swarm-Organ project focuses on systems containing large numbers of autonomous but relatively simple agents, whose goal is to collectively organise themselves into complex spatial arrangements despite each agent having only local awareness. The Swarm-Organ project was conceived by a multidisciplinary team comprising experts from a variety of different backgrounds – developmental systems biology, computer science, morphogenetic robotics and physics. James Sharpe from Centre for Genomic Regulation in Barcelona, Spain as project coordinator will present SWARM-ORGAN.

ASSISI bf : http://assisi-project.eu

The main goal of ASSISI is to establish a robotic society that is able to develop communication channels to animal societies (honeybees & fish swarms) on its own. These robots will adapt by evolutionary algorithms until they have learned to interact with animals in a desired way. This new technology is aimed to lay new foundations on the way in which humans can interfere with animal societies in order to manage the environment. The researchers expect their work to have impact on agriculture, live stock management and environmental protection. In parallel, the mixed societies of animals and robots will represent a novel kind of bio-hybrid ICT system, as the animals will enrich the capabilities of the machines and vice versa. The research is conducted by six European institutions from Austria, Croatia, France, Germany, Portugal and Switzerland. The project is coordinated by Thomas Schmickl from the Artificial Life Lab in Graz who will present this poster.

FoCAS : www.focas.eu

The FoCAS coordination action is an EC-umbrella project aiming to integrate, coordinate and help increase visibility for research carried out in the FOCAS Proactive Initiative and in research fields related to collective adaptive systems. Activities include: *Roadmapping* to define future research directions; *Facilitating community building* and collaboration opportunities for researchers interested in collective adaptive systems through workshops and conferences; *Online media lounge* with downloadable resources to encourage improved collaboration; *Providing dissemination opportunities*, a positive interface between scientists, industry and the science-aware public to demonstrate how CAS can impact on society; *Providing training opportunities* for researchers through summer schools and exchange opportunities. FoCAS project manager Jennifer Willies will present this poster.

Equipment, poster boards and WIFI info

Poster Board Sizes
Poster boards are portrait configuration: 140 cm tall by 100 cm wide and can accommodate posters of A0 size. Pins are the best fixing materials. Storage for posters will be available at the registration desk. The poster stands will be set out on Wednesday around 1730.

Poster Printing
If looking for a local printer for your poster, a printing shop near the venue offers the facility to upload files beforehand and then just pick up when you need it. However prices are not cheap : A0 size is 429 DKK (approx 50 EUR) and A1 is 260 DKK (approx. 30 EUR). For more information, see www.vesterkopi.dk/en/find-a-shop/norregade

Equipment
Data projectors (beamers) are available in each conference room but computers are not supplied, so best to bring your laptop or make sharing arrangements with others.

WIFI
Free guest wireless internet access is available for Evo* participants with two networks available:

Natmus_Konference login: Natmus1234

Natmus_Free_Wifi : no login

Voltage and Adapters
Voltage in Denmark is 230v operating at 50 Hz frequency, similar to most European countries at 220-240v (North America is 110-120v). Denmark uses the European two-pin type C/E/F sockets. Power cables from North and South America, the UK, and many parts of Asia will need *plug adapters* for these sockets. Most laptops (and camera/phone chargers) will adapt to the voltage automatically, but it is worth checking as some equipment brought in from outside Europe may need a *voltage converter* as well as a *plug adapter*.

International Vehicle Routing Competition

Calling all researchers with an interest in optimisation…

We have pallet loads of food waiting to be delivered to customers, who expect frozen or chilled deliveries on time! Our problems are inspired by real-word scenarios that require deliveries within time windows, but also using the appropriate size and type of vehicle for deliveries. A large number of problem instances will be made available to entrants, along with Java libraries to load problems and evaluate solutions.

Are you up to the challenge?
www.logistics-competition.co.uk

Prize: a complementary registration for Evo* 2016

Competition opens 1st May 2015
Closing date for entries December 1st 2015

Organised by Edinburgh Napier University and the University of Stirling

Edinburgh Napier UNIVERSITY

UNIVERSITY of STIRLING

EuroGP conference programme

Wednesday 8 April, room 1

1120-1300	**EuroGP 1 : Scaling GP** **session chairs : Penousal Machado & Malcolm Heywood** Indirectly Encoded Fitness Predictors Coevolved with Cartesian Programs **Michaela Sikulova, Jiri Hulva, Lukas Sekanina** Automatic Derivation of Search Objectives for Test-Based Genetic Programming **Krzysztof Krawiec, Paweł Liskowski** Evolutionary Design of Transistor Level Digital Circuits using Discrete Simulation **Vojtech Mrazek, Zdenek Vasicek** Improving Geometric Semantic Genetic Programming with Safe Tree Initialisation **Grant Dick**
1300-1415	**Lunch**
1415-1555	**EuroGP 2 : Applications** **session chair : Sara Silva** Learning Text Patterns using Separate-and-Conquer Genetic Programming **Alberto Bartoli, Andrea De Lorenzo, Eric Medvet, Fabiano Tarlao** Evolving Ensembles of Dispatching Rules using Genetic Programming for Job Shop Scheduling **John Park, Su Nguyen, Mengjie Zhang, Mark Johnston** M3GP - Multiclass Classification with GP **Luis Muñoz, Sara Silva, Leonardo Trujillo** Tapped Delay Lines for GP Streaming Data Classification with Label Budgets **Ali Vahdat, Jillian Morgan, Andrew R. McIntyre, Malcolm I. Heywood, A. Nur Zincir-Heywood**
1555-1620	**Coffee break**
1620-1800	**EuroGP 3 : Best Paper Candidates** **session chair : Krzysztof Krawiec** Cartesian GP in Optimization of Combinational Circuits with Hundreds of Inputs and Thousands of Gates **Zdenek Vasicek** On the Generalization Ability of Geometric Semantic Genetic Programming **Ivo Gonçalves, Sara Silva, Carlos M. Fonseca** Attributed Grammatical Evolution using Shared Memory Spaces and Dynamically Typed Semantic Function Specification **James Vincent Patten, Conor Ryan** The Effect of Distinct Geometric Semantic Crossover Operators in Regression Problems **Julio Albinati, Gisele L. Pappa, Fernando E. B. Otero, Luiz Otávio V. B. Oliveira**

EuroGP conference programme

1815-1945	**EvoStar poster session and conference reception**
	EuroGP posters Genetic Programming for Feature Selection and Question-Answer Ranking in IBM Watson **Urvesh Bhowan, D. J. McCloskey** Automatic Evolution of Parallel Recursive Programs **Gopinath Chennupati, Muhammad R. Atif Azad, Conor Ryan** Proposal and Preliminary Investigation of a Fitness Function for Partial Differential Models **Igor S. Peretta, Keiji Yamanaka, Paul Bourgine, Pierre Collet** Evolutionary Methods for the Construction of Cryptographic Boolean Functions **Stjepan Picek, Domagoj Jakobovic, Julian F. Miller, Elena Marchiori, Lejla Batina** Templar - a Framework for Template-Method Hyper-Heuristics **Jerry Swan, Nathan Burles** Circuit Approximation Using Single- and Multi-Objective Cartesian GP **Zdenek Vasicek, Lukas Sekanina**
Thursday 9 April, room 1	
0930-1110	**EuroGP 4 : Panel Discussion :** **Future and Emerging Trends in Genetic Programming (open to all)**

EuroGP session 1 : Scaling GP

Wednesday 8 April 1120-1300

session chairs : Penousal Machado & Malcolm Heywood

Indirectly Encoded Fitness Predictors Coevolved with Cartesian Programs
Michaela Sikulova, Jiri Hulva, Lukas Sekanina
We investigate coevolutionary Cartesian genetic programming that coevolves fitness predictors in order to diminish the number of target objective vector (TOV) evaluations, needed to obtain a satisfactory solution, to reduce the computational cost of evolution. This paper introduces the use of coevolution of fitness predictors in CGP with a new type of indirectly encoded predictors. Indirectly encoded predictors are operated using the CGP and provide a variable number of TOVs used for solution evaluation during the coevolution. It is shown in 5 symbolic regression problems that the proposed predictors are able to adapt the size of TOVs array in response to a particular training data set.

Automatic Derivation of Search Objectives for Test-Based Genetic Programming
Krzysztof Krawiec, Paweł Liskowski
In genetic programming (GP), programs are usually evaluated by applying them to tests, and fitness function indicates only how many of them have been passed. We posit that scrutinizing the outcomes of programs' interactions with individual tests may help making program synthesis more effective. To this aim, we propose DOC, a method that autonomously derives new search objectives by clustering the outcomes of interactions between programs in the population and the tests. The derived objectives are subsequently used to drive the selection process in a single- or multiobjective fashion. An extensive experimental assessment on 15 discrete program synthesis tasks representing two domains shows that DOC significantly outperforms conventional GP and implicit fitness sharing.

Evolutionary Design of Transistor Level Digital Circuits using Discrete Simulation
Vojtech Mrazek, Zdenek Vasicek
The objective of the paper is to introduce a new approach to the evolutionary design of digital circuits conducted directly at transistor level. In order to improve the time consuming evaluation of candidate solutions, a discrete event-driven simulator was introduced. The proposed simulator operates on multiple logic levels to achieve reasonable trade-off between performance and precision. A suitable level of abstraction reflecting the behaviour of real MOSFET transistors is utilized to minimize the production of incorrectly working circuits. The proposed approach is evaluated in the evolution of basic logic circuits having more than 20 transistors. The goal of the evolutionary algorithm is to design a circuit having the minimal number of transistors and exhibiting the minimal delay. In addition to that, various parameter settings are investigated to increase the success rate of the evolutionary design.

Improving Geometric Semantic Genetic Programming with Safe Tree Initialisation
Grant Dick
Researchers in genetic programming (GP) are increasingly looking to semantic methods to increase the efficacy of search. Semantic methods aim to increase the likelihood that a structural change made in an individual will be correlated with a change in behaviour. Recent work has promoted the use of geometric semantic methods, where offspring are generated within a bounded interval of the parents' behavioural space. Extensions of this approach use random trees wrapped in logistic functions to parameterise the blending of parents. This paper identifies limitations in the logistic wrapper approach, and suggests an alternative approach based on safe initialisation using interval arithmetic to produce offspring. The proposed method demonstrates greater search performance than using a logistic wrapper approach, while maintaining an ability to produce offspring that exhibit good generalisation capabilities.

EuroGP session 2 : Applications

Wednesday 8 April 1415-1555

session chair : Sara Silva

Learning Text Patterns using Separate-and-Conquer Genetic Programming
Alberto Bartoli, Andrea De Lorenzo, Eric Medvet, Fabiano Tarlao
The problem of extracting knowledge from large volumes of unstructured textual information has become increasingly important. We consider the problem of extracting text slices that adhere to a syntactic pattern and propose an approach capable of generating the desired pattern automatically, from a few annotated examples. Our approach is based on Genetic Programming and generates extraction patterns in the form of regular expressions that may be input to existing engines without any post-processing. Key feature of our proposal is its ability of discovering automatically whether the extraction task may be solved by a single pattern, or rather a set of multiple patterns is required. We obtain this property by means of a separate-and-conquer strategy: once a candidate pattern provides adequate performance on a subset of the examples, the pattern is inserted into the set of final solutions and the evolutionary search continues on a smaller set of examples including only those not yet solved adequately. Our proposal outperforms an earlier state-of-the-art approach on three challenging datasets

Evolving Ensembles of Dispatching Rules using Genetic Programming for Job Shop Scheduling
John Park, Su Nguyen, Mengjie Zhang, Mark Johnston
Job shop scheduling (JSS) problems are important optimisation problems that have been studied extensively in the literature due to their applicability and computational difficulty. This paper considers static JSS problems with makespan minimisation, which are NP-complete for more than two machines. Because finding optimal solutions can be difficult for large problem instances, many heuristic approaches have been proposed in the literature. However, designing effective heuristics for different JSS problem domains is difficult. As a result, hyper-heuristics (HHs) have been proposed as an approach to automating the design of heuristics. The evolved heuristics have mainly been priority based dispatching rules (DRs). To improve the robustness of evolved heuristics generated by HHs, this paper proposes a new approach where an ensemble of rules are evolved using Genetic Programming (GP) and cooperative coevolution, denoted as Ensemble Genetic Programming for Job Shop Scheduling (EGP-JSS). The results show that EGP-JSS generally produces more robust rules than the single rule GP.

M3GP - Multiclass Classification with GP
Luis Muñoz, Sara Silva, Leonardo Trujillo
Data classification is one of the most ubiquitous machine learning tasks in science and engineering. However, Genetic Programming is still not a popular classification methodology, partially due to its poor performance in multiclass problems. The recently proposed M2GP - Multidimensional Multiclass Genetic Programming algorithm achieved promising results in this area, by evolving mappings of the p-dimensional data into a d-dimensional space, and applying a minimum Mahalanobis distance classifier. Despite good performance, M2GP employs a greedy strategy to set the number of dimensions d for the transformed data, and fixes it at the start of the search, an approach that is prone to locally optimal solutions. This work presents the M3GP algorithm, that stands for M2GP with multidimensional populations. M3GP extends M2GP by allowing the search process to progressively search for the optimal number of new dimensions d that maximize the classification accuracy. Experimental results show that M3GP can automatically determine a good value for d depending on the problem, and achieves excellent performance when compared to state-of-the-art-methods like Random Forests, Random Subspaces and Multilayer Perceptron on several benchmark and real-world problems.

EuroGP session 2 : Applications

Wednesday 8 April 1415-1555

session chair : Sara Silva

Tapped Delay Lines for GP Streaming Data Classification with Label Budgets
Ali Vahdat, Jillian Morgan, Andrew R. McIntyre, Malcolm I. Heywood, A. Nur Zincir-Heywood
Streaming data classification requires that a model be available for classifying stream content while simultaneously detecting and reacting to changes to the underlying process generating the data. Given that only a fraction of the stream is `visible' at any point in time (i.e. some form of window interface) then it is difficult to place any guarantee on a classifier encountering a `well mixed' distribution of classes across the stream. Moreover, streaming data classifiers are also required to operate under a limited label budget (labelling all the data is too expensive). We take these requirements to motivate the use of an active learning strategy for decoupling genetic programming training epochs from stream throughput. The content of a data subset is controlled by a combination of Pareto archiving and stochastic sampling. In addition, a significant benefit is attributed to support for a tapped delay line (TDL) interface to the stream, but this also increases the dimensionality of the task. We demonstrate that the benefits of assuming the TDL can be maintained through the use of oversampling without recourse to additional label information. Benchmarking on 4 dataset demonstrates that the approach is particularly effective when reacting to shifts in the underlying properties of the stream. Moreover, an online formulation for class-wise detection rate is assumed, where this is able to robustly characterize classifier performance throughout the stream.

EuroGP session 3 : Best Papers

Wednesday 8 April 1620-1800

session chair : Krzysztof Krawiec

Cartesian GP in Optimization of Combinational Circuits with Hundreds of Inputs and Thousands of Gates

Zdenek Vasicek

A new approach to the evolutionary optimization of large digital circuits is introduced in this paper. In contrast with evolutionary circuit design, the goal of the evolutionary circuit optimization is to minimize the number of gates (or other non-functional parameters) of already functional circuit. The method combines a circuit simulation with a formal verification in order to detect the functional inequivalence of the parent and its offspring. An extensive set of 100 benchmarks circuits is used to evaluate the performance of the method as well as the utilized evolutionary approach. Moreover, the role of neutral mutations in the context of evolutionary optimization is investigated. In average, the method enabled a 34% reduction in gate count even if the optimizer was executed only for 15 minutes.

On the Generalization Ability of Geometric Semantic Genetic Programming

Ivo Gonçalves, Sara Silva, Carlos M. Fonseca

Geometric Semantic Genetic Programming (GSGP) is a recently proposed form of Genetic Programming (GP) that searches directly the space of the underlying semantics of the programs. The fitness landscape seen by the GSGP variation operators is unimodal with a linear slope by construction and, consequently, easy to search. Despite this advantage, the offspring produced by these operators grow very quickly. A new implementation of the same operators was proposed that computes the semantics of the offspring without having to explicitly build their syntax. This allowed GSGP to be used for the first time in real-life multidimensional datasets. GSGP presented a surprisingly good generalization ability, which was justified by some properties of the geometric semantic operators. In this paper, we show that the good generalization ability of GSGP was the result of a small implementation deviation from the original formulation of the mutation operator, and that without it the generalization results would be significantly worse. We explain the reason for this difference, and then we propose two variants of the geometric semantic mutation that deterministically and optimally adapt the mutation step. They reveal to be more efficient in learning the training data, and they also achieve a competitive generalization in only a single operator application. This provides a competitive alternative when performing semantic search, particularly since they produce small individuals and compute fast.

Attributed Grammatical Evolution using Shared Memory Spaces and Dynamically Typed Semantic Function Specification

James Vincent Patten, Conor Ryan

In this paper we introduce a new Grammatical Evolution (GE) system designed to support the specification of problem semantics in the form of attribute grammars (AG). We discuss the motivations behind our system design, from its use of shared memory spaces for attribute storage to the use of a dynamically type programming language, Python, to specify grammar semantics. After a brief analysis of some of the existing GE AG system we outline two sets of experiments carried out on four symbolic regression type (SR) problems. The first set using a context free grammar (CFG) and second using an AG. After presenting the results of our experiments we highlight some of the potential areas for future performance improvements, using the new functionality that access to Python interpreter and storage of attributes in shared memory space provides.

EuroGP session 3 : Best Papers

Wednesday 8 April 1620-1800

session chair : Krzysztof Krawiec

The Effect of Distinct Geometric Semantic Crossover Operators in Regression Problems

Julio Albinati, Gisele L. Pappa, Fernando E. B. Otero, Luiz Otávio V. B. Oliveira

This paper investigates the impact of geometric semantic crossover operators in a wide range of symbolic regression problems. First, it analyses the impact of using Manhattan and Euclidean distance geometric semantic crossovers in the learning process. Then, it proposes two strategies to numerically optimize the crossover mask based on mathematical properties of these operators, instead of simply generating them randomly. An experimental analysis comparing geometric semantic crossovers using Euclidean and Manhattan distances and the proposed strategies is performed in a test bed of twenty datasets. The results show that the use of different distance functions in the semantic geometric crossover has little impact on the test error, and that our optimized crossover masks yield slightly better results. For SGP practitioners, we suggest the use of the semantic crossover based on the Euclidean distance, as it achieved similar results to those obtained by more complex operators.

EuroGP posters

Wednesday 8 April 1815-1945

Genetic Programming for Feature Selection and Question-Answer Ranking in IBM Watson

Urvesh Bhowan, D. J. McCloskey

IBM Watson is an intelligent open-domain question answering system capable of finding correct answers to natural language questions in real-time. Watson uses machine learning over a large heterogeneous feature set derived from many distinct natural language processing algorithms to identify correct answers. This paper develops a Genetic Programming (GP) approach for feature selection in Watson by evolving ranking functions to order candidate answers generated in Watson. We leverage GP's automatic feature selection mechanisms to identify Watson's key features through the learning process. Our experiments show that GP can evolve relatively simple ranking functions that use much fewer features from the original Watson feature set to achieve comparable performances to Watson. This methodology can aid Watson implementers to better identify key components in an otherwise large and complex system for development, troubleshooting, and/or customer or domain-specific enhancements.

Automatic Evolution of Parallel Recursive Programs

Gopinath Chennupati, Muhammad R. Atif Azad, Conor Ryan

Writing recursive programs for fine-grained task-level execution on parallel architectures, such as the current generation of multi-core machines, often require the application of skilled parallelization knowledge to fully realize the potential of the hardware. This paper automates the process by using Grammatical Evolution (GE) to exploit the multi-cores through the evolution of natively parallel programs. We present Multi-core Grammatical Evolution (MCGE-II), which employs GE and OpenMP specific pragmatic information to automatically evolve task-level parallel recursive programs. MCGE-II is evaluated on six recursive C programs, and we show that it solves each of them using parallel code. We further show that MCGE-II significantly decreases the parallel computational effort as the number of cores increase, when tested on an Intel processor.

Proposal and Preliminary Investigation of a Fitness Function for Partial Differential Models

Igor S. Peretta, Keiji Yamanaka, Paul Bourgine, Pierre Collet

This work proposes and presents a preliminary investigation of a fitness evaluation scheme supported by a proper genotype representation intended to guide an under development expansion to EASEA/EASEA-CLOUD platforms to evolve partial differential equations as models for a specific system of interest, starting with measures from that system. A simple proof of concept using a dynamic bidirectional surface wave is presented, showing that the proposed fitness evaluation scheme is very promising to enable automate system modelling, even when dealing with up to +-10% noise-added data.

EuroGP posters

Wednesday 8 April 1815-1945

Evolutionary Methods for the Construction of Cryptographic Boolean Functions
Stjepan Picek, Domagoj Jakobovic, Julian F. Miller, Elena Marchiori, Lejla Batina
Boolean functions represent an important primitive when constructing many stream ciphers. Since they are often the only nonlinear element of such ciphers, without them the algorithm would be trivial to break. Therefore, it is not surprising there exist a substantial body of work on the methods of constructing Boolean functions. Among those methods, evolutionary computation (EC) techniques play a significant role. Previous works show it is possible to use EC methods to generate high-quality Boolean functions that even surpass those built by algebraic constructions. However, up to now, there was no work investigating the use of Cartesian Genetic Programming (CGP) for producing Boolean functions suitable for cryptography. In this paper we compare Genetic Programming (GP) and CGP algorithms in order to reach the conclusion which algorithm is better suited to evolve Boolean functions suitable for cryptographic usage. Our experiments show that CGP performs much better than the GP when the goal is obtaining as high as possible nonlinearity. Our results indicate that CGP should be further tested with different fitness objectives in order to check the boundaries of its performance.

Templar - a Framework for Template-Method Hyper-Heuristics
Jerry Swan, Nathan Burles
In this work we introduce Templar, a software framework for customising algorithms via the generative technique of template-method hyper-heuristics. We first discuss the need for such an approach, presenting Quicksort as an example. We provide a functional definition of template-method hyper-heuristics, describe how this is implemented by Templar, and show how Templar may be invoked using simple client-code. Finally, we describe experiments using Templar to define a 'hyper-quicksort' with the aim of reducing power consumption - the results demonstrate that the generated algorithm has significantly improved performance on the test set.

Circuit Approximation Using Single- and Multi-Objective Cartesian GP
Zdenek Vasicek, Lukas Sekanina
In this paper, the approximate circuit design problem is formulated as a multi-objective optimization problem in which the circuit error and power consumption are conflicting design objectives. We compare multi-objective and single-objective Cartesian genetic programming in the task of parallel adder and multiplier approximation. It is analyzed how the setting of the methods, formulating the problem as multi-objective or single-objective, and constraining the execution time can influence the quality of results. One of the conclusions is that the multi-objective approach is useful if the number of allowed evaluations is low. When more time is available, the single-objective approach becomes more efficient.

EuroGP session 4 : panel discussion

Thursday 9 April 0930-1110

Future and Emerging Trends in Genetic Programming (open to all)

EvoMUSART conference programme

Wednesday 8 April, room 2

1120-1300	**EvoMusArt 1 : Evolution Everywhere: Drawing, Design, Games and Voice** **session chair: Adrian Carballal** Avoidance Drawings Evolved Using Virtual Drawing Robots **Gary Greenfield** Evolving Diverse Design Populations using Fitness Sharing and Random Forest based Fitness Approximation **Kate Reed, Duncan Gillies** AudioInSpace: A Proof-of-Concept Exploring the Creative Fusion of Generative Audio, Visuals and Gameplay **Amy K. Hoover, William Cachia, Antonios Liapis, Georgios N. Yannakakis** Towards an Evolutionary Computational Approach to Articulatory Vocal Synthesis with PRAAT **Jared Drayton, Eduardo Miranda**
1300-1415	**Lunch**
1415-1555	**EvoMusArt 2 : Bio-inspired Algorithms as Composers** **session chair: João Nuno** The Sound Digestive System: a Strategy for Music and Sound Composition **Juan Manuel Escalante** Toward Certain Sonic Properties of an Audio Feedback System by Evolutionary Control of Second-Order Structures **Seunghun Kim, Juhan Nam, Graham Wakefield** Generative Music with Stochastic Diffusion Search **Asmaa Majid al-Rifaie, Mohammad Majid al-Rifaie** Music with Unconventional Computing: Towards a Step Sequencer From Plasmodium of Physarum Polycephalum **Edward Braund, Eduardo Miranda**
1555-1620	**Coffee break**
1620-1800	**EvoMusArt 3 : Best Paper Candidates** **session chair: Colin Johnson** Interior Illumination Design Using Genetic Programming **Kelly Moylan, Brian Ross** Moody Music Generator: Characterising Control Parameters Using Crowdsourcing **Marco Scirea, Julian Togelius, Mark Nelson** Evotype: Evolutionary Type Design **Tiago Martins, João Correia, Ernesto Costa, Penousal Machado** Lichtsuchende: Exploring the Emergence of a Cybernetic Society **Dave Murray-Rust, Rocio von Jungenfeld**

EvoMUSART conference programme

1815-1945	EvoStar poster session and conference reception

EvoMusArt posters

Biological Content Generation: Evolving Game Terrains through Living Organisms
Wim van Eck, Maarten Lamers

DrawCompileEvolve: Sparking Interactive Evolutionary Art with Human Creations
Jinhong Zhang, Rasmus Taarnby, Antonios Liapis, Sebastian Risi

On the Stylistic Evolution of a Society of Virtual Melody Composers
Valerio Velardo, Mauro Vallati

Feature Discovery by Deep Learning for Aesthetic Analysis of Evolved Abstract Images
Allan Campbell, Vic Ciesielski, A. K. Qin

Automatic Generation of Chord Progressions with an Arti cial Immune System
Maria Navarro, Leandro Nunes de Castro, Marcelo Caetano, Gilberto Bernandes, Juan Manuel Corchado

Schemographe: Application for a New Representation Technique and Methodology of Analysis in Tonal Harmony
Anna Shvets, Myriam Desainte-Cathérine

A Genetic Programming Approach to Generating Musical Compositions
David M. Hofmann

Echo
Christoph Klemmt, Rajat Sodhi

Interpretability of Music Classification as a Criterion for Evolutionary Multi-Objective Feature Selection
Igor Vatolkin, Guenter Rudolph, Claus Weihs

Chorale Music Splicing System: an algorithmic music composer inspired by molecular splicing
Clelia De Felice, Roberto De Prisco, Delfina Malandrino, Gianluca Zaccagnino, Rocco Zaccagnino, Rosalba Zizza

FuXi: a Fish-Driven Instrument for Real-Time Music Performance
Joao Cordeiro

EvoMUSART session 1 : Evolution Everywhere, Drawing, Design, Games and Voice

Wednesday 8 April 1120-1300

session chair : Adrian Carballal

Avoidance Drawings Evolved Using Virtual Drawing Robots
Gary Greenfield
We introduce a generative system for "avoidance drawings", drawings made by virtual drawing robots executing a random walk while simultaneously avoiding the paths of other robots. The random walk method is unique and is based on a curvature controlling
scheme initially introduced by Chappell. We design a fitness function for evaluating avoidance drawings and an evolutionary framework for evolving them. This requires us to follow principles we elucidate for simulated evolution where the generative system is highly stochastic in nature. Examples document the evolutionary system's efficacy and success.

Evolving Diverse Design Populations using Fitness Sharing and Random Forest based Fitness Approximation
Kate Reed, Duncan Gillies
A large, diverse design space will contain many non-viable designs. To locate the viable designs we need to have a method of testing the designs and a way to navigate the space. We have shown that using machine learning on artificial data can accurately predict the viability of chairs based on a range of ergonomic considerations. We have also shown that the design space can be explored using an evolutionary algorithm with the predicted viability as a fitness function. We find that this method in conjunction with a fitness sharing technique can maintain a diverse population with many potential viable designs.

AudioInSpace: A Proof-of-Concept Exploring the Creative Fusion of Generative Audio, Visuals and Gameplay
Amy K. Hoover, William Cachia, Antonios Liapis, Georgios N. Yannakakis
Computer games are unique creativity domains in that they elegantly fuse several facets of creative work including visuals, narrative, music, architecture and design. While the exploration of possibilities across facets of creativity offers a more realistic approach to the game design process, most existing autonomous (or semi-autonomous) game content generators focus on the mere generation of single domains (creativity facets) in games. Motivated by the sparse literature on multifaceted game content generation, this paper introduces a multifaceted procedural content generation (PCG) approach that is based on the interactive evolution of multiple artificial neural networks that orchestrate the generation of visuals, audio and gameplay. The approach is evaluated on a spaceship shooter game. The generated artefacts - a fusion of audiovisual and gameplay elements - showcase the capacity of multifaceted PCG and its evident potential for computational game creativity.

Towards an Evolutionary Computational Approach to Articulatory Vocal Synthesis with PRAAT
Jared Drayton, Eduardo Miranda
This paper presents our current work into developing an evolutionary computing approach to articulatory speech synthesis. Specifically, we implement genetic algorithms to find optimised parameter combinations for the re-synthesis of a vowel using the articulatory synthesiser PRAAT. Our framework analyses the target sound using Fast Fourier Transform (FFT) to obtain formant information, which is then harnessed in a fitness function applied to a real valued genetic algorithm using a generation size of 75 sounds over 50 generations. In this paper, we present three differently configured genetic algorithms (GAs) and offer a comparison of their suitability for elevating the average fitness of the re-synthesised sounds.

EvoMUSART session 2 : Bio-inspired Algorithms as Composers

Wednesday 8 April 1415-1555

session chair : João Nuno

The Sound Digestive System: a Strategy for Music and Sound Composition
Juan Manuel Escalante
Sound Digestive System is an audio visual project that uses the digestive system processes into algorithmic sound composition. This project proposes different strategies to bring bio-data, translations and interpretations of living processes into the sound domain, thus generating an artistic result based on scientific data. To hear the result and browse additional material visit the following address: http://goo.gl/DT1Wy0

Toward Certain Sonic Properties of an Audio Feedback System by Evolutionary Control of Second-Order Structures
Seunghun Kim, Juhan Nam, Graham Wakefield
Aiming for high-level intentional control of audio feedback, though microphones, loudspeakers and digital signal processing, we present a system adapting toward chosen sonic features. Users control the system by selecting and changing feature objectives in real-time. The system has a second-order structure in which the internal signal processing algorithms are developed according to an evolutionary process. Genotypes develop into signal-processing algorithms, and fitness is measured by analysis of the incoming audio feedback. A prototype is evaluated experimentally to measure changes of audio feedback depending on the chosen target conditions. By enhancing interactivity of an audio feedback through the intentional control, we expect that feedback systems could be utilized more effectively in the fields of musical interaction, finding balance between nonlinearity and interactivity.

Generative Music with Stochastic Diffusion Search
Asmaa Majid al-Rifaie, Mohammad Majid al-Rifaie
This paper introduces an approach for using a swarm intelligence algorithm, Stochastic Diffusion Search (SDS) - inspired by one species of ants, Leptothorax acervorum - in order to generate music from plain text. In this approach, SDS is adapted in such a way to vocalise the agents, to hear their "chit-chat". While the generated music depends on the input text, the algorithm's search capability in locating the words in the input text is reflected in the duration and dynamic of the resulting musical notes. In other words, the generated music depends on the behaviour of the algorithm and the communication between its agents. This novel approach, while staying loyal to the original input text, when run each time, "vocalises" the input text in varying "flavours".

Music with Unconventional Computing: Towards a Step Sequencer From Plasmodium of Physarum Polycephalum
Edward Braund, Eduardo Miranda
The field of computer music has evolved in tandem with advances made in computer science. We are interested in how the developing field of unconventional computation may provide new pathways for music and related technologies. In this paper, we outline our initial work into harnessing the behaviour of the biological computing substrate Physarum polycephalum for a musical step sequencer. The plasmodium of Physarum polycephalum is an amorphous unicellular organism, which moves like a giant amoeba as it navigates its environment for food. Our research manipulates the organism's route-efficient propagation characteristics in order to create a growth environment for musical/sound arrangement. We experiment with this device in two different scenarios: sample triggering and MIDI note triggering using sonification techniques.

EvoMUSART session 3 : Best Paper Candidates

Wednesday 8 April 1620-1800

session chair : Colin Johnson

Interior Illumination Design Using Genetic Programming
Kelly Moylan, Brian Ross
Interior illumination is a complex problem involving numerous interacting factors. This research applies genetic programming towards problems in illumination design. The Radiance system is used for performing accurate illumination simulations. Radiance accounts for a number of important environmental factors, which we exploit during fitness evaluation. Illumination requirements include local illumination intensity from natural and artificial sources, colour, and uniformity. Evolved solutions incorporate design elements such as artificial lights, room materials, windows, and glass properties. A number of case studies are examined, including a many-objective problem involving 6 illumination requirements, the design of a decorative wall of lights, and the creation of a stained-glass window for a large public space. Our results show the technical and creative possibilities of applying genetic programming to illumination design.

Moody Music Generator: Characterising Control Parameters Using Crowdsourcing
Marco Scirea, Julian Togelius, Mark Nelson
We characterise the expressive effects of a music generator capable of varying its moods through two control parameters. The two control parameters were constructed on the basis of existing work on valence and arousal in music, and intended to provide control over those two mood factors. In this paper we conduct a listener study to determine how people actually perceive the various moods the generator can produce. Rather than directly attempting to validate that our two control parameters represent arousal and valence, instead we conduct an open-ended study to crowd-source labels characterising different parts of this two-dimensional control space. Our aim is to characterise perception of the generator's expressive space, without constraining listeners' responses to labels specifically aimed at validating the original arousal/valence motivation. Subjects were asked to listen to clips of generated music over the Internet, and to describe the moods with free-text labels. We find that the arousal parameter does roughly map to perceived arousal, but that the nominal "valence" parameter has strong interaction with the arousal parameter, and produces different effects in different parts of the control space. We believe that the characterisation methodology described here is general and could be used to map the expressive range of other parameterisable generators.

Evotype: Evolutionary Type Design
Tiago Martins, João Correia, Ernesto Costa, Penousal Machado
An evolutionary generative system for type design, Evotype, is described. The system uses a Genetic Algorithm to evolve a set of individuals composed of line segments, each encoding the shape of a specific character, i.e. a glyph. To simultaneously evolve glyphs for the entire alphabet, an island model is adopted. To assign fitness we resort to a scheme based on Optical Character Recognition. We study the evolvability of the proposed approach as well as the impact of the migration in the evolutionary process. The migration mechanism is explored through three experimental setups: fitness guided migration, random migration, and no migration. We analyse the experimental results in terms of fitness, migration paths, and appearance of the glyphs. The results show the ability of the system to find suitable glyphs and the impact of the migration strategy in the evolutionary process.

EvoMUSART session 3 : Best Paper Candidates

Wednesday 8 April 1620-1800

session chair : Colin Johnson

Lichtsuchende: Exploring the Emergence of a Cybernetic Society
Dave Murray-Rust, Rocio von Jungenfeld
In this paper, we describe "Lichtsuchende", an interactive installation, built using a society of biologically inspired, cybernetic creatures who exchange light as a source of energy and a means of communication. Visitors are invited to engage with the installation using torches to influence and interact with the phototropic robots. As well as describing the finished piece, we explore some of the issues around creating works based on biologically inspired robots. We present an account of the development of the creatures in order to highlight the gulfs between conceptual ideas of how to allow emergent behaviours and the manners in which they are implemented. We also expose the interrelations and tensions between the needs of the creatures as they emerge and the needs of the creators, to understand the duet between the cyber-organisms and their initiators. Finally, we look at the ways in which creators, robots and visitors are enrolled, to perform their functions, so that the network of activity can be woven between all parties.

EvoMUSART posters

Wednesday 8 April 1815-1945

Biological Content Generation: Evolving Game Terrains through Living Organisms
Wim van Eck, Maarten Lamers
This study explores the concept of evolving game terrains through intermediation of living biological organisms and presents a proof of concept realization thereof. We explore how fungal and bacterial cultures can be used to generate an evolving game terrain in real-time. By visually capturing growing cultures inside a Petri-dish, heightmaps are generated that form the basis of naturally evolving terrains. Possible consequences and benefits of this approach are discussed, as are its effects on the visual appearance of simulated terrains. A novel and convenient method for visually capturing growing microorganisms is presented, with a technical description for translating captured footage to virtual terrains. This work is experimental in nature and is an initial venture into the novel domain of organically growing virtual terrains.

DrawCompileEvolve: Sparking Interactive Evolutionary Art with Human Creations
Jinhong Zhang, Rasmus Taarnby, Antonios Liapis, Sebastian Risi
This paper presents DrawCompileEvolve, a web-based drawing tool which allows users to draw simple primitive shapes, group them together or define patterns in their groupings (e.g. symmetry, repetition). The user's vector drawing is then compiled into an indirectly encoded genetic representation, which can be evolved interactively, allowing the user to change the image's colors, patterns and ultimately transform it. The human artist has direct control while drawing the initial seed of an evolutionary run and indirect control while interactively evolving it, thus making DrawCompileEvolve a mixed-initiative art tool. Early results in this paper show the potential of DrawCompileEvolve to jump-start evolutionary art with meaningful drawings as well as the power of the underlying genetic representation to transform the user's initial drawing into a different, yet potentially meaningful, artistic rendering.

On the Stylistic Evolution of a Society of Virtual Melody Composers
Valerio Velardo, Mauro Vallati
In the field of computational creativity, the area of automatic music generation deals with techniques that are able to automatically compose human-enjoyable music. Although investigations in the area started recently, numerous techniques based on artificial intelligence have been proposed. Some of them produce pleasant results, but none is able to evolve the style of the musical pieces generated. In this paper, we fill this gap by proposing an evolutionary memetic system that composes melodies, exploiting a society of virtual composers. An extensive validation, performed by using both quantitative and qualitative analyses, confirms that the system is able to evolve its compositional style over time.

EvoMUSART posters

Wednesday 8 April 1815-1945

Automatic Generation of Chord Progressions with an Arti cial Immune System
Maria Navarro, Leandro Nunes de Castro, Marcelo Caetano, Gilberto Bernandes, Juan Manuel Corchado
Chord progressions are widely used in music. The automatic generation of chord progressions can be challenging because it depends on many factors, such as the musical context. This work proposes a penalty function that encodes musical rules to automatically generate chord progressions. Then we use an arti cial immune system (AIS) to minimize the penalty function when proposing candidates for the next chord in a sequence. The AIS is capable of nding multiple optima in parallel, resulting in several di_erent chords as appropriate candidates. Thus we performed a listening test to evaluate the chords subjectively and validate the penalty function. We found that chords with a low penalty value were considered better candidates than chords with higher penalty values.

A Genetic Programming Approach to Generating Musical Compositions
David M. Hofmann
Evolutionary algorithms have frequently been applied in the field of computer-generated art. In this paper, a novel approach in the domain of automated music composition is proposed. It is inspired by genetic programming and uses a tree-based domain model of compositions. The model represents musical pieces as a set of constraints changing over time, forming musical contexts allowing to compose, reuse and reshape musical fragments. The system implements a multi-objective optimization aiming for statistical measures and structural features of evolved models. Furthermore a correspondent domain-specific computer language is introduced used to transform domain models to a comprehensive, human-readable text representation and vice versa. The language is also suitable to limit the search space of the evolution and as a composition language for human composers.

Interpretability of Music Classification as a Criterion for Evolutionary Multi-Objective Feature Selection
Igor Vatolkin, Guenter Rudolph, Claus Weihs
The development of numerous audio signal characteristics led to an increase of classification performance for automatic categorisation of music audio recordings. Unfortunately, models built with such low-level descriptors lack of interpretability. Musicologists and listeners can not learn musically meaningful properties of genres, styles, composers, or personal preferences. On the other side, there are new algorithms for the mining of interpretable features from music data: instruments, moods and melodic properties, tags and meta data from the social web, etc. In this paper, we propose an approach how evolutionary multi-objective feature selection can be applied for a systematic maximisation of interpretability without a limitation to the usage of only interpretable features. We introduce a simple hypervolume based measure for the evaluation of trade-off between classification performance and interpretability and discuss how the results of our study may help to search for particularly relevant high-level descriptors in future.

EvoMUSART posters

Wednesday 8 April 1815-1945

FuXi: a Fish-Driven Instrument for Real-Time Music Performance
Joao Cordeiro
In this paper we present a system for real-time computer music performance (live electronics) and live visuals based on the behavior of a fish in an aquarium. The system is comprised of 1) an aquarium with a fish; 2) a computer vision module (USB Camera); 3) a visual display of the fish overlaid by graphical elements controlled by the user, 4) a sound synthesis module and 5) a standard MIDI controller. The musical expression and graphic generation is a combination of the fish movements and decisions made by the performer in real-time, together contributing to the audiovisual experience. By making use of a live animal, the system provides indeterminacy and natural gestures to the sound being generated. The match between sound and image shows some semantic redundancy, aiming at a more narrative compositional approach where the fish is the main character. The system is targeted to soundscape composition and electroacoustic music featuring a high degree of improvisation.

Echo
Christoph Klemmt, Rajat Sodhi
This paper is interested in the artistic possibilities of systematic translations of sound or music into three-dimensional form. The generation of static two and three-dimensional form based on music or sound has been used by various artists, architects, scientists and technicians. The time-based attributes of a sound can be directly transformed into spatial dimensions of the generated form. A two-dimensional example is the visualisation of a sound wave in which the time of the sound is recorded from left to right, while the frequency, another time-based attribute of the sound, is recorded in the vertical direction. Many attempts in generating systematic three-dimensional translations are taking the form of single-surface morphologies, due to most data which can be extracted from a sound being dependent variables for any given time-frequency coordinate. We are proposing a system of analysing reassigned sound data within a variable time frame as a tool to extract multiple consecutive layers of information, which in their combination have the potential to form non-surface morphologies. The artistic possibilities of the morphologies as an architectural geometry has been tested with the design of an exhibition for Design Shanghai 2013.

Chorale Music Splicing System: an algorithmic music composer inspired by molecular splicing
Clelia De Felice, Roberto De Prisco, Delfina Malandrino, Gianluca Zaccagnino, Rocco Zaccagnino, Rosalba Zizza
Splicing systems are a formal model of a generative mechanism of words (strings of characters), inspired by a recombinant behavior of DNA. They are defined by a finite alphabet A, an initial set I of words and a set R of rules. Many of the studies about splicing systems focused on the properties of the generated languages and their theoretical computational power. In this paper we propose the use of splicing systems for algorithmic music composition. Although the approach is general and can be applied to many types of music, in this paper, we focus the attention to the algorithmic composition of 4-voice chorale-like music. We have developed a Java implementation of this approach and we have provided an evaluation of the music output by the system.

Schemographe: Application for a New Representation Technique and Methodology of Analysis in Tonal Harmony

Anna Shvets, Myriam Desainte-Cathérine

A recent development of music theory focuses basically on neo-riemannian angle of harmonic analysis with the use of Tonnetz as a space for harmonic change representation. However the Tonnetz does not cover the functional relations between accords within tonality and is feebly suitable to capture the features of neo-tonal postmodern music based on a new use of tonal functionality. This work presents an alternative method for music harmony progressions representation and analysis which uses two levels of representation. The first level is represented as a system of horizontal and vertical triads of graphs where each graph is an exo-frame filled out by information of specified degree of the scale. The graph pattern in this system represents the specified segment of harmonic progression taken from harmonic analysis of the musical composition. The pattern is then schematized for the second level of representation which examines its structural resemblance to the other schemas received similarly from the segments of harmonic progression. In order to facilitate the understanding of a new methodology and encourage its use in tonal harmony analysis an Android application for tablets called Schemographe has been created. The application presents the possibilities of the system on the two described levels of representation on example of three vocal pieces by neo-tonal postmodern composer Valentin Silvestrov. Link to the media file: https://drive.google.com/file/d/0BwEd8DFYhDSGUm5mOTR2bG9rb2s/view?usp=sharing

Feature Discovery by Deep Learning for Aesthetic Analysis of Evolved Abstract Images

Allan Campbell, Vic Ciesielski, A. K. Qin

We investigated the ability of a Deep Belief Network with logistic nodes, trained unsupervised by Contrastive Divergence, to discover features of evolved abstract art images. Two Restricted Boltzmann Machine models were trained independently on low and high aesthetic class images. The receptive fields (filters) of both models were compared by visual inspection. Roughly 10% of these filters in the high aesthetic model approximated the form of the high aesthetic training images. The remaining 90% of filters in the high aesthetic model and all filters in the low aesthetic model appeared noise like. The form of discovered filters was not consistent with the Gabor filter like forms discovered for MNIST training data, possibly revealing an interesting property of the evolved abstract training images.We joined the datasets and trained a Restricted Boltzmann Machine finding that roughly 30% of the filters approximate the form of the high aesthetic input images. We trained a 10 layer Deep Belief Network on the joint dataset and used the output activities at each layer as training data for traditional classifiers (decision tree and random forest). The highest classification accuracy from learned features (84%) was achieved at the second hidden layer, indicating that the features discovered by our Deep Learning approach have discriminative power. Above the second hidden layer, classification accuracy decreases.

EvoCOP conference programme

Thursday 9 April

	room 2
0930-1110	**EvoCOP 1 : Scheduling and Graph Problems** **session chair: Gabriela Ochoa** A New Solution Representation for the Firefighter Problem **Bin Hu, Andreas Windbichler, Günther Raidl** A Variable Neighborhood Search Approach for the Interdependent Lock Scheduling Problem **Matthias Prandtstetter, Ulrike Ritzinger, Peter Schmidt, Mario Ruthmair** The New Memetic Algorithm HEAD for Graph Coloring: an Easy Way for Managing Diversity **Laurent Moalic, Alexandre Gondran** Using Local Search to Evaluate Dispatching Rules in Dynamic Job Shop Scheduling **Rachel Hunt, Mark Johnston, Mengjie Zhang**
1110-1135	**Coffee break**
1135-1315	**EvoCOP 2 : Multi-objective Optimisation** **session chair: Marc Schoenauer** Analysis of Solution Quality of a Multiobjective Optimization-based Evolutionary Algorithm for Knapsack Problem **Jun He, Yong Wang, Yuren Zhou** Improving the Performance of the Germinal Center Artificial Immune System using ϵ-dominance : A Multi-objective Knapsack Problem Case Study **Ayush Joshi, Jonathan Rowe, Christine Zarges,** The Sim-EA Algorithm with Operator Autoadaptation for the Multiobjective Firefighter Problem **Krzysztof Michalak** True Pareto Fronts for Multi-Objective AI Planning Instances **Alexandre Quemy, Marc Schoenauer**
1315-1430	**Lunch**
1430-1610	**EvoCOP 3 : Routing and Location Problems** **session chair: Hoong Chuin Lau** A computational comparison of different algorithms for very large p-median problems **Pascal Rebreyend, Laurent Lemarchand, Reinhardt Eurler** A Variable Neighborhood Search for the Generalized Vehicle Routing Problem with Stochastic Demands **Benjamin Biesinger, Bin Hu, Günther Raidl** An Iterated Local Search Algorithm for Solving the Orienteering Problem with Time Windows **Aldy Gunawan, Hoong Chuin Lau, Kun Lu** Multi-Start Iterated Local Search for the Mixed Fleet Vehicle Routing Problem with Heterogenous Electric Vehicles **Ons Sassi, Wahiba Ramdane Cherif-Khettaf, Ammar Oulamara**

1610-1630	**Coffee break**
1630-1810	**EvoCOP 4 : Other Applications and Theory** **session chair: tbc** A Biased Random-Key Genetic Algorithm for the Cloud Resource Management Problem **Leonard Heilig, Eduardo Lalla-Ruiz, Stefan Voß** Evolving Deep Recurrent Neural Networks Using Ant Colony Optimization **Travis Desell, Sophine Clachar, James Higgins, Brandon Wild** Mixing Network Extremal Optimization for Community Structure Detection **Mihai Suciu, Rodica Ioana Lung, Noemi Gasko** Runtime Analysis of (1+1) Evolutionary Algorithm Controlled with Q-learning using Greedy Exploration Strategy on OneMax+ZeroMax Problem **Denis Antipov, Maxim Buzdalov, Benjamin Doerr**

Friday 10 April

	room 2
0930-1110	**EvoCOP 5 : Best Paper Candidates** **session chair: Francisco Chicano** Hyper-heuristic Operator Selection and Acceptance Criteria **Richard Marshall, Mark Johnston, Mengjie Zhang** On the Complexity of Searching the Linear Ordering Problem Neighborhoods **Benjamin Correal, Philippe Galinier** Upper and Lower Bounds on Unrestricted Black-Box Complexity of Jumpn,l **Maxim Buzdalov, Mikhail Kever, Benjamin Doerr**

EvoCOP session 1 : Scheduling & Graph Problems

Thursday 9 April 0930-1110

session chair : Gabriela Ochoa

A New Solution Representation for the Firefighter Problem
Bin Hu, Andreas Windbichler, Günther Raidl
The firefighter problem (FFP) is used as a model to simulate how a fire breaks out and spreads to its surroundings over a discrete time period. The goal is to deploy a given number of firefighters on strategic points at each time step to contain the fire in a most efficient way, so that as many areas are saved from the fire as possible. In this paper we introduce a new solution representation for the FFP which can be applied in metaheuristic approaches. Compared to the existing approach in the literature, it is more compact in a sense that the solution space is smaller although the complexity for evaluating a solution remains unchanged. We use this representation in conjunction with a variable neighborhood search (VNS) approach to tackle the FFP. To speed up the optimization process, we propose an incremental evaluation technique that omits unnecessary re-calculations. Computational tests were performed on a benchmark instance set containing 120 random graphs of different size and density. Results indicate that our VNS approach is highly competitive with existing state-of-the-art approaches.

A Variable Neighborhood Search Approach for the Interdependent Lock Scheduling Problem
Matthias Prandtstetter, Ulrike Ritzinger, Peter Schmidt, Mario Ruthmair
We investigate a so far not examined problem called the Interdependent Lock Scheduling Problem. A Variable Neighborhood Search approach is proposed for finding lock schedules along the Austrian part of the Danube River in order to minimize the overall ship travel times. In computational experiments the performance of our approach is assessed and compared to real-world ship trajectories. Notable improvements can be achieved. In addition, the number of (empty) lockages can be significantly reduced when taking them into account during optimization without loosing too much of quality in travel time optimization.

The New Memetic Algorithm HEAD for Graph Coloring: an Easy Way for Managing Diversity
Laurent Moalic, Alexandre Gondran
This paper presents an effective memetic approach HEAD designed for coloring difficult graphs. In this algorithm a powerful tabu search is used inside a very specific population of individuals. Indeed, the main characteristic of HEAD is to work with a population of only two individuals. This provides a very simple algorithm with neither selection operator nor replacement strategy. Because of its simplicity, HEAD allows an easy way for managing the diversity. We focus this work on the impact of this diversity management on well-studied graphs of the DIMACS challenge benchmarks, known to be very difficult to solve. A detailed analysis is provided for three graphs on which HEAD finds a legal coloring with less colors than reference algorithms: DSJC500.5 with 47 colors, DSJC1000.5 with 82 colors and flat1000_76_0 with 81 colors.The analysis performed in this work will allow to improve HEAD efficiency in terms of computation time and maybe to decrease the number of needed colors for other graphs.

EvoCOP session 1 : Scheduling & Graph Problems

Thursday 9 April 0930-1110

session chair : Gabriela Ochoa

Using Local Search to Evaluate Dispatching Rules in Dynamic Job Shop Scheduling

Rachel Hunt, Mark Johnston, Mengjie Zhang

Improving scheduling methods in manufacturing environments such as job shops offers the potential to increase throughput, decrease costs, and therefore increase profit. This makes scheduling an important aspect in the manufacturing industry. Job shop scheduling has been widely studied in the academic literature because of its real-world applicability and difficult nature. Dispatching rules are the most common means of scheduling in dynamic environments. We use genetic programming to search the space of potential dispatching rules. Dispatching rules are often short-sighted as they make one instantaneous decision at each decision point. We incorporate local search into the evaluation of dispatching rules to assess the quality of decisions made by dispatching rules and encourage the dispatching rules to make good local decisions for effective overall performance. Results show that the inclusion of local search in evaluation led to the evolution of DRs which make better decisions over the local time horizon, and attain lower TWT. The advantages of using local search as a tie-breaking mechanism are not so pronounced.

EvoCOP session 2 : Multi-objective Optimisation

Thursday 9 April 1135-1315

session chair : Marc Schoenauer

Analysis of Solution Quality of a Multiobjective Optimization-based Evolutionary Algorithm for Knapsack Problem
Jun He, Yong Wang, Yuren Zhou
Multi-objective optimisation is regarded as one of the most promising ways for dealing with constrained optimisation problems in evolutionary optimisation. This paper presents a theoretical investigation of a multi-objective optimisation evolutionary algorithm for solving the 0-1 knapsack problem. Two initialisation methods are considered in the algorithm: local search initialisation and greedy search initialisation. Then the solution quality of the algorithm is analysed in terms of the approximation ratio.

Improving the Performance of the Germinal Center Artificial Immune System using ϵ-dominance : A Multi-objective Knapsack Problem Case Study
Ayush Joshi, Jonathan E Rowe, Christine Zarges
The Germinal center artificial immune system (GC-AIS) is a novel immune algorithm inspired by recent research in immunology, which requires very few parameters to be set by hand. The population of solutions in GC-AIS is dynamic in nature and has no restrictions on its size which can cause problems of population explosion, where the population keeps growing very rapidly, leading to wasteful fitness evaluations. In this paper we try to address this problem in the GC-AIS by incorporating ϵ-dominance, which is a well-known mechanism in multi-objective optimization to regulate population size. The improved variant of GC-AIS is compared with a well-known multi-objective evolutionary algorithm NSGA-II on the multi-objective knapsack problem. We show that our improved GC-AIS performs better than NSGA-II on the instances of the knapsack problem taken from (Zitzler& Thiele, 1999) inheriting the same benefits of having to set fewer parameters manually

The Sim-EA Algorithm with Operator Autoadaptation for the Multiobjective Firefighter Problem
Krzysztof Michalak
The firefighter problem is a graph-based optimization problem that can be used for modelling the spread of fires, and also for studying the dynamics of epidemics. Recently, this problem gained interest from the soft computing research community and papers were published on applications of ant colony optimization and evolutionary algorithms to this problem. Also, the multiobjective version of the problem was formulated. In this paper a multipopulation algorithm Sim-EA is applied to the multiobjective version of the firefighter problem. The algorithm optimizes firefighter assignment for a predefined set of weight vectors, which determine the importance of individual objectives. A migration mechanism is used for improving the effectiveness of the algorithm. Obtained results confirm that the multipopulation approach works better than the decomposition approach in which a single specimen is assigned to each direction. Given less computational resources than the decomposition approach, the Sim-EA algorithm produces better results than a decomposition-based algorithm

EvoCOP session 2 : Multi-objective Optimisation

Thursday 9 April 1135-1315

session chair : Marc Schoenauer

True Pareto Fronts for Multi-Objective AI Planning Instances
Alexandre Quemy, Marc Schoenauer
Multi-objective AI planning suffers from a lack of benchmarks with known Pareto Fronts. A tunable benchmark generator is proposed, together with a specific solver that provably computes the true Pareto Front of the resulting instances. A wide range of Pareto Front shapes of various difficulties can be obtained by varying the parameters of the generator. The experimental performances of an actual implementation of the exact solver are demonstrated, and some large instances with remarkable Pareto Front shapes are proposed, that will Multi-objective AI planning suffers from a lack of benchmarks with known Pareto Fronts. A tunable benchmark generator is proposed, together with a specific solver that provably computes the true Pareto Front of the resulting instances. A wide range of Pareto Front shapes of various difficulty can be obtained by varying the parameters of the generator. The experimental performances of an actual implementation of the exact solver are demonstrated, and some large instances with remarkable Pareto Front shapes are proposed, that will hopefully become standard benchmarks of the AI planning domain.

EvoCOP session 3 : Routing and Location Problems

Thursday 9 April 1430-1610

session chair : Hoong Chuin Lau

A Computational Comparison of Different Algorithms for Very Large p-median Problems

Pascal Rebreyend, Laurent Lemarchand, Reinhardt Eurler

In this paper, we propose a new method for solving large-scale p-median problem instances based on real data. We compare different approaches both in terms of runtime, memory footprint and quality of solutions obtained. In order to test the different methods on real data, we introduce a new benchmark for the p-median problem based on real Swedish data. Because of the size of the problem addressed, up to 1938 candidate nodes, a number of algorithms, both exact and heuristic, are considered. We also propose an improved hybrid version of a Genetic Algorithm called impGA. Experiments show that impGA behaves as well as other methods for the standard set of medium-size problems taken from Beasley's benchmark, but produces comparatively good results in terms of quality, runtime and memory footprint on our specific benchmark

A Variable Neighborhood Search for the Generalized Vehicle Routing Problem with Stochastic Demands

Benjamin Biesinger, Bin Hu, Günther Raidl

In this work we consider the generalized vehicle routing problem with stochastic demands (GVRPSD) being a combination of the generalized vehicle routing problem, in which the nodes are partitioned into clusters, and the vehicle routing problem with stochastic demands, where the exact demands of the nodes are not known beforehand. It is an NP-hard problem for which we propose a variable neighborhood search (VNS) approach to minimize the expected tour length through all clusters. We use a permutation encoding for the cluster sequence and consider the preventive restocking strategy where the vehicle restocks before it potentially runs out of goods. The exact solution evaluation is based on dynamic programming and is very time-consuming. Therefore we propose a multi-level evaluation scheme to significantly reduce the time needed for solution evaluations. Two different algorithms for finding an initial solution and three well-known neighborhood structures for permutations are used within the VNS. Results show that the multi-level evaluation scheme is able to drastically reduce the overall run-time of the algorithm and that it is essential to be able to tackle larger instances. A comparison to an exact approach shows that the VNS is able to find an optimal or near-optimal solution in much shorter time.

EvoCOP session 3 : Routing and Location Problems

Thursday 9 April 1430-1610

session chair : Hoong Chuin Lau

Multi-Start Iterated Local Search for the Mixed Fleet Vehicle Routing Problem with Heterogenous Electric Vehicles

Ons Sassi, Wahiba Ramdane Cherif-Khettaf, Ammar Oulamara

This paper deals with a real world application that consists in the vehicle routing problem with mixed fleet of conventional and heterogenous electric vehicles including new constraints, denoted VRPHFCC. This problem is defined by a set of customers that have to be served by a mixed fleet of vehicles composed of heterogenous fleet of Electric Vehicles (EVs) with distinct battery capacities and operating costs, and a set of identical Conventional Vehicles (CVs). The EVs could be charged during their trips in the available charging stations, which offer charging with a given technology of chargers and time dependent charging costs. Charging stations are also subject to operating time window constraints. EVs are subject to the compatibility constraints with the available charging technologies and they could be partially charged. Intermittent charging at the depot is also allowed provided that constraints related to the electricity grid are satisfied. The objective is to minimize the number of employed vehicles and to minimize the total travel and charging costs. The developed multi-start algorithm is based on the Iterated Local Search metaheuristic which uses a Large Neighborhood Search with two different insertion strategies in the Local Search procedure. Different implementation schemes of the proposed method are tested on a set of real data instances with up to 550 customers as well as on generalized benchmark instances

An Iterated Local Search Algorithm for Solving the Orienteering Problem with Time Windows

Aldy Gunawan, Hoong Chuin Lau, Kun Lu

The Orienteering Problem with Time Windows (OPTW) is a variant of the Orienteering Problem (OP). Given a set of nodes including their scores, service times and time windows, the goal is to maximize the total of scores collected by a particular route considering a predefined time window during which the service has to start. We propose an Iterated Local Search (ILS) algorithm to solve the OPTW, which is based on several local search operations, such as Swap, 2-opt, Insert and Replace. We also implement the combination between Acceptance Criterion and Perturbation mechanisms to control the balance between diversification and intensification of the search. In Perturbation, Shake strategy is introduced. The computational results obtained by our proposed algorithm are compared against optimal solutions or best-known solution values obtained by state-of-the-art algorithms. We show experimentally that our proposed algorithm is effective on well-known benchmark instances available in the literature. It is also able to improve the best-known solution of some benchmark instances.

EvoCOP session 4 : Other Applications & Theory

Thursday 9 April 1630-1810

session chair : Bin Hu

A Biased Random-Key Genetic Algorithm for the Cloud Resource Management Problem

Leonard Heilig, Eduardo Lalla-Ruiz, Stefan Voß

Flexible use options and associated cost savings of cloud computing are increasingly attracting the interest from both researchers and practitioners. Since cloud providers offer various cloud services in different forms, there is a great potential of optimizing the selection of those services from the consumer perspective. In this paper, we address the Cloud Resource Management Problem that is a recent optimization problem aimed at reducing the payment cost and the execution time of consumer applications. In the related literature, there is one approach that successfully addresses this problem based on a Greedy Randomized Adaptive Search Procedure (GRASP). Due to the fact, that consumers require fast and high-quality solutions to economically automate cloud resource management and deployment processes, we propose an efficient Biased Random-Key Genetic Algorithm (BRKGA-CC). The computational experiments over a benchmark suite generated based on real data indicate that the performance of our approach outperforms the approaches proposed in the literature.

Evolving Deep Recurrent Neural Networks Using Ant Colony Optimization

Travis Desell, Sophine Clachar, James Higgins, Brandon Wild

This paper presents a novel strategy for using ant colony optimization (ACO) to evolve the structure of deep recurrent neural networks. While versions of ACO for continuous parameter optimization have been previously used to train the weights of neural networks, to the authors' knowledge they have not been used to actually design neural networks. The strategy presented is used to evolve deep neural networks with up to 5 hidden and 5 recurrent layers for the challenging task of predicting general aviation flight data, and is shown to provide improvements of 63% for airspeed, a 97% for altitude and 120% for pitch over previously best published results, while at the same time not requiring additional input neurons for residual values. The strategy presented also has many benefits for neuro-evolution, including the fact that it is easily parallizable and scalable, and can operate using any method for training neural networks. Further, the networks it evolves can typically be trained in fewer iterations than fully connected networks

Mixing Network Extremal Optimization for Community Structure Detection

Mihai Suciu, Rodica Ioana Lung, Noémi Gaskó

Mixing Network Extremal Optimization is a new algorithm designed to identify the community structure in networks by using a game theoretic approach and a network mixing mechanism as a diversity preserving method. Numerical experiments performed on synthetic and real networks illustrate the potential of the approach.

Runtime Analysis of (1+1) Evolutionary Algorithm Controlled with Q-learning using Greedy Exploration Strategy on OneMax+ZeroMax Problem

Denis Antipov, Maxim Buzdalov, Benjamin Doerr

The setting is an EA that must contend with more than a single objective, but in contrast to the classical multi-objective setting, the paper deals with a so-called "helper-objective" setting in which a single-objective optimization algorithm needs to switch between multiple objectives from time to time. The EA+RL approach augments a single-objective EA with a reinforcement learning strategy to learn the correct objective for optimization. In this paper, the extra objective function is misleading (indeed it is in some sense the additive inverse of the target objective). Therefore, the runtime of the EA must account for the time that the reinforcement learning procedure takes to learn the extra objective function is worthless

EvoCOP session 5 : Best Paper Nominations

Friday 10 April 0930-1110

session chair : Francisco Chicano

Hyper-heuristic Operator Selection and Acceptance Criteria
Richard Marshall, Mark Johnston, Mengjie Zhang
Earlier research has shown that an adaptive hyper-heuristic can be a successful approach to solving combinatorial optimisation problems. By using a pairing of an operator (low-level heuristic) selection vector and a solution acceptance criterion, an adaptive hyper-heuristic can manage development of a "good" solution within an unseen low-level problem domain in a commercially realistic computational time. However not all selection vectors and solution acceptance criteria pairings deliver competitive results when faced with differing problem instance features and computational time limits. We evaluate pairings of six different operator selection vectors and eight solution acceptance criteria, and monitor the performance of the adaptive hyper-heuristic when applying each pairing to a set of Capacitated Vehicle Routing Problem instances of the same size but with different features. The results show that a few pairings of operator selection vector and acceptance criterion perform consistently well, while others require a longer computational time to deliver competitive results. We also investigate some of the features of a problem instance that may influence the performance of the selection vector and acceptance criterion pairings.

On the Complexity of Searching the Linear Ordering Problem Neighborhoods
Benjamin Correal, Philippe Galinier
The linear ordering problem is an important and much studied NP-hard problem. The most efficient neighborhood for this problem is the so-called insert neighborhood. According to the literature, the best insert move can be found in *O(n^2).* In this paper, we present a tree data structure that we name the maximum partial sum data structure. We show that using this data structure makes it possible to find, iteration after iteration, a best insert move in *O(n log n)* -- after an initialization in *O(n^2)*. We also consider an alternative neighborhood named the interchange neighborhood. We show that this neighborhood can be searched in *O(n^2)* -- versus *O(n^3)* in the best existing implementation**.**

Upper and Lower Bounds on Unrestricted Black-Box Complexity of $\mathtt{Jump}_{n,1}$
Maxim Buzdalov, Mikhail Kever, Benjamin Doerr
We analyse the unrestricted black-box complexity of $\mathbf{Jump}_{n,l}$ functions. For upper bounds, we present three algorithms for small, medium and extreme values of *l* We present a matrix lower bound theorem which is capable of giving better lower bounds than a general information theory approach if one is able to assign different types to queries and define relationships between them. Using this theorem, we prove lower bounds for **Jump** separately for odd and even values of *n*. For several cases, notably for extreme **Jump** the first terms of lower and upper bounds coincide.

EvoAPPLICATIONS conference programme

Wednesday 8 April

	room 3
1120-1300	**EvoApps 1 : Industrial Applications** **(APPs topics: INDUSTRY+ENERGY+STOC)** Many-Objective Optimization of a Hybrid Car Controller **Tobias Rodemann, Kaname Narukawa, Michael Fischer, Mohammed Awada** Multi-Noisy-Hard-Objective Robust Design of Balanced Surface Acoustic Wave Filters Based on Prediction of Worst-Case Performance **Kiyoharu Tagawa, Shoichi Harada** Evolutionary Optimization of Smart Buildings with Interdependent Devices **Ingo Mauser, Julian Feder, Jan Mueller, Hartmut Schmeck** Optimising the scheduling and planning of urban milk deliveries **Neil Urquhart** Clustering local tourism systems by Threshold Acceptance **Joseph Andria, Giacomo Di Tollo**
1300-1415	**Lunch**
1415-1555	**EvoApps 2 : Stochastic & Dynamic Environments** **(APPs topics: STOC+COMPLEX)** Applying Ant Colony Optimization to Dynamic Binary-Encoded Problems **Michalis Mavrovouniotis, Shengxiang Yang** An experimental study of combining Evolutionary Algorithms with KD-Tree to solving dynamic optimisation problems **Trung Thanh Nguyen, Ian Jenkinson, Zaili Yang** Coevolutionary intransitivity in games: A landscape analysis **Hendrik Richter** Making IDEA-ARIMA efficient in Dynamic Constrained Optimization Problems **Patryk Filipiak, Piotr Lipinski**
1555-1620	**Coffee break**
1620-1800	**EvoApps 3 : Complex Systems** **(APPs topics: COMPLEX+FIN)** Hierarchic Genetic Search with α-Stable Mutation **Adam Obuchowicz, Maciej Smolka, Robert Schaefer** Emergence of Cooperation in the Prisoner's Dilemma Driven by Conformity **Marco Alberto Javarone, Antonio Emanuele Atzeni, Serge Galam** An Experimental Evaluation of Multi-Objective Evolutionary Algorithms for Detecting Critical Nodes in Complex Networks **Mario Ventresca, Kyle Harrison, Beatrice Ombuki-Berman** Self-Balancing Multimemetic Algorithms in Dynamic Scale-Free Networks **Rafael Nogueras, Carlos Cotta**

1815-1945	EvoStar poster session in conjunction with conference reception	
	EvoAPPLICATIONS posters	**EvoAPPLICATIONS posters**
	Studying the Geographical Cluster Paging with delay constraint in Registration Areas with the Algorithm NSGAII **Victor Berrocal-Plaza, Miguel A. Vega-Rodriguez, Juan M. Sanchez-Perez**	Parallel cooperation for large-scale multiobjective optimization on feature selection problems **Dragi Kimovski, Julio Ortega, Andrés Ortiz, Raúl Baños**
	Investigating Fitness Measures for the Automatic Construction of Graph Models **Kyle Harrison, Mario Ventresca, Beatrice Ombuki-Berman**	Collaborative Diffusion on the GPU for Path-finding in Games **Craig McMillan, Emma Hart, Kevin Chalmers**
	Evolutionary Training of Robotised Architectural Elements **Claudio Rossi, Pablo Gil, William Coral**	A Multiobjective Evolutionary Algorithm for Personalized Tours in Street Networks **Ivanoe De Falco, Umberto Scafuri, Ernesto Tarantino**
	Heat Map Based Feature Selection: A Case Study for Ovarian Cancer, **Carlos Huertas, Reyes Juárez-Ramírez**	A Projection-Based Approach for Real-time Assessment and Playability Check for Physics-Based Games **Mohammad Shaker, Noor Shaker, Mohamed Abou-Zleikha, Julian Togelius**
	PowerSurge: A Serious Game on Power Transmission Networks **Sebastian von Mammen, Fabian Hertwig, Florain Obermayer, Patrick Lehner**	Analysis of Diversity Methods for Evolutionary Multi-Objective Ensemble Classifiers **Stefan Oehmcke, Justin Heinermann, Oliver Kramer**
	How the world was MADE: parametrization of evolved agent-based models for backstory generation **Rubén Héctor García Ortega, Pablo García Sánchez, Juan Julián Merelo Guervós, Maribel García Arenas, Pedro A. Castillo Valdivieso, Antonio Mora García**	Fair Resource Allocation Using Multi-Population Evolutionary Algorithm **Tohid Erfani, Rasool Erfani**
		A Benchmark For Virtual Camera Control **Paolo Burelli, Georgios Yannakakis**
	Object Detection in Natural Images using the Brain Programming Paradigm with a Multi-Objective Approach **Eddie Clemente, Gustavo Olague, Daniel E. Hernández, Jose L. Briseño, Jose Mercado**	Planning the Deployment of Indoor Wireless Sensor Networks through Multiobjective Evolutionary Techniques **J. M. Lanza-Gutierrez, J. A. Gomez-Pulido, S. Priem-Mendes, M. Ferreira, J. S. Pereira**
	A Novel Multi-Objectivisation Approach for Optimising the Protein Inverse Folding Problem **Sune S. Nielsen, Grégoire Danoy, Wiktor Jurkowski, Juan Luis Jiménez Laredo, Reinhard Schneider, El-Ghazali Talbi, Pascal Bouvry**	Automatic Evolution of Parallel Sorting Programs on Multi-cores **Gopinath Chennupati, R. Muhammad Atif Azad, Conor Ryan**
		A Concept for Real-Valued Multi-Objective Landscape Analysis Realized on Biochemcial Optimization Problems **Susanne Rosenthal, Bernd Freisleben, Markus Borschbach**
	Evolving Controllers for Programmable Robots to Influence Non-Programmable Lifeforms: A Casy Study **Payam Zahadat, Thomas Schmickl**	Chromatic Selection -- an Oversimplified Approach to Multi-Objective Optimization **Giovanni Squillero**

EvoAPPLICATIONS conference programme

Thursday 9 April

	room 1	room 3
0930-1110		**EvoApps 4: Computer Vision & Pattern Recognition** **(APPs topics: IASP+NUM)** Alternating Optimization of Unsupervised Regression with Evolutionary Embeddings **Oliver Kramer, Daniel LÃ¼ckehe** Hybrid Manifold Clustering with Evolutionary Tuning **Oliver Kramer** Gaussian Transformation based Representation in Particle Swarm Optimisation for Feature Selection **Hoai Bach Nguyen, Bing Xue, Ivy Liu, Peter Andreae, Mengjie Zhang** Genetic Programming with Alternative Search Drivers for Detection of Retinal Blood Vessels **Krzysztof Krawiec, MikoÅ‚aj Pawlak**
1110-1135	**Coffee break**	
1135-1315	**EvoApps 5: Game Agents** **(APPs topics: GAMES+STOC)** Evolving Diverse Strategies Through Combined Phenotypic Novelty and Objective Function Search **Davy Smith, Laurissa Tokarchuk, Chrisantha Fernando** It's time to stop: A comparison of termination conditions in the evolution of game bots **Antonio Fernández Ares, Antonio Mora García, Pablo García Sánchez, Pedro Castillo Valdivieso, Maribel García Arenas, Gustavo Romero López, Juan Julián Merelo Guervós** General Video Game Evaluation Using Relative Algorithm Performance Profiles **Thorbjorn S. Nielsen, Gabriella A.B. Barros, Julian Togelius, Mark J. Nelson** The Role of Behavioral Diversity and Difficulty of Opponents in Coevolving Game-Playing Agents **Marcin Szubert, Wojciech Jaśkowski, Paweł Liskowski, Krzysztof Krawiec**	**EvoApps 6: Computer Vision** **(APPs topics: IASP)** A Supervised Figure-ground Segmentation Method using Genetic Programming **Yuyu Liang, Mengjie Zhang, Will Browne** A Multi-objective Evolutionary Algorithm for Interaction Systems Based on Laser Pointers **Francisco Chavez, Eddie Clemente, Daniel E. Hernandez, Francisco Fernandez de Vega, Gustavo Olague** Topology-preserving ordering of the RGB space with an evolutionary algorithm **Francisco Florez-Revuelta** Planar Surfaces Recognition in 3D Point Cloud Using a Real-Coded Multistage Genetic Algorithm **Mosab Bazargani, Luís Mateus, Maria Amélia R. Loja**
1315-1430	**Lunch**	
1430-1610	**EvoApps 7: Content Generation and Learning in Games** **(APPs topics: GAMES)** A Procedural Method for Automatic Generation of Spelunky Levels **Noor Shaker, Walaa Baghdadi, Fawzya Shams Eddin, Rawan Al-Omari, Ziena Alhalawani, Mohammad Shaker** Evolving Random Forest for Preference Learning **Mohamed Abou-Zleikha, Noor Shaker** Procedural Personas as Critics for Dungeon Generation **Antonios Liapis, Christoffer Holmgard, Georgios N. Yannakakis, Julian Togelius** A Progressive Approach to Content Generation **Mohammad Shaker, Noor Shaker, Julian Togelius, Mohamed Abou-Zleikha**	**EvoApps 8: Communication Networks** **(APPs topics: COMNET)** A Novel Grouping Genetic Algorithm for Assigning Resources to Users in WCDMA Networks **Lucas Cuadra, Sancho Salcedo-Sanz, Antonio D. Carnicer, Miguel A. Del Arco, Jose A. Portilla-Figueras** Parallel Extremal Optimization with Guided State Changes applied to Load Balancing **Eryk Laskowski, Marek Tudruj, Umberto Scafuri, Richard Olejnik, Ivanoe De Falco, Ernesto Tarantino** A Fast FPGA-Based Classification of Application Protocols Optimized Using Cartesian GP **David Grochol, Lukas Sekanina, Martin Zadnik, Jan Korenek** A Swarm Intelligence Approach to 3D Distance-based Indoor Localization **Stefania Monica, Gianluigi Ferrari**

EvoAPPLICATIONS conference programme

Thursday 9 April

1610-1630 Coffee break

	room 1	room 3
1630-1810	**EvoApps 9: Robotics** **(APPs topics: ROBOT)** On the Tradeoff between Hardware Protection and Optimization Success: A Case Study in Onboard Evolutionary Robotics for Autonomous Parallel Parking **Mostafa Wahby, Heiko Hamann** Real-World Reproduction of Evolved Robot Morphologies: Automated Categorization and Evaluation **Eivind Samuelsen, Kyrre Glette** Evolving Generalised Maze Solvers **David Shorten, Geoff Nitschke** Evolving Robot Controllers for Structured Environments through Environment Decomposition **Rodrigo Moreno, Andres Faina, Kasper Stoy** Autonomous Learning of Procedural Knowledge in an Evolutionary Cognitive Architecture for Robots **Rodrigo Salgado, Francisco Bellas, Richard J. Duro**	**EvoApps 10: Risk Management & Security** **(APPs topics: COMNET+RISK)** Black Holes and Revelations: Using Evolutionary Algorithms to Uncover Vulnerabilities in Disruption-Tolerant Networks **Doina Bucur, Giovanni Iacca, Giovanni Squillero, Alberto Tonda** Heuristics for the design of safe humanitarian aid distribution itineraries **José María Ferrer, María Teresa Ortuño, Gregorio Tirado, Begoña Vitoriano** Improving Maritime Awareness with Semantic Genetic Programming and Linear Scaling: Prediction of Vessels Position Based on AIS Data **Leonardo Vanneschi, Mauro Castelli, Ernesto Costa, Alessandro Re, Henrique Vaz, Victor Lobo, Paulo Urbano** Combining Ensemble of Classifiers by using Genetic Programming for Cyber Security Applications **Gianluigi Folino, Francesco Sergio Pisani** Automatic Generation of Mobile Malwares Using Genetic Programming **Emre Aydogan, Sevil Sen**

Friday 10 April

	room 1	room 3
0930-1110	**EvoApps 11 : Energy & Finance** **(APPs topics: ENERGY+FIN)** Multiobjective methodology for assessing the location of distributed electric energy storage **Jose Goncalves, Luis Neves, Antonio Gomes Martins** An energy management system aggregator based on an integrated evolutionary and differential evolution approach **Andreia M. Carreiro, Carlos Oliveira, Carlos Henggeler Antunes, Humberto M. Jorge** An Evolutionary Optimization Approach to Risk Parity Portfolio Selection **Ronald Hochreiter** Generating Directional Change Based Trading Strategies with Genetic Programming **Jeremie Gypteau, Fernando Otero, Michael Kampouridis** Training Financial Decision Support Systems with Thousands of Decision Rules using Differential Evolution with Embedded Dimensionality Reduction **Piotr Lipinski**	**EvoApps 12 : Continuous Parameter Optimisation** **(APPs topics: NUM+STOC)** Seed Disperser Ant Algorithm: An Evolutionary Approach for Optimization **Wen Liang Chang, Jeevan Kanesan, Anand Jayant Kulkarni** Neuro-evolutionary Topology Optimization with Adaptive Improvement Threshold **Nikola Aulig, Markus Olhofer** Evaluating Reward Definitions for Parameter Control **Giorgos Karafotias, Mark Hoogendoorn, A.E. Eiben** Applying Non-Dominated Sorting Genetic Algorithm II to Multi-Objective Optimization of a Weighted Multi-Metric Distance for Performing Data Mining Tasks **Muhammad Marwan Muhammad Fuad**

EvoAPP session 1 : Industrial Applications

Wednesday 8 April 1120-1300

EvoAPP topics: GAMES & STOC

Many-Objective Optimization of a Hybrid Car Controller
Tobias Rodemann, Kaname Narukawa, Michael Fischer, Mohammed Awada
Hybrid cars are considered to be a promising approach for providing individual mobility with lower CO2 -emissions without compromising on affordability and driving range. In order to reach these targets a highly efficient control (energy management) is required. In mass production vehicles control is often organized using simple, quick and easy to understand rule-based systems. Such a rule-base typically contains a moderate number of parameters which can be tuned using methods like evolutionary algorithms to improve performance. However, prior work basically targets a minimization of fuel consumption. In this work we present a many-objective evolutionary optimization that considers up to 7 objectives in parallel. We outline the additional optimization challenges that arise due to the large number of objectives and demonstrate that a substantial performance increase, over all objectives, can be achieved.

Optimising the scheduling and planning of urban milk deliveries
Neil Urquhart
This paper investigates the optimisation of the delivery of dairy products to households in three urban areas. The requirement for the optimisation to be part of the existing business process has determined the approach taken. The solution is maintained in an existing customer database, with manual amendments as customers are added and deleted. The optimization challenge is to take this solution, reduce the distance travelled, and balance the load across rounds making the minimum number of changes to the delivery network. The approach taken utilizes an Evolutionary Algorithm for ordering deliveries and a multi-agent approach to reassigning deliveries between rounds. The case study suggests that distance traveled may be reduced by up to 19%, the deviation between round lengths may be considerably reduced, with only ~10% of customers being moved between rounds.

Multi-Noisy-Hard-Objective Robust Design of Balanced Surface Acoustic Wave Filters Based on Prediction of Worst-Case Performance
Kiyoharu Tagawa, Shoichi Harada
This paper presents a novel computer-aided design method of Surface Acoustic Wave (SAW) filters which are widely used in the modern RF circuits of mobile communication systems. The performance of a SAW filter is specified by a number of criteria. Besides, the performance is deteriorated due to the uncertainties of physical coefficients and design parameters. In the multi-noisy-objective optimization problem of the SAW filter, the worst-case performance of a solution is considered based on the upper bounds of respective noisy-objective functions predicted statistically by multiple sampling. For finding various solutions for the problem effectively, a new evolutionary algorithm is proposed with three sample saving techniques. Finally, the influence of noise on the SAW filter is discussed through analysis of the obtained solutions.

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EvoAPP session 1 : Industrial Applications

Wednesday 8 April 1120-1300

EvoAPP topics: GAMES & STOC

Evolutionary Optimization of Smart Buildings with Interdependent Devices
Ingo Mauser, Julian Feder, Jan Mueller, Hartmut Schmeck
To enable a more efficient utilization of energy carriers, energy management systems (EMS) are designed to optimize the usage of energy in future smart buildings. In this paper, we present an EMS for buildings that uses a novel approach towards optimization of energy flows. The system is capable of handling interdependencies between multiple devices consuming energy, while keeping a modular approach towards components of the EMS and their optimization. Evaluations of the EMS in a realistic scenario, which consists of a building with adsorption chiller, hot and cold water storage tanks as well as combined heat and power plant, show the ability to reduce energy consumption and costs by an improved scheduling of the generation of hot and chilled water for cooling purposes

Clustering local tourism systems by Threshold Acceptance
Joseph Andria, Giacomo Di Tollo
Despite the importance of tourism as a leading industry in the development of a country's economy, there is a lack of criteria and methodologies for the detection, promotion and governance of local tourism systems. We propose a quantitative approach for the detection of local tourism systems that are optimal with respect to geographical, economic, and demographical criteria. To this end, we formulate the issue as an optimization problem, and we solve it by means of Threshold Acceptance, a meta-heuristic algorithm which allows us not to predefine the number of clusters and to allow some geographic areas not to belong to any cluster.

EvoAPP session 2 : Stochastic & Dynamic Environments

Wednesday 8 April 1415-1555

EvoAPP topics: STOC & COMPLEX

Applying Ant Colony Optimization to Dynamic Binary-Encoded Problems
Michalis Mavrovouniotis, Shengxiang Yang
Ant colony optimization (ACO) algorithms have proved to be able to adapt to dynamic optimization problems (DOPs) when stagnation behaviour is addressed. Usually, permutation-encoded DOPs, e.g. dynamic travelling salesman problems, are addressed using ACO algorithms whereas binary-encoded DOPs, e.g., dynamic knapsack problems, are tackled by evolutionary algorithms (EAs). This is because of the initial developments of the algorithms. In this paper, a binary version of ACO is introduced to address binary-encoded DOPs and compared with existing EAs. The experimental results show that ACO with an appropriate pheromone evaporation rate outperforms EAs in most dynamic test cases

An experimental study of combining Evolutionary Algorithms with KD-Tree to solving dynamic optimisation problems
Trung Thanh Nguyen, Ian Jenkinson, Zaili Yang
This paper studies the idea of separating the explored and unexplored regions in the search space to improve change detection and optima tracking. When an optimum is found, a simple sampling technique is used to estimate the basin of attraction of that optimum. This estimated basin is marked as an area already explored. Using a special tree-based data structure named KD-Tree to divide the search space, all explored areas can be separated from unexplored areas. Given such a division, the algorithm can focus more on searching for unexplored areas, spending only minimal resource on monitoring explored areas to detect changes in explored regions. The experiments show that the proposed algorithm has competitive performance, especially when change detection is taken into account in the optimisation process. The new algorithm was proved to have less computational complexity in term of identifying the appropriate sub-population/region for each individual. We also carry out investigations to find out why the algorithm performs well. These investigations reveal a positive impact of using the KD-Tree.

EvoAPP session 2 : Stochastic & Dynamic Environments

Wednesday 8 April 1415-1555

EvoAPP topics: STOC & COMPLEX

Coevolutionary intransitivity in games: A landscape analysis
Hendrik Richter
Intransitivity is supposed to be a main reason for deficits in coevolutionary progress and inheritable superiority. Besides, coevolutionary dynamics is characterized by interactions yielding subjective fitness, but aiming at solutions that are superior with respect to an objective measurement. Such an approximation of objective fitness may be, for instance, generalization performance. In the paper a link between rating- and ranking-based measures of intransitivity and fitness landscapes that can address the dichotomy between subjective and objective fitness is explored. The approach is llustrated by numerical experiments involving a simple random game with continuously tunable degree of randomness.

Making IDEA-ARIMA efficient in Dynamic Constrained Optimization Problems
Patryk Filipiak, Piotr Lipinski
A commonly used approach in Evolutionary Algorithms for Dynamic Constrained Optimization Problems forces re-evaluation of a population of individuals whenever the landscape changes. On the contrary, there are algorithms like IDEA-ARIMA that can effectively anticipate certain types of landscapes rather than react to changes which already happened and thus be one step ahead with the dynamic environment. However, the computational cost of IDEA-ARIMA and its memory consumption are barely acceptable in practical applications. This paper proposes a set of modifications aimed at making this algorithm an efficient and competitive tool by reducing the use of memory and proposing the new anticipation mechanism.

EvoAPP session 3 : Complex Systems

Wednesday 8 April 1620-1800

EvoAPP topics: COMPLEX & FIN

Hierarchic Genetic Search with α-Stable Mutation
Adam Obuchowicz, Maciej Smolka, Robert Schaefer
The paper analyzes the performance improvement imposed by the application of α-stable probability distributions to the mutation operator of the Hierarchic Genetic Strategy (HGS), in solving ill-conditioned, multimodal global optimization problems in continuous domains. The performed experiments range from standard benchmarks (Rastrigin and multi-peak Gaussian) to an advanced inverse parametric problem of the logging measurement inversion, associated with the oil and gas resource investigation. The obtained results show that the application of α-stable mutation can first of all decrease the total computational cost. The second advantage over the HGS with the standard, normal mutation consists in finding much more well-fitted individuals at the highest-accuracy HGS level located in attraction basins of local and global fitness minimizers. It might allow us to find more minimizers by performing local convex searches started from that points. It also delivers more information about the attraction basins of the minimizers, which can be helpful in their stability analysis.

Emergence of Cooperation in the Prisoner's Dilemma Driven by Conformity
Marco Alberto Javarone, Antonio Emanuele Atzeni, Serge Galam
We study the relations between strategies in game theory and the conformity. The latter is a behavior deemed relevant in social psychology and, as shown in several works, it strongly influences many social dynamics. We consider a population of agents that evolves in accordance with a payoff matrix which embodies two main strategies: cooperation and defection. In particular, agents play a game (e.g., the Prisoner's Dilemma) by choosing between these two strategies, in order to increase their payoff, i.e., their gain. During the evolution of the system, agents can change strategy according to an update rule, i.e., they can play sometimes as cooperators and sometimes as defectors. Usually, rules to update the strategy are driven by the payoffs of the neighbors of each agent. For instance, an agent imitates its best neighbor, i.e., the one having the highest payoff among the other neighbors. In this context, `imitation' means to adopt the strategy of another agent. In order to study if and how the emergence of cooperation can be affected by a social influence, we provide agents with two different behaviors, i.e., conformity and nonconformity, they use to select their strategy. Numerical simulations show that conformity strongly affects these dynamics, as cooperation emerges in the population, even under conditions of the games that usually lead, almost all agents, to play as defectors.

EvoAPP session 3 : Complex Systems

Wednesday 8 April 1620-1800

EvoAPP topics: COMPLEX & FIN

An Experimental Evaluation of Multi-Objective Evolutionary Algorithms for Detecting Critical Nodes in Complex Networks
Mario Ventresca, Kyle Harrison, Beatrice Ombuki-Berman
Identifying critical nodes in complex networks has become an important task across a variety of application domains. In this paper we propose a multi-objective version of the critical node detection problem, which aims to minimize pairwise connectivity in a graph by removing a subset of K nodes. Interestingly, while it has been recognized that this problem is inherently multi-objective since it was formulated, until now only single-objective algorithms have been proposed. After explicitly stating the new multi-objective problem variant, we then give a brief comparison of six common multi-objective evolutionary algorithms using sixteen common benchmark problem instances. A comparison of the results attained by viewing the algorithm as a single versus multi-objective problem is also conducted. We find that of the examined algorithms, NSGAII generally produces the most desirable approximation fronts. We also demonstrate that while related, the best multi-objective solutions do not translate into the best single-objective solutions.

Self-Balancing Multimemetic Algorithms in Dynamic Scale-Free Networks
Rafael Nogueras, Carlos Cotta
We study the behavior and performance of island-based multimemetic algorithms, namely memetic algorithms which explicitly represent and evolve memes alongside solutions, in unstable computational environments whose topology is modeled as scale-free networks, a pattern of connectivity observed in real-world networks, such as peer-to-peer systems. We consider the utilization of self-balancing strategies in order to efficiently adjust population sizes to cope with the phenomenon of churn, as well as the dynamic re-wiring of connections in order to deal with connectivity losses caused by node failures. A broad experimental evaluation on different problems and computational scenarios featuring diverse volatility conditions shows that the combination of these two strategies leads to more robust performance, in particular in situations in which churn rates are large.

EvoAPP session 4 : Computer Vision & Pattern Recognition

Thursday 9 April 0930-1110

EvoAPP topics: IASP & NUM

Alternating Optimization of Unsupervised Regression with Evolutionary Embeddings

Oliver Kramer, Daniel Lückehe

Unsupervised regression is a dimensionality reduction method that allows embedding high-dimensional patterns in low-dimensional latent spaces. In the line of research on iterative unsupervised regression, numerous methodological variants have been proposed in the recent past. This works extends the set of methods by evolutionary embeddings. We propose to use a (1+\lambda)-ES with Rechenberg mutation strength control to iteratively embed patterns and show that the learned manifolds are better with regard to the data space reconstruction error than the embeddings generated with naive Gaussian sampling. Further, we introduce a hybrid optimization approach of alternating gradient descent and the iterative evolutionary embeddings. Experimental comparisons on artificial test data sets confirm the expectation that a hybrid approach is superior or at least competitive to known methods like principal component analysis or Hessian local linear embedding.

Hybrid Manifold Clustering with Evolutionary Tuning

Oliver Kramer

Manifold clustering, also known as submanifold learning, is the task to embed patterns in submanifolds with different characteristics. This paper proposes a hybrid approach of clustering the data set, computing a global map of cluster centers, embedding each cluster, and then merging the scaled submanifolds with the global map. We introduce various instantiations of cluster and embedding algorithms based on hybridization of k-means, principal component analysis, isometric mapping, and locally linear embedding. A (1+1)-ES is employed to tune the submanifolds by rotation and scaling. The submanifold learning algorithms are compared w.r.t. the nearest neighbor classification performance on various experimental data sets.

EvoAPP session 4 : Computer Vision & Pattern Recognition

Thursday 9 April 0930-1110

EvoAPP topics: IASP & NUM

Gaussian Transformation based Representation in Particle Swarm Optimisation for Feature Selection

Hoai Bach Nguyen, Bing Xue, Ivy Liu, Peter Andreae, Mengjie Zhang

In classification, feature selection is an important but challenging task, which requires a powerful search technique. Particle swarm optimisation (PSO) has recently gained much attention for solving feature selection problems, but the current representation typically forms a high-dimensional search space. A new representation based on feature clusters was recently proposed to reduce the dimensionality and improve the performance, but it does not form a smooth fitness landscape, which may limit the performance of PSO. This paper proposes a new Gaussian based transformation rule for interpreting a particle as a feature subset, which is combined with the feature cluster based representation to develop a new PSO-based feature selection algorithm. The proposed algorithm is examined and compared with two recent PSO-based algorithms, where the first uses a Gaussian based updating mechanism and the conventional representation, and the second uses the feature cluster representation without using Gaussian distribution. Experiments on commonly used datasets of varying difficulty show that the proposed algorithm achieves better performance than the other two algorithms in terms of the classification performance and the number of features in both the training sets and the test sets. Further analyses show that the Gaussian transformation rule improves the stability, i.e. selecting similar features in different independent runs and almost always selects the most important features.

Genetic Programming with Alternative Search Drivers for Detection of Retinal Blood Vessels

Krzysztof Krawiec, Mikołaj Pawlak

A classification task is a test-based problem, with examples corresponding to tests. A correct classification is equivalent to passing a test, while incorrect to failing it. This applies also to classifying pixels in an image, viz. image segmentation. A natural performance indicator in such a setting is the accuracy of classification, i.e., the fraction of passed tests. When solving a classification tasks with genetic programming, it is thus common to employ this indicator as a fitness function. However, recent developments in GP as well as some earlier work suggest that the quality of evolved solutions may benefit from using other search drivers to guide the traversal of the space of programs. In this study, we systematically verify the usefulness of selected alternative search drivers in the problem of detection of blood vessels in ophthalmology imaging.

EvoAPP session 5 : Game Agents

Thursday 9 April 1135-1315

EvoAPP topics: GAMES & STOC

Evolving Diverse Strategies Through Combined Phenotypic Novelty and Objective Function Search

Davy Smith, Laurissa Tokarchuk, Chrisantha Fernando

Novelty search is an algorithm which proposes open-ended exploration of the search space by maximising behavioural novelty, removing the need for an objective fitness function. However, we show that when applied to complex tasks, training through novelty alone is not sufficient to produce useful controllers. Alongside this, the definition of phenotypic behaviour significantly effects the strategies of the evolved solutions. Controller networks for the spaceship in the arcade game Asteroids were evolved with five different phenotypic distance measures. Each of these phenotypic measures are shown to produce controllers which adopt different strategies of play than controllers trained through standard objective fitness. Combined phenotypic novelty and objective fitness is also shown to produce differing strategies within the same evolutionary run. Our results demonstrate that for domains such as video games, where a diverse range of interesting behaviours are required, training agents through a combination of phenotypic novelty and objective fitness is a viable method.

It's time to stop: A comparison of termination conditions in the evolution of game bots

Antonio Fernández Ares, Antonio Mora García, Pablo García Sánchez, Pedro Castillo Valdivieso, Maribel García Arenas, Gustavo Romero López, Juan Julián Merelo Guervós

Evolutionary Algorithms (EAs) are frequently used as a mechanism for the optimization of autonomous agents in games (bots), but knowing when to stop the evolution, when the bots are good enough, is not as easy as it would a priori seem. The first issue is that optimal bots are either unknown (and thus unusable as termination condition) or unreachable. In most EAs trying to find optimal boots fitness is evaluated through game playing. Many times it is found to be noisy, making its use as a termination condition also complicated. A fixed amount of evaluations or, in the case of games, a certain level of victories does not guarantee an optimal result. Thus the main objective of this paper is to test several termination conditions in order to find the one that yields optimal solutions within a restricted amount of time, and that allows researchers to compare different EAs as fairly as possible. To achieve this we will examine several ways of finishing an EA who is finding an optimal bot design process for a particular game, Planet Wars in this case, with the characteristics described above, determining the capabilities of every one of them and, eventually, selecting one for future designs.

General Video Game Evaluation Using Relative Algorithm Performance Profiles

Thorbjorn S. Nielsen, Gabriella A.B. Barros, Julian Togelius, Mark J. Nelson

In order to generate complete games through evolution we need generic and reliably evaluation functions for games. It has been suggested that game quality could be characterised through playing a game with different controllers and comparing their performance. This paper explores that idea through investigating the relative performance of different general game-playing algorithms. Seven game-playing algorithms was used to play several hand-designed, mutated and randomly generated VGDL game descriptions. Results discussed appear to support the conjecture that well-designed games have, in average, a higher performance difference between better and worse game-playing algorithms.

EvoAPP session 5 : Game Agents

Thursday 9 April 1135-1315

EvoAPP topics: GAMES & STOC

The Role of Behavioral Diversity and Difficulty of Opponents in Coevolving Game-Playing Agents
Marcin Szubert, Wojciech Jaśkowski, Paweł Liskowski, Krzysztof Krawiec
Generalization performance of learning agents depends on the training experience to which they have been exposed. In game-playing domains, that experience is determined by the opponents faced during learning. This analytical study investigates two characteristics of opponents in competitive coevolutionary learning: behavioral diversity and difficulty (performance against other players). To assess diversity, we propose a generic intra-game behavioral distance measure, that could be adopted to other sequential decision problems. We monitor both characteristics in two-population coevolutionary learning of Othello strategies, attempting to explain their relationship with the generalization performance achieved by the evolved solutions. The main observation is the existence of a non-obvious trade-off between difficulty and diversity, with the latter being essential for obtaining high generalization performance

EvoAPP session 6 : Computer Vision

Thursday 9 April 1135-1315

EvoAPP topic: IASP

A Supervised Figure-ground Segmentation Method using Genetic Programming
Yuyu Liang, Mengjie Zhang, Will Browne
Figure-ground segmentation is an important preprocessing
phase in many computer vision applications. As different classes of objects require specific segmentation rules, supervised (or top-down) methods, which learn from prior knowledge of objects, are suitable for figure-ground segmentation. However, existing top-down methods, such as model-based and fragment-based ones, involve a lot of human work. As genetic programming (GP) can evolve computer programs to solve problems automatically, it requires less human work. Moreover, since GP contains little human bias, it is possible for GP-evolved methods to obtain better results than human constructed approaches. This paper develops a su-
pervised GP-based segmentation system. Three kinds of simple features, including raw pixel values, six dimension and eleven dimension grayscale statistics, are employed to evolve image segmentors. The evolved segmentors are tested on images from four databases with increasing difficulty, and results are compared with four conventional techniques including thresholding, region growing, clustering, and active contour models. The results show that GP-evolved segmentors perform better than the four traditional methods with consistently good results on both simple and complex images.

A Multi-objective Evolutionary Algorithm for Interaction Systems Based on Laser Pointers
Francisco Chavez, Eddie Clemente, Daniel E. Hernandez, Francisco Fernandez de Vega, Gustavo Olague
In this paper we face the problem of accurate location of a laser spot that is used as interaction system in real environments. The work presented is compared with previous approaches where different algorithms work with a single objective, using images that has been previously simplified to reduce computing time. Instead, the new approach presented in this paper is capable of processing whole images. The results show that the inclusion of multi-objective methods allows us not only to detect the presence of the laser spot, the single objective in previous works, but also to obtain accurate information of the laser spot in the image, and thus provide the location of the device on which the user wants to act.

Topology-preserving ordering of the RGB space with an evolutionary algorithm
Francisco Florez-Revuelta
Colour mathematical morphology (MM) requires an ordering of the colour space. Many works have been focused on establishing different colour orders mapping a colour space onto a linear ordered space. However, most of them are not validated in terms of topology preservation but in terms of the results once MM operations are applied. This work presents an evolutionary method to obtain total- and P-orderings of a colour space, i.e. RGB, maximising topology preservation. This approach can be used to order a whole colour space as well as to get a specific ordering for an image. These alternatives improve the results obtained with the orderings usually employed, in both topology preservation and noise reduction.

EvoAPP session 6 : Computer Vision

Thursday 9 April 1135-1315

EvoAPP topic: IASP

Planar Surfaces Recognition in 3D Point Cloud Using a Real-Coded Multistage Genetic Algorithm

Mosab Bazargani, Luís Mateus, Maria Amélia R. Loja

Most frequent surface shapes of man-made constructions are planar surfaces. Discovering those surfaces is a big step toward extracting as-built/-is construction information from 3D point cloud. In this paper, a real-coded genetic algorithm (GA) formulation for planar surfaces recognition in 3D point clouds is presented. The algorithm developed based on a multistage approach; thereby, it finds one planar surface (part of solution) at each stage. In addition, the logarithmically proportional objective function that is used in this approach can adapt itself to scale and spatial density of the point cloud. We tested the proposed application on a synthetic point cloud containing several planar surfaces with different shapes, positions, and with a wide variety of sizes. The results obtained showed that the proposed method is capable to find all plane's configurations of flat surfaces with a minor distance to the actual configurations.

EvoAPP session 7 : Content Generation & Learning in Games

Thursday 9 April 1430-1610

EvoAPP topic: GAMES

A Procedural Method for Automatic Generation of Spelunky Levels
Noor Shaker, Walaa Baghdadi, Fawzya Shams Eddin, Rawan Al-Omari, Ziena Alhalawani, Mohammad Shaker
Spelunky is a game that combines characteristics from 2D platform and rogue-like genres. In this paper, we propose an evolutionary search-based approach for the automatic generation of levels for such games. A genetic algorithm is used to generate new levels according to aesthetic and design requirements. A graph is used as a genetic representation in the evolution process to describe the structure of the levels and the connections between the rooms while an agent-based method is employed to specify the interior design of the rooms. The results show that endless variations of playable content satisfying predefined difficulty requirements can be efficiently generated. The results obtained are investigated through an expressivity analysis framework defined to provide thorough insights of the generator's capabilities.

Evolving Random Forest for Preference Learning
Mohamed Abou-Zleikha, Noor Shaker
This paper introduces a novel approach for pairwise preference learning through a combination of an evolutionary method and random forest. Grammatical evolution is used to describe the structure of the trees in the Random Forest (RF) and to handle the process of evolution. Evolved random forests are evaluated based on their efficiency in predicting reported preferences. The combination of these two efficient methods for evolution and modelling yields a powerful technique for learning pairwise preferences. To test the proposed methodology and compare it to other methods in the literature, a dataset of 1560 sessions with detail information about user behaviour and their self-reported preferences while interacting with a game is used for training and evaluation. The method demonstrates ability to construct accurate models of user experience from preferences, behavioural and context data. The results obtained for predicting pairwise self-reports of users for the three emotional states: engagement, frustration and challenge show very promising results that are comparable and in some cases superior to those obtained from state-of-the-art methods.

Procedural Personas as Critics for Dungeon Generation
Antonios Liapis, Christoffer Holmgard, Georgios N. Yannakakis, Julian Togelius
This paper introduces a constrained optimization method which uses procedural personas to evaluate the playability and quality of evolved dungeon levels. Procedural personas represent archetypical player behaviors, and their controllers have been evolved to maximize a specific utility which drives their decisions. A "baseline" persona evaluates whether a level is playable by testing if it can survive in a worst-case scenario of the playthrough. On the other hand, a Monster Killer persona or a Treasure Collector persona evaluates playable levels based on how many monsters it can kill or how many treasures it can collect, respectively. Results show that the implemented two-population genetic algorithm discovers playable levels quickly and reliably, while the different personas affect the layout, difficulty level and tactical depth of the generated dungeons.

EvoAPP session 7 : Content Generation & Learning in Games

Thursday 9 April 1430-1610

EvoAPP topic: GAMES

A Progressive Approach to Content Generation
Mohammad Shaker, Noor Shaker, Julian Togelius, Mohamed Abou-Zleikha
PCG approaches are commonly categorised as constructive, generate-and-test or search-based. Each of these approaches has its distinctive advantages and drawbacks. In this paper, we propose an approach to Content Generation (CG)-- in particular level generation -- that combines the advantages of constructive and search-based approaches thus providing a fast, flexible and reliable way of generating diverse content of high quality. In our framework, CG is seen from a new perspective which differentiates between two main aspects of the gameplay experience, namely the order of the in-game interactions and the associated level design. The framework first generates timelines following the search-based paradigm. Timelines are game-independent and they reflect the rhythmic feel of the levels. A progressive, constructive-based approach is then implemented to evaluate timelines by mapping them into level designs. The framework is applied for the generation of puzzles for the "Cut the Rope" game and the results in terms of performance, expressivity and controllability are characterised and discussed.

EvoAPP session 8 : Communication Networks

Thursday 9 April 1430-1610

EvoAPP topics: COMNET

A Novel Grouping Genetic Algorithm for Assigning Resources to Users in WCDMA Networks

Lucas Cuadra, Sancho Salcedo-Sanz, Antonio D. Carnicer, Miguel A. Del Arco, Jose A. Portilla-Figueras

In this work we explore the feasibility of applying a novel grouping genetic algorithm (GGA) to the problem of assigning resources to mobile terminals or users in Wideband Code Division Multiple Access (WCDMA) mobile networks. In particular, we propose: 1) A novel cost function (to be minimized) that contains, in addition to the common load factors, other utilization ratios for aggregate capacity, codes, power, and users without service. 2) A novel encoding scheme, and modifications for the crossover and mutation operators, tailored for resource assignment in WCDMA networks. The experimental work points out that our GGA approach exhibits a superior performance than that of the conventional method (which minimizes only the load factors), since all users receive the demanded service along with a minimum use of the assigned resources (aggregate capacity, power, and codes).

A Fast FPGA-Based Classification of Application Protocols Optimized Using Cartesian GP

David Grochol, Lukas Sekanina, Martin Zadnik, Jan Korenek

This paper deals with design of an application protocol classifier intended for high speed networks operating at 100 Gbps. Because a very low latency is the main design constraint, the classifier is constructed as a combinational circuit in a field programmable gate array. The classification is performed using the first packet carrying the application payload. In order to further reduce the latency, the circuit is optimized by Cartesian genetic programming. Using a real network data, we demonstrated viability of our approach in task of a very fast classification of three application protocols (HTTP, SMTP, SSH).

Parallel Extremal Optimization with Guided State Changes applied to Load Balancing

Eryk Laskowski, Marek Tudruj, Umberto Scafuri, Richard Olejnik, Ivanoe De Falco, Ernesto Tarantino

The paper concerns parallel methods for Extremal Optimization (EO) applied for processor load balancing for distributed programs. In these methods the EO approach is used which is parallelized and extended by a guided search of next solution state. EO detects the best strategy of tasks migration leading to a reduction of program execution time. We assume a multi-point solution improvement of the guided EO algorithm which provides a parallel search for a solution based on two step stochastic selection during the solution improvement based on two-fitness functions. The load balancing improvements based on EO aim in better convergence of the algorithm and better quality of program execution in terms of the execution time. The proposed load balancing algorithm is evaluated by experiments with simulated parallelized load balancing of distributed program graphs.

EvoAPP session 8 : Communication Networks

Thursday 9 April 1430-1610

EvoAPP topics: COMNET

A Swarm Intelligence Approach to 3D Distance-based Indoor Localization
Stefania Monica, Gianluigi Ferrari
In this paper, we focus on the application of Wireless Sensor Networks (WSNs) to the problem of locating static nodes in a three-dimensional indoor environments, assuming to know the position of a few of them, denoted as “beacons”. We consider two different approaches, both based on the Time Of Arrival (TOA) of signals traveling between pairs of nodes, namely: the Two-Stage Maximum-Likelihood (TSML) method and the Particle Swarm Optimization (PSO) algorithm. Simulation results show that the latter allows achieving accurate position estimates even in scenarios where the TSML fails, due to ill-conditioning problems.

EvoAPP session 9 : Robotics

Thursday 8 April 1630-1810

EvoAPP topics: ROBOT

On the Tradeoff between Hardware Protection and Optimization Success: A Case Study in Onboard Evolutionary Robotics for Autonomous Parallel Parking
Mostafa Wahby, Heiko Hamann
Making the transition from simulation to reality in evolutionary robotics is known to be challenging. What is known as the reality gap, summarizes the set of problems that arises when robot controllers have been evolved in simulation and then are transferred to the real robot. In this paper we study an additional problem that is beyond the reality gap. In simulations, the robot needs no protection against damage, while on the real robot that is essential to stay cost-effective. We investigate how the probability of collisions can be minimized by introducing appropriate penalties to the fitness function. A~change to the fitness function, however, changes the evolutionary dynamics and can influence the optimization success negatively. Therefore, we detect a tradeoff between a required hardware protection and a reduced efficiency of the evolutionary optimization process. We study this tradeoff on the basis of a robotics case study in autonomous parallel parking.

Real-World Reproduction of Evolved Robot Morphologies: Automated Categorization and Evaluation
Eivind Samuelsen, Kyrre Glette
This paper describes the real-world reproduction of a handful of robots selected from a larger sample of simulated models previously generated by an evolutionary algorithm. The five robots, which are selected by automatic clustering to be representative of different morphological niches present in the sample, are constructed in the real world using off-the-shelf motor components, combined with 3D printed structural parts that were automatically generated based on the simulator models. A lab setup, involving evolution of turning gaits for each robot, is used to automate the experiments. The forward walking speeds of the constructed robots are measured, and compared with the simulated speeds. While some of the robots achieve near-identical results, some show a large performance loss compared to their simulated prototypes, underlining the reality gap issue seen in similar previous works.

Evolving Generalised Maze Solvers
David Shorten, Geoff Nitschke

This paper presents a study of the efficacy of comparative controller design methods that aim to produce generalised problem solving behaviours. In this case study, the goal was to use neuro-evolution to evolve generalised maze solving behaviours. That is, evolved robot controllers that solve a broad range of mazes. To address this goal, this study compares objective, non-objective and hybrid approaches to direct the search of a neuro-evolution controller design method. The objective based approach was a fitness function, the non-objective based approach was novelty search, and the hybrid approach was a combination of both. Results indicate that, compared to the fitness function, the hybrid and novelty search evolve significantly more maze solving behaviours that generalise to larger and more difficult maze sets. Thus this research provides empirical evidence supporting novelty and hybrid novelty-objective search as approaches for potentially evolving generalised problem solvers

EvoAPP session 9 : Robotics

Thursday 8 April 1630-1810

EvoAPP topics: ROBOT

Evolving Robot Controllers for Structured Environments through Environment Decomposition

Rodrigo Moreno, Andres Faina, Kasper Stoy

In this paper we aim to develop a controller that allows a robot to traverse an structured environment. The approach we use is to decompose the environment into simple sub-environments that we use as basis for evolving the controller. Specifically, we decompose a narrow corridor environment into four different sub-environments and evolve controllers that generalize to traverse two larger environments composed of the sub-environments. We also study two strategies for presenting the sub-environments to the evolutionary algorithm: all sub-environments at the same time and in sequence. Results show that by using a sequence the evolutionary algorithm can find a controller that performs well in all sub-environments more consistently than when presenting all sub-environments together. We conclude that environment decomposition is an useful approach for evolving controllers for structured environments and that the order in which the decomposed sub-environments are presented in sequence impacts the performance of the evolutionary algorithm.

Autonomous Learning of Procedural Knowledge in an Evolutionary Cognitive Architecture for Robots

Rodrigo Salgado, Francisco Bellas, Richard J. Duro

This paper describes a procedure to provide a way for the Multilevel Darwinist Brain evolutionary cognitive architecture to be able to learn and preserve procedural knowledge while operating on-line. This procedural knowledge is acquired in the form of ANNs that implement behaviors in the sense of traditional evolutionary robotics. The behaviors are produced in real time as the robot is interacting with the world. It is interesting to see in the results presented that this approach of learning procedural representations instead of exhaustively selecting the appropriate action every instant of time provides better generalization results and more efficient action sequences

Best EvoROBOT paper award

Frontiers in Robotics and AI sponsors the EvoROBOT best paper award The winner receives a full waiver of the publication fee for submission of an extended version of the work presented at EvoROBOT in Copenhagen this year, with the final decision to publish the extended version made in conjunction with the Frontiers policies of originality and review. These five papers presented on these pages are all candidates for this award.

EvoAPP session 10 : Risk Management & Security

Thursday 9 April 1630-1810

EvoAPP topics: COMNET & RISK

Heuristics for the design of safe humanitarian aid distribution itineraries
José María Ferrer, María Teresa Ortuño, Gregorio Tirado, Begoña Vitoriano
After a disaster strikes, one of the main activities to be developed from a logistics point of view is the design of humanitarian aid distribution plans. In this work the problem of designing safe feasible itineraries for last-mile distribution under the risk of being assaulted, as well as assuring the equity of the distribution, is addressed. The task of simply finding feasible solutions for this problem is highly complex. In this paper we present a constructive randomized heuristic to generate a variety of solutions within a small computational time, and we also provide some ideas of how to modify this constructive algorithm in order to use it within a metaheuristic framework.

Black Holes and Revelations: Using Evolutionary Algorithms to Uncover Vulnerabilities in Disruption-Tolerant Networks
Doina Bucur, Giovanni Iacca, Giovanni Squillero, Alberto Tonda
A challenging aspect in open ad hoc networks is their resilience against malicious agents. This is especially true in complex, urban-scale scenarios where numerous moving agents carry mobile devices that create a peer-to-peer network without authentication. A requirement for the proper functioning of such networks is that all the peers act legitimately, forwarding the needed messages, and concurring to the maintenance of the network connectivity. However, few malicious agents may easily exploit the movement patterns in the network to dramatically reduce its performance. We propose a methodology where an evolutionary algorithm evolves the parameters of different malicious agents, determining their types and mobility patterns in order to minimize the data delivery rate and maximize the latency of communication in the network. As a case study, we consider a fine-grained simulation of a large-scale disruption-tolerant network in the city of Venice. By evolving malicious agents, we uncover situations where even a single attacker can hamper the network performance, and we correlate the performance decay to the number of malicious agents.

Improving Maritime Awareness with Semantic Genetic Programming and Linear Scaling: Prediction of Vessels Position Based on AIS Data
Leonardo Vanneschi, Mauro Castelli, Ernesto Costa, Alessandro Re, Henrique Vaz, Victor Lobo, Paulo Urbano
Maritime domain awareness deals with the situational understanding of maritime activities that could impact the security, safety, economy or environment. It enables quick threat identification, informed decision making, effective action support, knowledge sharing and more accurate situational awareness. In this paper, we propose a novel computational intelligence framework, based on genetic programming, to predict the position of vessels, based on information related to the vessels past positions in a specific time interval. Given the complexity of the task, two well known improvements of genetic programming, namely geometric semantic operators and linear scaling, are integrated in a new and sophisticated genetic programming system. The work has many objectives, for instance assisting more quickly and effectively a vessel when an emergency arises or being able to chase more efficiently a vessel that is accomplishing illegal actions. The proposed system has been compared to two different versions of genetic programming and three non-evolutionary machine learning methods, outperforming all of them on all the studied test cases.

EvoAPP session 10 : Risk Management & Security

Thursday 9 April 1630-1810

EvoAPP topics: COMNET & RISK

Combining Ensemble of Classifiers by using Genetic Programming for Cyber Security Applications
Gianluigi Folino, Francesco Sergio Pisani
Classification is a really relevant task in the cyber security domain, but it must be able to cope with unbalanced and/or incomplete datasets and must also react in real-time to changes in the data. Ensemble of classifiers are a useful tool for classification in hard domains as they combine different classifiers that together provide complementary information. However, most of the ensemble-based algorithms require an extensive training phase and must be re-trained in case of changes in the data. This work proposes a GP-based framework for generating a function for combining an ensemble, having some interesting properties: the models composing the ensemble are trained only on a portion of the training set, and then they can be combined and used without any extra phase of training; furthermore, in case of changes in the data, the function can be recomputed in an incrementally way, with a moderate computational effort. Experiments conducted on unbalanced datasets and on a well-known cyber-security dataset assess the goodness of the approach.

Automatic Generation of Mobile Malwares Using Genetic Programming
Emre Aydogan, Sevil Sen
The number of mobile devices has increased dramatically in the past few years. These smart devices provide many useful functionalities accessible from anywhere at anytime, such as reading and writing e-mails, surfing on the Internet, showing facilities nearby, and the like. Hence, they become an inevitable part of our daily lives. However the popularity and adoption of mobile devices also attract virus writers in order to harm our devices. So, many security companies have already proposed new solutions in order to protect our mobile devices from such malicious attempts. However developing methodologies that detect unknown malwares is a research challenge, especially on devices with limited resources. This study presents a method that evolves automatically variants of malwares from the ones in the wild by using genetic programming (GP). We aim to evaluate the efficacy of current anti-virus products, using static analysis techniques, in the market. The experimental results show the weaknesses of the static analysis tools available in the market, and the need of new detection techniques suitable for mobile devices.

EvoAPP session 11 : Energy & Finance

Friday 10 April 0930-1110

EvoAPP topics: ENERGY & FIN

Multiobjective methodology for assessing the location of distributed electric energy storage
Jose Goncalves, Luis Neves, Antonio Gomes Martins
The perception of the associated impacts among possible management schemes introduces a new way to assess energy storage systems. The ability to define a specific management scheme considering the different stakeholder objectives, both technical and economic, will increase the perception of available installation options. This paper presents a multiobjective feasibility assessment methodology using an improved version of the Non-dominated Sorting Genetic Algorithm II, to optimize the placement of electric energy storage units in order to improve the operation of distribution networks. The model is applied to a case study, using lithium-ion battery technology as an example. The results show the influence of different charging/discharging profiles on the choice of the best battery location, as well as the influence that these choices may have on the different network management objectives, e.g. increasing the integration of renewable generation. As an additional outcome, the authors propose a pricing scheme for filling the present regulatory gap regarding the pricing scheme to be applied to energy storage in order to allow the exploitation of viable business models.

Generating Directional Change Based Trading Strategies with Genetic Programming
Jeremie Gypteau, Fernando Otero, Michael Kampouridis
The majority of forecasting tools use a physical time scale for studying price fluctuations of financial markets, making the flow of physical time discontinuous. Therefore, using a physical time scale may expose companies to risks, due to ignorance of some significant activities. In this paper, an alternative and novel approach is explored to capture important activities in the market. The main idea is to use an intrinsic time scale based on Directional Changes. Combined with Genetic Programming, the proposed approach aims to find an optimal trading strategy to forecast the future price moves of a financial market. In order to evaluate its efficiency and robustness as forecasting tool, a series of experiments was performed, where we were able to obtain valuable information about the forecasting performance. The results from the experiments indicate that this new framework is able to generate new and profitable trading strategies.

An Evolutionary Optimization Approach to Risk Parity Portfolio Selection
Ronald Hochreiter
In this paper we present an evolutionary optimization approach to solve the risk parity portfolio selection problem. While there exist convex optimization approaches to solve this problem when long-only portfolios are considered, the optimization problem becomes non-trivial in the long-short case. To solve this problem, we propose a genetic algorithm as well as a local search heuristic. This algorithmic framework is able to compute solutions successfully. Numerical results using real-world data substantiate the practicability of the approach presented in this paper.

EvoAPP session 11 : Energy & Finance

Friday 10 April 0930-1110

EvoAPP topics: ENERGY & FIN

An energy management system aggregator based on an integrated evolutionary and differential evolution approach
Andreia M. Carreiro, Carlos Oliveira, Carlos Henggeler Antunes, Humberto M. Jorge
The increased penetration of renewable generation in the electric power system has been leading to a higher complexity of grid management due to its inherent intermittency, also with impact on the volatility of electricity prices. Setting the adequate operating reserve levels is one of the main concerns of the System Operator (SO), since the integration of a large share of intermittent generation requires an in-creased amount of reserve that is needed to balance generation and load. At the same time, the energy consumption in households has been steadily growing, representing a significant untapped savings potential due to waste and load flexibility (i.e., the possibility of time deferring the use of some loads). An aggregator has been designed to operate as an intermediary between individual energy management systems and the SO/Energy Market, capable of facilitating a load follows supply strategy in a Smart Grid context. The aggregator is aimed at using the flexibility provided by each end-user aggregated into clusters of demand-side resources to satisfy system service requirements, involving lowering or increasing the power requested in each time slot. This contributes to the balance between load and supply, avoiding peaks in the load diagram, and coping with the intermittency of renewable sources, thus offering an attractive alternative to supply side investments in peak and reserve generation. For this purpose, a multi-objective optimization model has been developed to maximize the aggregator profits, taking into account revenues from the SO/Energy Market and payments to end-user clusters, and minimize the inequity between the amounts of load flexibility provided by the clusters to satisfy grid requests. An approach based on an evolutionary algorithm coupled with a differential evolution algorithm has been designed to deal with this model.

Training Financial Decision Support Systems with Thousands of Decision Rules using Differential Evolution with Embedded Dimensionality Reduction
Piotr Lipinski
This paper proposes an improvement of the training process of financial decision support systems, where evolutionary algorithms are used to integrate a large number of decision rules. It especially concerns the new computational intelligence approaches that try to replace the expert knowledge with their own artificial knowledge discovered using very large models from very large training datasets, where the large number of decision rules is crucial, because it defines the degree of freedom for the further learning algorithm. The proposed approach focuses on enhancing Differential Evolution by embedding dimensionality reduction to process objective functions with thousands of possibly correlated variables. Experiments performed on a financial decision support system with 00$ decision rules tested on $ datasets from the Euronext Paris confirm that the proposed approach may significantly improve the training process.

EvoAPP session 12 : Continuous Parameter Optimisation

Friday 10 April 0930-1110

EvoAPP topics: NUM & STOC

Seed Disperser Ant Algorithm: An Evolutionary Approach for Optimization
Wen Liang Chang, Jeevan Kanesan, Anand Jayant Kulkarni
The Seed Disperser Ant Algorithm (SDAA) is inspired from the evolution of Seed Disperser Ant (Aphaenogaster senilis) colony. The ants in the colony are highly related siblings sharing average 75% similarity in genotype. Hence, the genotype of every ant represents variables in binary form that are used to locally search for optimum solution. Once the colony matures, in other words a local optimum solution reached, nuptial flights take place where female genotype copies the male genotype originating from another colony. Once all colonies saturate new young queen emerges to establish new colonies. This diversifies the search for global optimum. The SDAA is validated by solving four 30 dimensional classical benchmark problems and six composite benchmark functions from CEC 2005 special session. The optimal results are found to be better than the selected state-of-the-art swarm intelligence based optimization.

Neuro-evolutionary Topology Optimization with Adaptive Improvement Threshold
Nikola Aulig, Markus Olhofer
Recently a hybrid combination of neuro-evolution with a gradient-based topology optimization method was proposed, facilitating topology optimization of structures subject to objective functions for which gradient information is difficult to obtain. The approach substitutes analytical sensitivity information by an update signal represented by a neural network approximation model. Topology optimization is performed by optimizing the network parameters by an evolutionary algorithm in order to devise an update signal for each design step. However, the typically very large number of required evaluations renders the method difficult to apply in practice. In this paper, we aim at a more efficient use of computational resources by augmenting the original approach by an adaptive improvement threshold as stopping criterion for the neuro-evolution. The original and augmented methods are studied on the minimum compliance problem for different feature types and different number of hidden neurons. It is demonstrated that the number of evaluations can be reduced by up to 80% with very little change of the resulting objective values and structures.

Evaluating Reward Definitions for Parameter Control
Giorgos Karafotias, Mark Hoogendoorn, A.E. Eiben
Parameter controllers for Evolutionary Algorithms (EAs) deal with adjusting parameter values during an evolutionary run. Many ad hoc approaches have been presented for parameter control, but few generic parameter controllers exist. Recently, successful parameter control methods based on Reinforcement Learning (RL) have been suggested for one-off applications, i.e. relatively long runs with controllers used out-of-the-box with no tailoring to the problem at hand. However, the reward function used was not investigated in depth, though it is a non-trivial factor with an important impact on the performance of a RL mechanism. In this paper, we address this issue by defining and comparing four alternative reward functions for such generic and RL-based EA parameter controllers. We conducted experiments with different EAs, test problems and controllers and results showed that the simplest reward function performs at least as well as the others, making it an ideal choice for generic out-of-the-box parameter control.

EvoAPP session 12 : Continuous Parameter Optimisation

Friday 10 April 0930-1110

EvoAPP topics: NUM & STOC

Applying Non-Dominated Sorting Genetic Algorithm II to Multi-Objective Optimization of a Weighted Multi-Metric Distance for Performing Data Mining Tasks
Muhammad Marwan Muhammad Fuad
Multi-objective optimization (MOO) is a class of optimization problems where several objective functions must be simultaneously optimized. Traditional search methods are difficult to extend to MOO problems so many of these problems are solved using bio-inspired optimization algorithms. One of the famous optimization algorithms that have been applied to MOO is the non-dominated sorting genetic algorithm II (NSGA-II). NSGA-II algorithm has been successfully used to solve MOO problems owing to its lower computational complexity compared with the other optimization algorithms. In this paper we use NSGA-II to solve a MOO problem of time series data mining. The problem in question is determining the optimal weights of a multi-metric distance that is used to perform several data mining tasks. NSGA-II is particularly appropriate to optimize data mining problems where fitness functions evaluation usually involves intensive computing resources. Whereas several previous papers have proposed different methods to optimize time series data mining problems, this paper is, to our knowledge, the first paper to optimize several time series data mining tasks simultaneously. The experiments we conducted show that the performance of the optimized combination of multi-metric distances we propose in executing time series data mining tasks is superior to that of the distance metrics that constitute the combination when they are applied separately.

Studying the Geographical Cluster Paging with delay constraint in Registration Areas with the Algorithm NSGAII
Victor Berrocal-Plaza, Miguel A. Vega-Rodriguez, Juan M. Sanchez-Perez
The mobility management strategy based on registration areas is one of the most popular strategies to manage the subscribers' mobility in current Public Land Mobile Networks. For it, the network cells are arranged in continuous and non-overlapped sets in order to partially track the subscribers' movement. In this way, the network knows the location of its subscribers at a registration area level and the paging should only be performed in the cells within the last updated registration area. The paging scheme studied in this work is the geographical cluster paging, a probabilistic paging in which it is assumed that the probability of finding a mobile station (i.e. the subscriber's terminal) decreases as we move away from the last updated network cell following a normal distribution. The main appeal of this paging scheme is that we can considerably reduce the signaling traffic (with respect to the simultaneous paging) without including new elements in the network. Furthermore, we analyze it for different probability thresholds and considering delay constraints. On the other hand, we use our implementation of the Non-dominated Sorting Genetic Algorithm II (NSGAII) with the aim of finding the best possible sets of non-dominated solutions. Results show that each probability threshold has its own non-dominated region in the objective space, and that the signaling traffic can be reduced by about 30\% (with respect to the simultaneous paging).

Investigating Fitness Measures for the Automatic Construction of Graph Models
Kyle Harrison, Mario Ventresca, Beatrice Ombuki-Berman
Graph models are often constructed as a tool to better understand the growth dynamics of complex networks. Traditionally, graph models have been constructed through a very time consuming and difficult manual process. Recently, there have been various methods proposed to alleviate the manual efforts required when constructing these models, using statistical and evolutionary strategies. A major difficulty associated with automated approaches lies in the evaluation of candidate models. To address this difficulty, this paper examines a number of well-known network properties using a proposed meta-analysis procedure. The meta-analysis demonstrated how these network measures interacted when used together as classifiers to determine network, and thus model, (dis)similarity. The analytical results formed the basis of a fitness evaluation scheme used in a genetic programming (GP) system to automatically construct graph models for complex networks. The GP-based automatic inference system was used to reproduce two well-known graph models, the results of which indicated that the evolved models exemplified striking similarity when compared to their respective targets on a number of structural network properties.

Evolutionary Training of Robotised Architectural Elements
Claudio Rossi, Pablo Gil, William Coral
We present our work on the training of robotised architectural components of intelligent buildings, focusing on main architectural components and features such as facades, roofs and partitions. The parameters governing such components may be either quantitative (such as temperature, humidity, configuration of the elements) or qualitative (such as ergonomics and aesthetics), which cannot easily be described by mathematical parameters. Due to their complexity, it is often impossible -or at least impractical, to hardcode suitable controllers for such robotised structures. Thus, we propose the use of Artificial Intelligence learning techniques, concretely Evolutionary Algorithms, so that the

user can teach the robotised components how to behave in response to changing environmental conditions or user preferences. This idea is tested on an intelligent rooftop with variable geometry, that learns optimal configurations with respect to ambient light during training sessions.

Heat Map Based Feature Selection: A Case Study for Ovarian Cancer
Carlos Huertas, Reyes Juárez-Ramírez
Public health is a critical issue, therefore we can find a great research interest to find faster and more accurate methods to detect diseases. In the particular case of cancer, the use of mass spectrometry data has become very popular but some problems arise due to that the number of mass-to-charge ratios exceed by a huge margin the number of patients in the samples. In order to deal with the high dimensionality of the data, most works agree with the necessity to use pre-processing. In this work we propose an algorithm called Heat Map Based Feature Selection (HmbFS) that can work with huge data without the need of pre-processing, thanks to a built-in compression mechanism based on color quantization. Results shows that our proposal is very competitive against some of the most popular algorithms and succeeds where other methodologies may fail due to the high dimensionality of the data

PowerSurge: A Serious Game on Power Transmission Networks
Sebastian von Mammen, Fabian Hertwig, Florain Obermayer, Patrick Lehner
In this paper, we present an interactive serious game about power transmission systems. The system familiarizes novices with the basic design and behavior of such systems. Using simple drag and drop interactions, power plants and consumers are placed and connected in a virtual landscape that is presented from an isometric perspective. A series of tutorials fosters the user's mastery in building and controlling a complex system. The advanced user is challenged by tasks such as the redesign of an established power infrastructure to integrate a large percentage of regenerative power plants. Next to the interface, we detail the model that drives the simulation. The methodologies presented in this paper can be applied to a wide range of serious games about complex network designs.

Parallel cooperation for large-scale multiobjective optimization on feature selection problems
Dragi Kimovski, Julio Ortega, Andrés Ortiz, Raúl Baños
Recently, the interest on multiobjective optimization problems with a large number of decision variables has grown since many significant real problems, for example on machine learning and pattern recognition, imply to process patterns with a high number of components (features). This paper deals with parallel multiobjective optimization on high-dimensional feature selection problems. Thus, several parallel multiobjective evolutionary alternatives based on the cooperation of subpopulations are proposed and experimentally evaluated by using some synthetic and BCI (Brain-Computer Interface) benchmarks. The results obtained show different improvements achieved in the solution quality and speedups, depending on the parallel alternative and benchmark profile. Some alternatives even provide superlinear speedups with only small reductions in the solution quality.

Collaborative Diffusion on the GPU for Path-finding in Games
Craig McMillan, Emma Hart, Kevin Chalmers
Exploiting the powerful processing power available on the GPU in many machines, we investigate the performance of parallelised versions of pathnding algorithms in typical game environments. We describe a parallel implementation of a collaborative difusion algorithm that is shown to find short paths in real-time across a range of graph sizes and provide a comparison to the well known Dijkstra and A* algorithms. Although some trade-off of cost vs path-length is observed under specific environmental conditions, results show that it is a viable contender for pathfinding in typical real-time game scenarios, freeing up CPU computation for other aspects of game AI.

A Multiobjective Evolutionary Algorithm for Personalized Tours in Street Networks
Ivanoe De Falco, Umberto Scafuri, Ernesto Tarantino
The paper presents a novel optimizer to plan multiple-day walking itineraries, tailored to tourists' personal interests, in a street network modeled as a graph.
The tour is automatically designed by maximizing the number of the Points of Interest (POIs) to visit as a function of both tourists' preferences and requirements, and constraints such as opening hours, visiting times and accessibility of the POIs, and weather forecasting. Since this itineray planning is classified as an NP--complete combinatorial optimization problem, a multiobjective evolutionary optimizer is here proposed. Such an optimizer is proven to be effective in designing personalized multiple-day tourist routes.

A Projection-Based Approach for Real-time Assessment and Playability Check for Physics-Based Games
Mohammad Shaker, Noor Shaker, Mohamed Abou-Zleikha, Julian Togelius
This paper introduces an authoring tool for physics-based puzzle games that supports game designers through providing visual feedback about the space of interactions. The method proposed accounts for the type and physical properties of the different game components. An area of influence, which identifies the possible space of interaction, is identified for each component. The influence areas of all components in a given design are then merged considering the components' type and the context information. The tool can be used offline where complete designs are analyzed and the final interactive space is projected, and online where edits in the interactive space are projected on the canvas in realtime permitting continues assistance for game designers and providing informative feedback about playability.

Analysis of Diversity Methods for Evolutionary Multi-Objective Ensemble Classifiers
Stefan Oehmcke, Justin Heinermann, Oliver Kramer
Ensemble classifiers are strong and robust methods for classification and regression tasks. Optimizing the classifier becomes a multi-objective optimization problem. In this work, we propose an evolutionary multi-objective algorithm based on non-dominated sorting that balances runtime and accuracy properties of nearest neighbor classifier ensembles and decision tree ensembles. We identify relevant ensemble parameters with a significant impact on the accuracy and runtime. In the experimental part of this paper, we analyze the behavior on typical classification benchmark problems.

How the world was MADE: parametrization of evolved agent-based models for backstory generation

Rubén Héctor García Ortega, Pablo García Sánchez, Juan Julián Merelo Guervós, Maribel García Arenas, Pedro A. Castillo Valdivieso, Antonio Mora García

Generating fiction environments for a multi-agent system optimized by genetic algorithms (with some specific requirements related to the desirable plots), presents two main problems: first it is impossible to know in advance the optimal value for the particular designed fitness function, and at the same time, it creates a vast search space for the parameters that it needs. The purpose of this paper is to define a methodology to find the best parameter values for both, the evolutionary algorithm, and the own fictional world configuration. This design includes running, to completion, a world simulation represented as a chromosome, and assigning a fitness to it, thus composing a very complex fitness landscape. In order to optimize the resources allocated to evolution and to have some guarantees that the final result will be close to the optimum, we systematically analyze a set of possible values of the most relevant parameters, obtaining a set of generic rules. These rules, when applied to the plot requisites, and thus, to the fitness function, will lead to a reduced range of parameter values that will help the storyteller to create optimal worlds with a reduced computation budget.

Object Detection in Natural Images using the Brain Programming Paradigm with a Multi-Objective Approach

Eddie Clemente, Gustavo Olague, Daniel E. Hernández, Jose L. Briseño, Jose Mercado

In the last few decades the human vision system has been the focus of several researches, using it as a model for solving the object detection problem in digital images. In this work this approach is taken to define the algorithm called Artificial Visual Cortex (AVC) which is inspired in the information flow in the human visual cortex. Additionally, a new methodology for image description is proposed, which allows the detection and description of an object in the scene. Furthermore, this paper describes a new multi-objective learning technique called brain programming. This paradigm is implemented for the training stage of the proposed model in order to classify the \textit{persons} set of the GRAZ-02 image database. The solutions found in this research outperform other techniques in the state-of-the-art.

Evolving Controllers for Programmable Robots to Influence Non-Programmable Lifeforms: A Casy Study

Payam Zahadat, Thomas Schmickl

In this paper, a decentralized reaction-diffusion-based controller is evolved for a set of robots in an arena interacting with two simulated juvenile bees as non-programmable agents. The bees react to the stimuli that are emitted by the robots. The evolutionary process successfully finds controllers that produce proper patterns which guide the bees towards a number of given targets. The results show a preference of heat as the dominant stimulus causing movement of the bees.

A Novel Multi-Objectivisation Approach for Optimising the Protein Inverse Folding Problem
Sune S. Nielsen, Grégoire Danoy, Wiktor Jurkowski, Juan Luis Jiménez Laredo, Reinhard Schneider, El-Ghazali Talbi, Pascal Bouvry
In biology, the subject of protein structure prediction is of continued interest, not only to chart the molecular map of the living cell, but also to design proteins of new functions. The Inverse Folding Problem (IFP) is in itself an important research problem, but also at the heart of most rational protein design approaches. In brief, the IFP consists in finding sequences that will fold into a given structure, rather than determining the structure for a given sequence - as in conventional structure prediction. In this work we present a Multi Objective Genetic Algorithm (MOGA) using the diversity-as-objective (DAO) variant of multi-objectivisation, to optimise secondary structure similarity and sequence diversity at the same time, hence pushing the search farther into wide-spread areas of the sequence solution-space. To control the high diversity generated by the DAO approach, we add a novel Quantile Constraint (QC) mechanism to discard an adjustable worst quantile of the population. This DAO-QC approach can efficiently emphasise exploitation rather than exploration to a selectable degree achieving a trade-off producing both better and more diverse sequences than the standard Genetic Algorithm (GA). To validate the final results, a subset of the best sequences was selected for tertiary structure prediction. The superpositioning with the original protein structure demonstrated that meaningful sequences are generated underlining the potential of this work.

Chromatic Selection -- an Oversimplified Approach to Multi-Objective Optimization
Giovanni Squillero
This short paper introduces the chromatic selection, a simple technique implementable with few tens of lines of code, that enable handling multi-value fitness functions with a single-objective evolutionary optimizer. The chromatic selection is problem independent, requires no parameter tuning, and can be used as a drop-in replacement for both parent and survival selections. The resulting tool will not be a full-fledged multi-objective optimizer, lacking the ability to manage Pareto fronts, but it will efficiently seek a single, reasonable, compromise solution. In several practical problems, the time saved, both in computation and development, could represent a substantial advantage.

Automatic Evolution of Parallel Sorting Programs on Multi-cores
Gopinath Chennupati, R. Muhammad Atif Azad, Conor Ryan
Sorting algorithms that offer the potential for data-parallel execution on parallel architectures are an excellent tool for the current generation of multi-core processors that often require the skilled parallelization knowledge to fully realize the potential of the hardware. We propose to automate the evolution of natively parallel programs using the Grammatical Evolution (GE) approach to utilise the computational potential of multi-cores. The proposed system, Multi-core Grammatical Evolution for Parallel Sorting (MCGE-PS), applies GE mapping along with explicit OpenMP #pragma compiler directives to automatically evolve data-level parallel iterative sorting algorithms. MCGE-PS is assessed on the generation of four non-recursive sorting programs in C. We show that it generated programs that can solve the problem that are also parallel. On a high performance Intel processor, MCGE-PS significantly reduced the execution time of the evolved programs for all the benchmark problems.

A Concept for Real-Valued Multi-Objective Landscape Analysis Realized on Biochemcial Optimization Problems

Susanne Rosenthal, Bernd Freisleben, Markus Borschbach

Landscape analysis is an established method to provide an insight into the characteristic properties of an optimization problem with the aim of designing a suitable evolutionary algorithm for a given problem. However, these conventional landscape structures require sophisticated notions for multi-objective optimization problems. This work presents a real-valued multi-objective landscape analysis concept that allows the investigation of multi-objective molecular optimization problems. Sophisticated definitions for ruggedness, correlation and plateaus on multi-objective real-valued landscapes are introduced and indicators are proposed for this purpose. This landscape concept is realized on a generic three- and four-dimensional biochemical minimization problem and the results of this analysis are discussed regarding the design principles of a multi-objective evolutionary algorithm.

Fair Resource Allocation Using Multi-Population Evolutionary Algorithm

Tohid Erfani, Rasool Erfani

Resource allocation between selfish agents are performed under centralised and/or distributed mechanisms. However, there are issues in both cases. In centralised solution, although the resources are allocated in an efficient way, the allocation decisions may not be acceptable for some selfish agents making them reluctant to cooperation. In decentralised solution, although the problem is solved from each agent's perspective, the allocation leads to an inefficient usage of provided resources. For example, such an issue is evident in a water network distribution system where different agents share the river water and a central planner (CP) maximises the social welfare to the whole system. Issue arises when the CP solution is not acceptable by some agents. Therefore, a mechanism should be devised to encourage each agent to accept the CP decision. This paper introduces a mechanism in re-distributing the CP revenue value amongst the competing agents based on their contribution to the CP value. To find each user's contribution, this paper develops a parallel evolutionary search algorithm which enables the agents to autonomously solve their local optimisation problem whilst interacting with the other agents and the whole system. The search evolves towards a solution which is used as an incentive for calculating a fair revenue for each agent. The framework is applied to a river reach with five competitive users. Results show decentralised coupled centralised approaches has the potential to represent mechanisms for a fair resource allocation among competing self-interested agents.

A Benchmark For Virtual Camera Control
Paolo Burelli, Georgios Yannakakis
Automatically animating and placing the virtual camera in a dynamic environment is a challenging task. The camera is expected to maximise and maintain a set of properties --- i.e. visual composition --- while smoothly moving through the environment and avoiding obstacles. A large number of different solutions to the problem have been proposed so far including, for instance, evolutionary techniques, swarm intelligence or ad hoc solutions. However, the large diversity of the solutions and the lack of a common benchmark, made any comparative analysis of the different solutions extremely difficult. For this reason, in this paper, we propose a benchmark for the problem of virtual camera control and we analyse a number of different problems in different virtual environments. Each of these scenarios is described through a set of complexity measures and, as a result of this analysis, a subset of scenarios is selected as the core of the benchmark.

Planning the Deployment of Indoor Wireless Sensor Networks through Multiobjective Evolutionary Techniques
J. M. Lanza-Gutierrez, J. A. Gomez-Pulido, S. Priem-Mendes, M. Ferreira, J. S. Pereira
Wireless sensor networks are widely considered for indoor applications, such as home automation. In this paper, we propose a novel approach, were given a set of low-cost sensors, which can be connected to a plug or powered by batteries, a collector node, and a building plan, including walls and plugs, the purpose is to deploy the sensors attending to four conflicting objectives: average sensitivity area, average energy cost, average reliability, and the total number of sensors deployed. To this end, we consider two multiobjective evolutionary algorithms, NSGA-II and SPEA2. The behaviour of these metaheuristics is studied assuming two quality indicators, hypervolume and set coverage. Checking as NSGA-II provides the best behaviour for our data set.

Conference Boat Trip and Dinner

The EvoStar conference dinner will take place on Thursday 9 April, starting with a boat trip which will allow you to see the sights of Copenhagen from the water canals. The boat trip will take approximately 50-55 minutes and will take us to the dinner venue at Aalborg University Copenhagen.

Our assembly point will be at 18:30 directly outside the National Museum and we shall walk to the nearby departure quay. Although seating on the boat is covered, bring warm clothes, as evenings on the water can be chilly.

DO NOT FORGET TO BRING YOUR BOAT/ DINNER TICKET (in your registration bag)

For those who want to skip the boat trip and go directly to the conference dinner, the address is A. C. Meyers Vænge 15 and the nearest S-train stop is at Sydhavn St with a very regular service to and from the centre.

The conference dinner is comprised of a typical Scandinavian smorgasbord with a range of foods so that all diets can be accommodated.

If not needing your dinner / boat ticket, please return to the conference desk so we can re-use to allow others to attend.

Optional Friday afternoon tours

For those staying on Friday afternoon, an optional excursion has been organised to enjoy more of Copenhagen's sights. Meeting at **14:00 on Friday, 10 April, outside the National Museum**, we offer a free 30-40 minute walking tour of the old town to take in some famous views and hear some local history.

Copenhagen has an abudance of visitor attractions and there are discounts for many of these holding a Copenhagen Card, so we suggest you check online at www.visitcopenhagen.com to see what is of interest to you.

Here is a selection of options to consider for Friday afternoon and you are bound to find other EvoStar participants attending these :

A visit to **Tivoli Gardens**, one of the world's original amusement parks and pleasure gardens which opened in 1843. It offers rides and includes a museum about the Titanic, an aquarium, theatres and concerts. Some of the EvoStar organisers are heading here after the walking tour. Tivoli admission prices are 99 DKK with additional ride and mult-ride options available, see http://www.tivoli.dk/en/praktisk/priser/ and discounts available if holding a Copenhagen Card. More information at http://en.wikipedia.org/wiki/Tivoli_Gardens and http://www.tivoli.dk/en/

Christiansborg Palace in the centre of Copenhagen with its magnificent Royal Reception Rooms, underground Ruins of medieval castles, and Royal Stables. A combination ticket offers the best value, see http://www.christiansborg.dk/english/plan-your-visit/entrance-fees/

Thorvaldsen's Museum which is the nearest to the conference venue. This private collection was donated to the state from Danish sculptor Bertel Thorvaldsen (1770-1844) who spent more than 40 years in Rome and amassed an impressive collection of paintings and sculptures. Admission is 40DKK with discounts available for Copenhagen Card holders.

Den Blå Planet or the Blue Planet is Northern Europe's largest aquarium which looks like a large whale and has water on all sides to give the visitors a feeling of being under water. It is near the airport so if you have limited time before heading home, this might be of interest.

Rosenborg Castle, a renaissance castle used previously as a royal residence and now a museum housing the Royal Collections including the Crown jewels, and with the Knights Hall, tapestries, life size silver lions.

Øresund Bridge, especially impressive for fans of television crime-drama *The Bridge*. This 8km joint rail-road bridge connects Copenhagen in Denmark with Malmo in Sweden. You can travel by bus or train, but you will need to take your passport with you. More information from se.**oresund**sbron.com/

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