12th International Conference on Parallel Problem Solving from Nature

September 1-5, 2012 - Taormina, Italy
# Parallel Problem Solving from Nature 2012

## Conference Program

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td>3</td>
</tr>
<tr>
<td>Program Overview</td>
<td>5</td>
</tr>
<tr>
<td>Workshops</td>
<td>10</td>
</tr>
<tr>
<td>Tutorials</td>
<td>15</td>
</tr>
<tr>
<td>Keynote Speakers</td>
<td>19</td>
</tr>
<tr>
<td>Poster Sessions Monday</td>
<td>22</td>
</tr>
<tr>
<td>Poster Sessions Tuesday</td>
<td>25</td>
</tr>
<tr>
<td>Poster Sessions Wednesday</td>
<td>28</td>
</tr>
<tr>
<td>Social Events</td>
<td>30</td>
</tr>
<tr>
<td>Conference Information</td>
<td>32</td>
</tr>
</tbody>
</table>
Preface

This LNCS volume contains the proceedings of the 12th International Conference on Parallel Problem Solving from Nature (PPSN 2012). This biennial event constitutes one of the most important and highly regarded international conferences in evolutionary computation and bio-inspired meta-heuristics. Continuing with a tradition that started in Dortmund, in 1990, PPSN 2012 was held during 1--5 September, 2012 in Taormina, Sicily, Italy.

PPSN 2012 received 226 submissions from 44 countries. After an extensive peer review process involving more than 230 reviewers, the program committee chairs went through all the reports and ranked the papers according to the reviewers' comments. Each paper was evaluated by at least four reviewers. The top 105 manuscripts were finally selected for inclusion in this LNCS volume and for presentation at the conference. This represents an acceptance rate of 46%, which guarantees that PPSN will continue to be one of the most respected conferences for researchers working in natural computing around the world.

PPSN 2012 featured four distinguished keynote speakers: Angelo Cangelosi (University of Plymouth, UK), Natalio Krasnogor (University of Nottingham, UK), Panos M. Pardalos (University of Florida, USA) and Leslie G. Valiant (Harvard University, USA).

The meeting began with six workshops: "Evolving Predictive Systems" (Bogdan Gabrys and Athanasios Tsakonas), "Joint Workshop on Automated Selection and Tuning of Algorithms" Part A: Continuous Search Spaces - Focus on Algorithm Selection (Heike Trautmann, Mike Preuss, Olaf Mersmann, and Bernd Bischl), Part B: Discrete Search Spaces - Focus on Parameter Selection (Andrew Parkes and Ender Özcan), "Theoretical Aspects of Evolutionary Multiobjective Optimization: Interactive Problem Solving Sessions and New Results" (Dimo Brockhoff and Günter Rudolph), "Modeling Biological Systems" (Julia Handl, Joshua Knowles and Yaochu Jin), and "Parallel Techniques in Search, Optimization, and Learning" (Enrique Alba and Francisco Luna). The workshops offered and ideal opportunity for the conference members to explore specific topics in evolutionary computation, bio-inspired computing and metaheuristics in an informal and friendly setting.
PPSN 2012 also included eight tutorials: "Introduction to Bioinformatics" (Jaume Bacardit, University of Nottingham, UK), "Evolutionary Multi-Objective Optimization" (Juergen Branke, University of Warwick, UK), "Implementing artificial evolution on GPGPU-based computing eco-systems with the EASEA-CLOUD massively parallel platform" (Pierre Collet, Strasbourg University, France), "Programming by Optimisation - A new Paradigm for Developing High-Performance Software" (Holger H. Hoos, University of British Columbia, Canada), "Computational Intelligence and Games" (Pier Luca Lanzi, Polytechnic of Milan, Italy), "Ant Colony Optimization" (Vittorio Maniezzo, University of Bologna, Italy), "Complex Systems Science in its thirties" (Roberto Serra, University of Modena and Reggio Emilia, Italy), and "Expressive Genetic Programming" (Lee Spector, Hampshire College, USA).

We wish to express our gratitude to the authors who submitted their papers to PPSN 2012 and to the Program Committee members and external reviewers who provided thorough evaluations of all these submissions. We also express our profound thanks to Marisa Lappano Anile, Claudio Angione, Jole Costanza, Giovanni Carapezza, Giovanni Murabito, and all the members of the Organizing Committee for their substantial efforts in preparing for and running the meeting. Thanks to all the keynote and tutorial speakers for their participation, which greatly enhanced the quality of this conference. Finally, we also express our gratitude to all the organizations that provided financial support for this event.

Taormina, Italy, 1-5 September 2012

Carlos Coello Coello
Vincenzo Cutello
Kalyanmoy Deb
Stephanie Forrest
Giuseppe Nicosia
Mario Pavone
# PPSN 2012 - Workshops Program

**Saturday, 1 September 2012**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 – 18:30</td>
<td>Registration Desk</td>
<td>Room A</td>
</tr>
<tr>
<td>9:00 – 10:45</td>
<td>Parallel Techniques in Search, Optimization and Learning – session I</td>
<td>Room B</td>
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<td></td>
<td>Modelling Biological Systems – session I</td>
<td>Room C</td>
</tr>
<tr>
<td>10:45 – 11:15</td>
<td>Coffee break</td>
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<tr>
<td>11:15 – 13:00</td>
<td>Automated Selection and Tuning Algorithms – part A, session II</td>
<td>Room A</td>
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<td></td>
<td>Parallel Techniques in Search, Optimization and Learning – session II</td>
<td>Room B</td>
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<tr>
<td></td>
<td>Modelling Biological Systems – session II</td>
<td>Room C</td>
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<tr>
<td>13:00 – 14:30</td>
<td>Lunch</td>
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<tr>
<td>14:30 – 16:15</td>
<td>Automated Selection and Tuning Algorithms – part B, session I</td>
<td>Room A</td>
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<td>Theoretical Aspects of Evolutionary Multiobjective Optimization: Interactive Problem Solving Sessions and New Results – session I</td>
<td>Room B</td>
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<td>Evolving Predictive Systems – session II</td>
<td>Room C</td>
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<tr>
<td>16:15 – 16:45</td>
<td>Coffee break</td>
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<tr>
<td>16:45 – 18:30</td>
<td>Automated Selection and Tuning Algorithms – part B, session II</td>
<td>Room A</td>
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<td>Theoretical Aspects of Evolutionary Multiobjective Optimization: Interactive Problem Solving Sessions and New Results – session I</td>
<td>Room B</td>
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<td>Evolving Predictive Systems – session II</td>
<td>Room C</td>
</tr>
</tbody>
</table>
PPSN 2012 - Tutorials Program
Sunday, 2 September 2012

8:00 – 18:30
Registration Desk

9:00 – 10:45
Complex Systems Science in its thirties – part I
Evolutionary Multi-Objective Optimization – part I
Programming by Optimisation - A new Paradigm for Developing High-Performance Software – part I
Implementing artificial evolution on GPGPU-based computing ecosystems with the EASEA-CLOUD massively parallel platform – part I

10:45 – 11:15
Coffee break

11:15 – 13:00
Complex Systems Science in its thirties – part II
Evolutionary Multi-Objective Optimization – part II
Programming by Optimisation - A new Paradigm for Developing High-Performance Software – part II
Implementing artificial evolution on GPGPU-based computing ecosystems with the EASEA-CLOUD massively parallel platform – part II

13:00 – 14:30
Lunch

14:30 – 16:15
Ant Colony Optimization – part I
Computational Intelligence and Games – part I
Expressive Genetic Programming – part I
Introduction to Bioinformatics – part I

16:15 – 16:45
Coffee break

16:45 – 18:30
Ant Colony Optimization – part II
Computational Intelligence and Games – part II
Expressive Genetic Programming – part II
Introduction to Bioinformatics – part II

room A  room B  room C  room Belvedere  room D
PPSN 2012 – Poster Sessions  
Monday, 3 September 2012

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 – 8:45</td>
<td>Registration Desk</td>
</tr>
</tbody>
</table>
| 8:45 – 9:45  | **Keynote Speaker: Leslie Valiant**  
*Biological Evolution as a Form of Learning*  
Chair: G. Nicosia |
| 9:45 – 10:05 | Poster Introduction S1  
Chair: C.A. Coello Coello |
| 10:05 – 11:15| Poster Session S1                                                                        |
| 11:15 – 11:45| Coffee break                                                                             |
| 11:45 – 12:05| Poster Introduction S2  
Chair: H. Ishibuchi |
| 12:05 – 13:15| Poster Session S2                                                                        |
| 13:15 – 14:30| Lunch                                                                                   |
| 14:30 – 15:30| **Keynote Speaker: Angelo Cangelosi**  
*Embodied Language Learning with the Humanoid Robot iCub*  
Chair: V. Cutello |
| 15:30 – 16:00| Coffee Break                                                                             |
| 16:00 – 16:20| Poster Introduction S3  
Chair: G. Nicosia |
| 16:20 – 17:30| Poster Session S3                                                                        |
| 18:35 – 20:30| Welcome Reception                                                                       |
## PPSN 2012 – Poster Sessions
Tuesday, 4 September 2012

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 – 17:30</td>
<td>Registration Desk</td>
</tr>
</tbody>
</table>
| 8:30 – 9:30| **Keynote Speaker: Panos Pardalos**  
*Global equilibrium search algorithm for combinatorial optimization problems*  
Chair: G. Nicosia |
| 9:30 – 9:50| Poster Introduction S4  
Chair: A. Reynolds |
| 9:50 – 11:00| Poster Session S4                                                      |
| 11:00 – 11:30| Coffee break                                                          |
| 11:30 – 11:50| Poster Introduction S5  
Chair: D. Arnold |
| 11:50 – 13:00| Poster Session S5                                                     |
| 13:00 – 14:30| Lunch                                                                 |
| 14:30 – 15:30| **Keynote Speaker: Natalio Krasnogor**  
*Ultimate Hacking: Programmable Parallel Problem Solving in vivo*  
Chair: M. Pavone |
| 15:30 – 16:00| Coffee Break                                                           |
| 16:00 – 16:20| Poster Introduction S6  
Chair: E. Özcan |
| 16:20 – 17:30| Poster Session S6                                                     |
| 18:00 – 24:00| Social Tour at Greek Theatre, and Social Dinner at Villa Diodoro Hotel |
# PPSN 2012 – Poster Sessions

Wednesday, 5 September 2012

<table>
<thead>
<tr>
<th>Time</th>
<th>Session Description</th>
<th>Chair</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 – 9:20</td>
<td>Poster Introduction S7</td>
<td>Chair: G. Rudolph</td>
</tr>
<tr>
<td>9:20 – 10:30</td>
<td>Poster Session S7</td>
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<tr>
<td>10:30 – 11:00</td>
<td>Coffee break</td>
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<tr>
<td>11:00 – 11:20</td>
<td>Poster Introduction S8</td>
<td>Chair: M. Pavone</td>
</tr>
<tr>
<td>11:20 – 12:30</td>
<td>Poster Session S8</td>
<td></td>
</tr>
<tr>
<td>12:30 – 13:00</td>
<td>Closing Ceremony</td>
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</tr>
<tr>
<td>13:00 – 14:30</td>
<td>Lunch</td>
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</tr>
</tbody>
</table>
Automated Selection and Tuning of Algorithms

Heike Trautmann, Mike Preuss, Olaf Mersmann, Bernd Bischl, Andrew Parkes and Ender Özcan

The steadily growing supply of new optimization methods makes the algorithm selection problem an increasingly pressing and challenging task, both in continuous as well as in discrete combinatorial optimization. Therefore, choosing and tuning a suitable optimization algorithm for a given instance of an optimization problem is a crucial issue and should be supported by automated tools based on problem characteristics.

The aim of this workshop is to collect research concepts and bring together researchers of interdisciplinary areas such as computer science, artificial intelligence, statistics, machine learning and optimization in order to interactively discuss the current state-of-the-art and most important research topics to be addressed in the near future.

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:15-11:30</td>
<td>Welcome/Introductions</td>
</tr>
</tbody>
</table>
| 11:30-11:55| Landscape Analysis of Surrogate-based Model Optimization Tasks  
Patrick Koch and Wolfgang Konen |
| 12:00-12:25| Features of Easy and Hard Instances for Approximation Algorithms and the Traveling Salesperson Problem  
Samadhi Nallaperuma, Markus Wagner, Frank Neumann, Bernd Bischl, Olaf Mersmann, and Heike Trautmann |
| 12:30-12:55| A Case Study of On-The-Fly Calibration for Artificial Immune Network Algorithms  
Elizabeth Montero Ureta |
| 13:00-14:30| Lunch                                        |
Manuel López-Ibáñez |
| 15:15-15:40| Parameter Tuning Using Hyper-heuristics in Uncertain Environments  
Muhammet Köle, A. Şima Eteran-Uyar, Berna Kiraz, and Ender Özcan |
| 15:45-16:10| Automatic Algorithm Selection for the Multi-mode Resource-constrained Project-scheduling Problem  
Tommy Messelis and Patrick De Causmaecker |
| 16:15-16:45| Coffee break                                  |
| 16:45-18:30| Panel discussion                              |
**Parallel Techniques in Search, Optimization and Learning**

*Enrique Alba and Francisco Luna*

Modern research during these last twenty years has expanded to address very interesting problems of large complexity (dimensionality, restrictions, computing intensive...). In particular, those coming from real-world scenarios are getting both larger in size and harder in complexity.

Aiming at finding accurate (and robust) solutions in the shortest possible computational time, these problems face researchers to new challenges of difficult solution with traditional techniques and computers. One way to achieve unseen numerical and efficient results is the use of parallel algorithms, hardware, and specialized techniques.

With the evolution of parallel architectures (symmetric multiprocessors, multi/many-cores, GPUs, etc.), many opportunities emerge for the design of efficient algorithms.

This workshop seeks contributions on new theoretical advances and carefully designed, well-analysed proposals in the field of parallel search algorithms. It is also intended to gather researchers from several domains (operations research, computer science, management science, communications and networks, ...) with an opportunity for presenting and discussing their more recent developments in theory and application of parallel search algorithms. An open atmosphere for discussion of future research lines will hopefully help in defining where we are and where are we going in this crossroad between parallelism and (Nature) problem solving.

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>9:30 - 9:45</td>
<td>Opening</td>
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</table>
*Samia Kouki, Talel Ladhari, and, Mohamed Jemni* |
| 10:05 - 10:25 | Computing UIO Sequences Using Parallel GAs  
*Qiang Guo, John McCall and Horacio González-Vélez* |
| 10:25 - 10:45 | Parallel Local Elimination Algorithms for Sparse Discrete Optimization Problems  
*Daria Lemtyuzhnikova and Oleg Shcherbina* |
| 10:45 - 11:15 | Coffee break                                       |
*Oleg Shcherbina and Eugene Levner* |
*J.J. Merelo, A.M. Mora, C. M. Fernandes, M. G. Arenas, and Anna I. Esparcia-Alcazar* |
| 11:55 - 12:15 | Using Theory for Designing Competitive Distributed EAs  
*K. Osorio, G. Luque, E. Alba* |
| 12:15 - 12:45 | Round-table open discussion                         |
| 12:45 - 13:00 | Closing                                             |
Modelling Biological Systems
Julia Handl, Joshua Knowles, and Yaochu Jin

The aim of the workshop is to provide a dedicated forum for discussion amongst those who are interested in the modelling of biological systems at various scales, ranging from molecular systems to ecological and social interactions. We thus invite papers on all aspects of computational modelling, including applied optimization and simulated evolution, and approaches founded in complexity theory and artificial life.

Topics of interest include, but are not limited to: network biology, signalling pathway modelling, evolution of complexity or "complexification", adaptive walks and fitness landscapes, the benefit of sex, non-adaptive evolution, drift and neutrality, reconstruction of gene regulatory networks, protein folding, structure prediction and docking modularity, robustness and evolvability in biological systems, self-organization and emergence, evolutionary game theory, immune systems modelling, embryogeny, development and pattern formation, models for neural plasticity and neural development, artificial development, and biomimetics.

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>9:00 - 9:15</td>
<td>Welcome</td>
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<tr>
<td>9:15 - 9:45</td>
<td>Modeling biological processes with cellular automata</td>
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<td><em>José Santos Reyes</em></td>
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<tr>
<td>9:45 – 10:15</td>
<td>Using evolutionary computations to understand the design and evolution of gene regulatory networks</td>
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<td><em>Alexander Spirov</em></td>
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<tr>
<td>10:15 – 10:45</td>
<td>Modelling Streptomyces coelicolor Using Evolutionary Algorithms</td>
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<td><em>Spencer Thomas, Yaochu Jin, Emma Laing, Colin Smith</em></td>
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<tr>
<td>10:45 – 11:15</td>
<td>Coffee break</td>
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<tr>
<td>11:15 – 11:45</td>
<td>Genetic Analysis of Prostate Cancer using Computational Evolution, Pareto Optimization and Post-Processing</td>
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<td><em>Jason H. Moore, Douglas P. Hill, Arvis Sulovari and La Creis Kidd</em></td>
</tr>
<tr>
<td>11:45 – 12:15</td>
<td>Analyses and Modelling for Predicting Antigenic Variability in Foot-and-Mouth Disease Virus</td>
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<td><em>Tameera Rahman, Emma Laing, Mana Mahapatra and Yaochu Jin</em></td>
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<tr>
<td>12:15 – 12:45</td>
<td>Self-Nonself discrimination and the role of Costimulation and Anergy</td>
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<td><em>Fernao Vistulo de Abreu, Patricia Mostardinha and Bruno F. Faria</em></td>
</tr>
<tr>
<td>12:45 – 13:00</td>
<td>Closing</td>
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Theoretical Aspects of Evolutionary Multiobjective Optimization: Interactive Problem Solving Sessions and New Results

Dimo Brockhoff, and Günter Rudolph

Evolutionary Multiobjective Optimization (EMO), i.e., the simultaneous optimization of 2 or more objective functions by means of bio-inspired search heuristics, has become one of the main research fields in evolutionary computation in recent years and as such also gained interest from the classical field of multicriteria decision making. Together with the rapid development in practice, also theoretical analyses of EMO gained more and more interest recently.

To foster this growing interest, the PPSN 2012 workshop on Theoretical Aspects of EMO aims at bringing together both theoreticians working in the field of EMO and from single-objective optimization and EMO practitioners. Besides presenting the newest theoretical results about EMO, the workshop aims at providing hands-on sessions in which practitioners and theoreticians work in collaboration on selected open questions proposed by the audience.

In this regard, we would like to invite both theoreticians and practitioners to either present an open problem or discuss about the latest developments in the field of theoretical analysis of evolutionary multiobjective optimization.

<table>
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<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>14:30 - 14:40</td>
<td>Welcome &amp; Introduction to EMO</td>
</tr>
</tbody>
</table>
| 14:40 - 15:10 | Evolutionary Multiobjective Optimisation and Constructive Duality
                     *Ignacy Kaliszewski and Janusz Miroforidis* |
| 15:10 - 15:30 | Open Questions in EMO Theory
                     *Dimo Brockhoff* |
| 15:30 - 16:00 | Interactive problem solving session         |
| 16:00 - 16:15 | Results of interactive problem solving      |
| 16:15 - 16:45 | Coffee break                                |
| 16:45 - 17:15 | Set-based Search and Selection of Concepts via EMO
                     *Amiram Moshaiov* |
| 17:15 - 17:45 | Topological and algorithmic aspects of uniform Pareto front approximations
                     *Günter Rudolph* |
| 17:45 - 18:15 | Hot topic session (topic decided by attendees during/after coffee break) |
| 18:15 - 18:30 | Interactive identification of open problems & wrap-up |
Evolving Predictive Systems

Bogdan Gabrys and Athanasios Tsakonas

In recent years, the data mining scientific community witnessed a very strong demand for predictive systems that will be able to evolve and adapt. The range of tasks fulfilled by evolving predictive systems is very broad and covering many different application areas. Despite the high number of publications dealing with applications, there are still unaddressed pressing issues of evolving predictive systems design and development, such as complexity analysis, ensemble architectures and meta-learning. This session is devoted to the discussion of robust, context aware and easy-to-use evolving predictive systems, which improve, adapt and possibly maintain themselves within their respective environments and constraints. The workshop addresses people from the scientific IT community who are active in the research domain of data-driven systems capable to adapt to changing situations and environments. The considered approaches can include evolutionary algorithms, other nature-inspired methods or heuristic approaches. Contributions presenting research dealing with ensemble architectures, complexity issues (size, form and interpretation of the solution formula, time and algorithm complexity) and meta-learning incorporation are particularly welcome.

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<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>14:30 - 14:45</td>
<td>Opening &amp; Workshop introduction</td>
</tr>
</tbody>
</table>
| 14:45 - 15:45 | Invited talk: Versatile schemes for evolving multi-component, multi-level combined systems  
A. Tsakonas                         |
| 15:45 - 16:15 | Online ensemble learning                                                
A. Bouchacha, E. Balaguer-Ballester |
| 16:15 - 16:45 | Coffee break                                                            |
| 16:45 - 17:15 | Dynamic Trading Systems based on Nature Inspired Intelligence and Statistical Techniques  
V. Vassiliadis, G. Dounias            |
| 17:15 - 17:45 | Business Plan Evaluation Using Ensembles of Evolutionary Classifiers  
G. Dounias, A. Tsakonas, D. Charalambakis, E. Vasilakis                |
| 17:45 - 18:15 | Panel discussion: Issues and future aspects on evolving systems for prediction and adaptation |
| 18:15 - 18:30 | Summary & Workshop closing                                              |
Complex Systems Science in its Thirties

Roberto Serra

Complex Systems Science is no longer new, so it is appropriate to try to provide a comprehensive view. This will be done in the spirit of a tutorial, therefore the various aspects that will be considered will be described without assuming previous high-level knowledge. After a brief historical sketch of the development of Complex Systems Science (CSS for short), that will comprise an excursus on its major concepts, achievements and open questions, two key concepts and two major applications in biology will be analysed in some detail.

Evolutionary Multi-Objective Optimization

Juergen Branke

Many practical optimization problems are multi-objective in nature in the sense that multiple, conflicting criteria need to be optimized simultaneously. As a result, there is usually not one optimal solution, but a set of Pareto-optimal solutions with different trade-offs. Which of these solutions is best depends on the decision maker’s preferences. As evolutionary algorithms always work with a population of solutions, this opens new opportunities in dealing with multi-objective problems by searching for multiple alternatives simultaneously. Consequently, evolutionary multi-objective optimization has become one of the most active research areas in evolutionary computation. This tutorial will give an in-depth introduction to evolutionary multi-objective optimization, with a particular focus on some of the more recent research trends such as the integration of user preferences.

Programming by Optimisation – A new Paradigm for Developing High-Performance Software

Holger H. Hoos

When creating software, particularly solvers for computationally challenging problems, developers frequently explore multiple ways of achieving certain tasks. Often, these alternatives are eliminated or abandoned early in the process, based on the belief that the flexibility afforded by them would be difficult or impossible to exploit later. Programming by Optimisation (PbO) is a design paradigm that aims to avoid such premature design choices and to actively develop promising alternatives for parts of the design. Rather than build a single program for a given purpose, software developers specify a rich and potentially large design space of programs. From this specification, programs that perform well in a given use context are generated automatically through powerful optimisation techniques. PbO allows
human experts to focus on the creative task of imagining possible mechanisms for solving given problems or subproblems, while the tedious job of determining what works best in a given use context is performed automatically, substituting human labor with computation. Furthermore, using PbO, per-instance algorithm selectors and parallel algorithm portfolios can be obtained from the same sequential source. In this tutorial, I will share the vision of how PbO can fundamentally change the way challenging computational problems are solved in the future. I will present examples from work done in my own group and elsewhere that clearly illustrate the viability and promise of the approach. These examples will cover substantial advances in the state of the art (often by orders of magnitude) in SAT-based software verification, planning and timetabling, as well as mixed integer programming - perhaps the most widely used approach for solving optimisation problems in industry. I will demonstrate the tools currently available to support PbO-based software development and outline additional support currently under development.

**Implementing Artificial Evolution on GPGPU-based Computing Eco-Systems with the EASEA-CLOUD Massively Parallel Platform**

Pierre Collet

With the advent of GPGPU cards, all computers are becoming massively parallel systems that are very difficult to program efficiently. Indeed, the next generation of NVIDIA cards will provide 1024 cores grouped into multi-processors of 32 SIMD cores. This means that in order to efficiently execute an existing algorithm on a single PC with a hexacore CPU and a top notch GPGPU card, one should decompose the algorithm into 6 major tasks and 1024 minor ones which, 32 by 32, should execute the same instruction at the same time! Because of necessary synchronizations between cores and data exchanges, exploiting efficiently such a machine (a standard PC) is virtually impossible with standard algorithms. Fortunately, Complex Systems produce results that emerge from the multi-level interaction of many independent entities that can be directly implemented in a very efficient way on multi-level massively parallel machines such as the ones described above. This tutorial will show how the EASEA-CLOUD massively parallel evolutionary platform implements evolutionary algorithms (that can optimize nearly any kind of continuous, discrete, combinatorial, mixed problems) as a kind of Complex System, where entities are individuals that interact through genetic operators, not only on one machine, but on computing eco-systems such as clusters or grids of GPGPU machines, or a cloud of computers.
Ant Colony Optimization

Vittorio Maniezzo

Ant Colony Optimization (ACO) is now 20 years old. During these years several – not to say many – researchers have contributed to the field. Some contributions kept close contact with the original natural metaphor, some were more mathematically oriented; some contributions were small variations of the original ant system, some departed much from it; some contributions considered only combinatorial optimization problems, some extended by much the spectrum of possible applications; some contributions were primarily of academic interest, some made their way to the market. This tutorial will focus on the latter of each mentioned pair. Hands-on examples of design and implementation of an ACO system will be presented.

Computational Intelligence and Games

Pier Luca Lanzi

Games are a rather young but fast growing application domain where methods of computational intelligence, and thus evolutionary computation, are widely applied. This tutorial gives a brief overview of the area and highlights the several research and application opportunities for computational intelligence and evolutionary computation methods. It also provides in-depth perspective on specific classes of problems where evolutionary computation has proved very successful. In particular, it covers the automatic/assisted design of game intelligence (NPC), the procedural generation of game contents (PCG), interactive evolution of personalized content, etc.

Expressive Genetic Programming

Lee Spector

The language in which evolving programs are expressed can have significant impacts on the problem-solving capabilities of a genetic programming system. These impacts stem both from the absolute computational power of the languages that are used, as elucidated by formal language theory, and from the ease with which various computational structures can be produced by random code generation and by the action of genetic operators. Highly expressive languages can facilitate the evolution of programs for any computable function using, when appropriate, multiple data types, evolved subroutines, evolved control structures, evolved data structures, and evolved modular program and data architectures. In some cases expressive languages can even support the evolution of programs that express methods for their own reproduction and variation (and hence for the evolution of their offspring). This tutorial will begin with a comparative survey of approaches to the evolution of programs in
expressive programming languages ranging from machine code to graphical and grammatical representations. Within this context it will then provide a detailed introduction to the Push programming language, which was designed specifically for expressiveness and specifically for use in genetic programming systems. Push programs are syntactically unconstrained but can nonetheless make use of multiple data types and express arbitrary control structures, supporting the evolution of complex, modular programs in a particularly simple and flexible way. The Push language will be described and ten years of Push-based research, including the production of human-competitive results, will be briefly surveyed. The tutorial will conclude with a discussion of recent enhancements to Push that are intended to support the evolution of complex and robust software systems.

Introduction to Bioinformatics

Jaume Bacardit

Bioinformatics is a very fascinating research area where many disciplines such as mathematics, computer science, engineering, etc. are put together to solve biological problems and bring new insight into our understanding of how life works. Biotechnological advances in the last decades have brought a continuously growing supply of biological data that requires non-trivial data analysis and management, from the handling, curation and efficient retrieval of biological data to the detection and analysis of patterns in such datasets. This tutorial will provide an introductory description of the field of bioinformatics and the challenges and opportunities available in this discipline, with particular examples of how genetic and evolutionary computation can be applied to tackle such problems. The tutorial will cover basic molecular biology concepts, common bioinformatics algorithms applied across all kinds of biological data, specialised algorithms for specific types of data (e.g. dna, rna, proteins) and the broad field of biological data mining with several examples of the usage of evolutionary computation methods for such tasks.
**Biological Evolution as a Form of Learning**

*Leslie G. Valiant*

Living organisms function according to protein circuits. Darwin’s theory of evolution suggests that these circuits have evolved through variation guided by natural selection. However, the question of which circuits can so evolve in realistic population sizes and within realistic numbers of generations has remained essentially unaddressed. We suggest that computational learning theory offers the framework for investigating this question, of how circuits can come into being adaptively from experience, without a designer. We formulate evolution as a form of learning from examples. The targets of the learning process are the functions of highest fitness. The examples are the experiences. The learning process is constrained so that the feedback from the experiences is Darwinian. We formulate a notion of evolvability that distinguishes function classes that are evolvable with polynomially bounded resources from those that are not. The dilemma is that if the function class, say for the expression levels of proteins in terms of each other, is too restrictive, then it will not support biology, while if it is too expressive then no evolution algorithm will exist to navigate it. We shall review current work in this area.

**Embodied Language Learning with the Humanoid Robot iCub**

*Angelo Cangelosi*

Growing theoretical and experimental research on action and language processing and on number learning and space representation clearly demonstrates the role of embodiment in cognition. These studies have important implications for the design of communication and linguistic capabilities in cognitive systems and robots, and have led to the new interdisciplinary approach of Cognitive Developmental Robotics. In the European FP7 project “ITALK” (www.italkproject.org) and the Marie Curie ITN “RobotDoc” (www.robotdoc.org) we follow this integrated view of action and language to develop cognitive capabilities in the humanoid robot iCub. During the talk we will present ongoing results from iCub experiments on embodiment biases in early word acquisition studies, word order cues for lexical development and number and space interaction effects. The talk will also introduce the simulation software of the iCub robot, an open source software tool to perform cognitive modelling experiments in simulation.
Global Equilibrium Search Algorithm for Combinatorial Optimization Problems

Panos M. Pardalos

Global Equilibrium Search (GES) is a meta-heuristic search method that shares similar ideas with simulated annealing method. GES accumulates a compact set of information about search space of an optimization problem that is used to generate promising initial solutions for local search techniques. This method has been successfully applied to classic discrete optimization problems, such as the unconstrained quadratic programming problem, the maximum satisfiability problem, the max-cut problem, the multidimensional knapsack problem and the job-shop scheduling problem. On all these domains, GES provides state-of-the-art performance compared to the current best-known algorithms when used for large-scale problems. In this talk, we provide an overview of Global Equilibrium Search, and discuss some successful applications. We explain counter-intuitive empirical observations of super linear speedup in parallel implementations and reveal how parallel acceleration is linked to restart properties of underlying serial algorithms. This is joint work with Dmytro Korenkevych and Oleg Shylo.

Ultimate Hacking: Programmable Parallel Problem Solving in vivo

Natalio Krasnogor

The decision making processes of a biological cell, e.g. a bacterium, often result in a variety of outputs such as the creation of more cells, chemotaxis, bio-film formation, antibiotic production, etc. It was recently shown that even the simplest of cells not only react to their environment but that they can even predict environmental changes. Synthetic Biology (SB) considers “the cell” to be a machine that can be built –from parts– in a manner similar to, e.g., computer programs, electronic circuits, airplanes, etc. and it has sought to co-opt biological cells abilities for nano-computation and nano-manufacturing purposes. In particular, synthetic biological programs that implement Boolean logic gates such as NOT gates and AND gates and other small-scale in vivo information processing tasks have been demonstrated in the laboratory. This talk presents an approach based on "Executable Biology" (also called "Algorithmic Systems/Synthetic Biology") for the specification, analysis and execution of parallel programs for living entities. The methodology enables the formal specification of programs for individual cells and the scaling up towards parallel multicellular computing systems. During the talk I will demonstrate how the proposed techniques have been used in
practice (i.e. in the wet lab) to calculate in vivo Turing Patterns and what the current capabilities and limitations are. Time permitting, I will detail what I believe are key areas of research opportunities in Synthetic Biology for the PPSN community.
Session 1  Monday, 9:45 – 11:15  Chair: Carlos A. Coello Coello

S1.1  A Spatial EA Framework for Parallelizing Machine Learning Methods  
Uday Kamath, Johan Kaers, Amarda Shehu, Kenneth A. De Jong

S1.2  Temporal Evolution of Design Principles in Engineering Systems: Analogies with Human Evolution  
Kalyanmoy Deb, Sunith Bandaru, Cem Celal Tutum

S1.3  A Genetic Programming Approach for Evolving Highly-Competitive General Algorithms for Envelope Reduction in Sparse Matrices  
Behrooz Koohestani, Riccardo Poli

S1.4  Transfer Learning, Soft Distance-Based Bias, and the Hierarchical BOA  
Martin Pelikan, Mark W. Hauschild, Pier Luca Lanzi

S1.5  Global Equilibrium Search Algorithms for Combinatorial Optimization Problems  
Oleg Shylo, Dmytro Korenkevych, Panos M. Pardalos

S1.6  Convergence of the IGO-Flow of Isotropic Gaussian Distributions on Convex Quadratic Problems  
Tobias Glasmachers

S1.7  Improving Lin-Kernighan-Helsgaun with Crossover on Clustered Instances of the TSP  
Doug Hains, Darrell Whitley, Adele Howe

S1.8  On the Anytime Behavior of IPOP-CMA-ES  
Manuel López-Ibáñez, Tianjun Liao, Thomas Stützle

S1.9  Reinforcement Learning with N-tuples on the Game Connect-4  
Markus Thill, Patrick Koch and Wolfgang Konen

S1.10  Length Scale for Characterising Continuous Optimization Problems  
Rachael Morgan, Marcus Gallagher

S1.11  Variable Neighborhood Search and GRASP for Three-Layer Hierarchical Ring Network Design  
Christian Schauer, Günther R. Raidl

S1.12  A Parameterized Runtime Analysis of Simple Evolutionary Algorithms for Makespan Scheduling  
Andrew M. Sutton, Frank Neumann

S1.13  Extracting Key Gene Regulatory Dynamics for the Direct Control of Mechanical Systems  
Jean Krohn, Denise Gorse

S1.14  Homogeneous and Heterogeneous Island Models for the Set Cover Problem  
Andrea Mambrini, Dirk Sudholt, Xin Yao
Session 2  Monday, 11:45 – 13:15  Chair: Hisao Ishibuchi

S2.1  Enhancing Profitability Through Interpretability in Algorithmic Trading with a Multiobjective Evolutionary Fuzzy System  
Adam Ghandar, Zbigniew Michalewicz, Ralf Zurbruegg

S2.2  An Artificial Bee Colony Algorithm for the Unrelated Parallel Machines Scheduling Problem  
Francisco J. Rodriguez, Carlos García-Martínez, Christian Blum, Manuel Lozano

S2.3  Are State-of-the-art Fine-tuning Algorithms Able to Detect a Dummy Parameter?  
Elizabeth Montero, María-Cristina Riff, Leslie Pérez-Caceres, Carlos A. Coello Coello

S2.4  A Memetic Approach for the Max-Cut Problem  
Qinghua Wu, Jín-Kao Hao

S2.5  Enhancing Learning Capabilities by XCS with Best Action Mapping  
Masaya Nakata, Pier Luca Lanzi, Keiki Takadama

S2.6  An Improved Choice Function Heuristic Selection for Cross Domain Heuristic Search  
John H. Drake, Ender Özcan, Edmund K. Burke

S2.7  Runtime Analysis of Simple Interactive Evolutionary Biobjective Optimization Algorithms  
Dimo Brockhoff, Manuel López Ibáñez, Boris Naujoks, Günter Rudolph

S2.8  Geometric Semantic Genetic Programming  
Alberto Moraglio, Krzysztof Krawiec, Colin G. Johnson

S2.9  Compressed Network Complexity Search  
Faustino Gomez, Jan Koutník, Jürgen Schmidhuber

S2.10  Analyzing the Behaviour of Population-based Algorithms Using Rayleigh Distribution  
Gabriel Luque, Enrique Alba

S2.11  On Measures to Build Linkage Trees in LTGA  
Peter A.N. Bosman, Dirk Thierens

S2.12  Clustering Criteria in Multiobjective Data Clustering  
Julia Handl, Joshua Knowles

S2.13  Study of cancer hallmarks relevance using a cellular automaton tumor growth model  
José Santos, Ángel Monteagudo

S2.14  Automatic Evaluation Methods in Evolutionary Music: An Example with Bossa Melodies  
A. R. R. Freitas, F. G. Guimarães, R. V. Barbosa
<table>
<thead>
<tr>
<th>Session 3</th>
<th>Monday, 16:00 – 17:30</th>
<th>Chair: Giuseppe Nicosia</th>
</tr>
</thead>
<tbody>
<tr>
<td>S3.1</td>
<td>An Improved Multiobjectivization Strategy for HP Model-based Protein Structure Prediction</td>
<td>Mario Garza-Fabre, Eduardo Rodriguez-Tello, Gregorio Toscano-Pulido</td>
</tr>
<tr>
<td>S3.2</td>
<td>Alternative Restart Strategies for CMA-ES</td>
<td>Ilya Loshchilov, Marc Schoenauer, Michèle Sebag</td>
</tr>
<tr>
<td>S3.3</td>
<td>Using Expert Knowledge to Guide Covering and Mutation in a Michigan Style Learning Classifier System to Detect Epistasis and Heterogeneity</td>
<td>Ryan J. Urbanowicz, Delaney Granizo-Mackenzie, Jason H. Moore</td>
</tr>
<tr>
<td>S3.4</td>
<td>Efficient Negative Selection Algorithms by Sampling and Approximate Counting</td>
<td>Johannes Textor</td>
</tr>
<tr>
<td>S3.5</td>
<td>Analyzing Module Usage in Grammatical Evolution</td>
<td>John Mark Swafford, Erik Hemberg, Michael O’Neill, Anthony Brabazon</td>
</tr>
<tr>
<td>S3.6</td>
<td>It’s Fate: A Self-Organising Evolutionary Algorithm</td>
<td>Jan Bim, Giorgos Karafotias, S.K. Smit, A.E. Eiben, Evert Haasdijk</td>
</tr>
<tr>
<td>S3.7</td>
<td>Controlling the Parameters of the Particle Swarm Optimization with a Self-Organized Criticality Model</td>
<td>Carlos M. Fernandes, Juan J. Merelo, Agostinho C. Rosa</td>
</tr>
<tr>
<td>S3.8</td>
<td>Local Optima Networks, Landscape Autocorrelation and Heuristic Search Performance</td>
<td>Francisco Chicano, Fabio Daolio, Gabriela Ochoa, Sébastien Vérel, Marco Tomassini, Enrique Alba</td>
</tr>
<tr>
<td>S3.9</td>
<td>Beware the Parameters: Estimation of Distribution Algorithms Applied to Circles in a Square Packing</td>
<td>Marcus Gallagher</td>
</tr>
<tr>
<td>S3.10</td>
<td>Elitist Archiving for Multi-Objective Evolutionary Algorithms: To Adapt or Not To Adapt</td>
<td>Hoang N. Luong, Peter A.N. Bosman</td>
</tr>
<tr>
<td>S3.11</td>
<td>Recombination of Similar Parents in SMS-EMOA on Many-Objective 0/1 Knapsack Problems</td>
<td>Hisao Ishibuchi, Naoya Akedo, Yusuke Nojima</td>
</tr>
<tr>
<td>S3.12</td>
<td>Applying Genetic Regulatory Networks to Index Trading</td>
<td>Miguel Nicolau, Michael O’Neill, Anthony Brabazon</td>
</tr>
<tr>
<td>S3.13</td>
<td>The Apiary Topology: Emergent Behavior in Communities of Particle Swarms</td>
<td>Andrew McNabb, Kevin Seppi</td>
</tr>
<tr>
<td>Session 4</td>
<td>Tuesday, 9:30 – 11:00</td>
<td>Chair: Alan Reynolds</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------</td>
<td>----------------------</td>
</tr>
</tbody>
</table>
| S4.1      | An Empirical Evaluation of O(1) Steepest Descent for NK-Landscapes.  
**Darrell Whitley, Wenxiang Chen, Adele Howe** |
| S4.2      | On the Behaviour of the (1, λ)-oSA-ES for a Constrained Linear Problem  
**Dirk V. Arnold** |
| S4.3      | Differential Gene Expression with Tree-Adjunct Grammars  
**Eoin Murphy, Miguel Nicolau, Erik Hemberg, Michael O’Neill, Anthony Brabazon** |
| S4.4      | Variable Transformations in Estimation of Distribution Algorithms  
**Davide Cucci, Luigi Malagó, Matteo Matteucci** |
| S4.5      | Evolvability Analysis of the Linkage Tree Genetic Algorithm  
**Dirk Thierens, Peter A.N. Bosman** |
| S4.6      | Controlling Overfitting in Symbolic Regression based on a Bias/Variance Error Decomposition  
**Alexandros Agapitos, Anthony Brabazon, and Michael O’Neill** |
| S4.7      | Between Selfishness and Altruism: Fuzzy Nash-Berge-Zhukovskii Equilibrium  
**Réka Nagy, Noémi Gaskó, Rodica Ioana Lung, D. Dumitrescu** |
| S4.8      | Real-time GPU based Road Sign Detection and Classification  
**Roberto Ugolotti, Youssef S.G. Nashed, Stefano Cagnoni** |
| S4.9      | A Hybrid Approach to Piecewise Modelling of Biochemical Systems  
**Zujian Wu, Shengxiang Yang, David Gilbert** |
| S4.10     | A Framework to Hybridize PBIL and a Hyper-heuristic for Dynamic Environments  
**Gönül Uludağ, Berna Kiraz, A. Şima Etaner-Uyar, Ender Özcan** |
| S4.11     | Parallelization Strategies for Hybrid Metaheuristics using a Single GPU and Multi-core Resources  
**Thé Van Luong, Eric Taillard, Nouredine Melab, El-Ghazali Talbi** |
| S4.12     | On-line Evolution of Controllers for Aggregating Swarm Robots in Changing Environments  
**Berend Weel, Mark Hoogendoorn, A.E. Eiben** |
| S4.13     | Evolving Femtocell Algorithms with Dynamic & Stationary Training Scenarios  
**Erik Hemberg, Lester Ho, Michael O’Neill, Holger Claussen** |
<table>
<thead>
<tr>
<th>Session 5</th>
<th>Tuesday, 11:30 – 13:00</th>
<th>Chair: Dirk Arnold</th>
</tr>
</thead>
</table>
| S5.1      | Exploiting Prior Information in Multi-Objective Route Planning  
Antony Waldock, David Corne |
| S5.2      | A Memetic Algorithm for Community Detection in Complex Networks  
Olivier Gach, Jin-Kao Hao |
| S5.3      | Experimental Supplements to the Computational Complexity Analysis of Genetic Programming for Problems Modelling Isolated Program Semantics  
Tommaso Urli, Markus Wagner, Frank Neumann |
| S5.4      | HappyCat - A Simple Function Class Where Well-Known Direct Search Algorithms Do Fail  
Hans-Georg Beyer, Steffen Finck |
| S5.5      | Guide Objective Assisted Particle Swarm Optimization and its Application to History Matching  
Alan P. Reynolds, Asaad Abdollahzadeh, David W. Corne, Mike Christie, Brian Davies, Glyn Williams |
| S5.6      | Adaptive Evolutionary Algorithms and Extensions to the HyFlex Hyper-heuristic Framework  
Gabriela Ochoa, James Walker, Matthew Hyde, Tim Curtois |
| S5.7      | A Meta-Learning Prediction Model of Algorithm Performance for Continuous Optimization Problems  
Mario A. Muñoz, Michael Kirley, Saman K. Halgamuge |
| S5.8      | Network Topology Planning Using MOEA/D with Objective-Guided Operators  
Wei Peng, Qingfu Zhang |
| S5.9      | An Evolutionary Optimization Approach for Bulk Material Blending Systems  
Michael P. Cipold, Pradyumn Kumar Shukla, Claus C. Bachmann, Kaibin Bao, Hartmut Schmeck |
| S5.10     | Community Detection Using Cooperative Co-evolutionary Differential Evolution  
Qiang Huang, Thomas White, Guanbo Jia, Mirco Musolesi, Nil Turan, Ke Tang, Shan He, John K. Heath, Xin Yao |
| S5.11     | A Spanning Tree-based Encoding of the MAX CUT Problem for Evolutionary Search  
Kisung Seo, Soohwan Hyun, Yong-Hyuk Kim |
| S5.12     | Cumulative Step-size Adaptation on Linear Functions  
Alexandre Chotard, Anne Auger, Nikolaus Hansen |
| S5.13     | Animal Spirits in Population Spatial Dynamics  
Matylda Jabłońska, Tuomo Kauranne |
Session 6  Tuesday, 16:00 – 17:30  Chair: Ender Özcan

S6.1  Parsimony Pressure versus Multi-Objective Optimization for Variable Length Representations  
      Markus Wagner, Frank Neumann

S6.2  On Spectral Invariance of Randomized Hessian and Covariance Matrix Adaptation schemes  
      Sebastian U. Stich, Christian L. Müller

S6.3  Acceleration of Evolutionary Image Filter Design Using Coevolution in Cartesian GP  
      Michaela Sikulova, Lukas Sekanina

S6.4  A Benchmark Generator for Dynamic Permutation-Encoded Problems  
      Michalis Mavrovouniotis, Shengxiang Yang, Xin Yao

S6.5  Efficient Sampling and Handling of Variance in Tuning Data Mining Models  
      Patrick Koch and Wolfgang Konen

S6.6  A Hyper-Heuristic Classifier for One Dimensional Bin Packing Problems: Improving Classification Accuracy by Attribute Evolution  
      Kevin Sim, Emma Hart, Ben Paechter

S6.7  Adaptive Operator Selection at the Hyper-Level  
      Eduardo Krempser, Álvaro Fialho, Helio J. C. Barbosa

S6.8  Convergence of the Continuous Time Trajectories of Isotropic Evolution Strategies on Monotonic $C^2$-composite Functions  
      Youhei Akimoto, Anne Auger, Nikolaus Hansen

S6.9  Multi-Objective Optimization for Selecting and Scheduling Observations by Agile Earth Observing Satellites  
      Panwadee Tangpattanakul, Nicolas Jozefowiez, Pierre Lopez

S6.10  Benchmarking CHC on a New Application: The Software Project Scheduling Problem  
        Javier Matos, Enrique Alba

S6.11  Tailoring $\varepsilon$-MOEA to Concept-based Problems  
        Amiram Moshaiov, Yafit Snir

S6.12  A comparative study of three GPU-based metaheuristics  
        Youssef S. G. Nashed, Pablo Mesejo, Roberto Ugozotti, Jérémie Dubois-Lacoste, Stefano Cagnoni

S6.13  Autonomous Shaping via Coevolutionary Selection of Training Experience  
        Marcin Szubert, Krzysztof Krawiec
Session 7  Wednesday, 9:00 – 10:30  Chair: Günther Rudolph

S7.1  A Parallel Cooperative Co-evolutionary Genetic Algorithm for the Composite SaaS Placement Problem in Cloud Computing  
Maolin Tang, Zeratul Izzah Mohd Yusoh

S7.2  On Algorithm-Dependent Boundary Case Identification for Problem Classes  
Chao Qian, Yang Yu, Zhi-Hua Zhou

S7.3  Generalized Compressed Network Search  
Rupesh Kumar Srivastava, Jürgen Schmidhuber, Faustino Gomez

S7.4  Single Node Genetic Programming on Problems with Side Effects  
David Jackson

S7.5  Analysing the Effects of Diverse Operators in a Genetic Programming System  
MinHyeok Kim, Bob (RI) McKay, Kangil Kim, Nguyen Xuan Hoai

S7.6  Competing Mutating Agents for Bayesian Network Structure Learning  
Olivier Regnier-Coudert, John McCall

S7.7  Pruning GP-Based Classifier Ensembles by Bayesian Networks  
C. De Stefano, G. Folino, F. Fontanella, A. Scotto di Freca

S7.8  Analysis on Population Size and Neighborhood Recombination on Many-Objective Optimization  
Naoya Kowatari, Akira Oyama Hernán Aguirre, Kiyoshi Tanaka

S7.9  A Study on Evolutionary Multi-Objective Optimization with Fuzzy Approximation for Computational Expensive Problems  
Alessandro G. Di Nuovo, Giuseppe Ascia, Vincenzo Catania

S7.10  Buildable Objects Revisited  
Martin Waßmann, Karsten Weicker

S7.11  Efficient Discovery of Chromatography Equipment Sizing Strategies for Antibody Purification Processes Using Evolutionary Computing  
Richard Allmendinger, Ana S. Simaria, Suzanne S. Farid

S7.12  Block Diagonal Natural Evolution Strategies  
Giuseppe Cuccu and Faustino Gomez

S7.13  Finding Good Affinity Patterns for Matchmaking Parties Assignment through Evolutionary Computation  
Sho Kuroiwa, Keiichi Yasumoto, Yoshihiro Murata, Minoru Ito
Session 8  Wednesday, 11:00 – 12:30  Chair:  Mario Pavone

S8.1  ACO beats EA on a Dynamic Pseudo-Boolean Function  
      Timo Kötzing, Hendrik Molter

S8.2  Quantitative Analysis of Locally Geometric Semantic Crossover  
      Krzysztof Krawiec, Tomasz Pawlak

S8.3  A Multi-Parent Search Operator for Bayesian Network Building  
      David Iclănzan

S8.4  Bootstrapping Aggregate Fitness Selection with Evolutionary Multi-objective Optimization  
      Shlomo Israel, Amiram Moshaiov

S8.5  MOEA/D with Iterative Thresholding Algorithm for Sparse Optimization Problems  
      Hui Li, Xiaolei Su, Zongben Xu, Qingfu Zhang

S8.6  An Empirical Comparison of CMA-ES in Dynamic Environments  
      Chun-Kit Au, Ho-Fung Leung

S8.7  An Evolutionary and Graph-based method for Image Segmentation  
      Alessia Amelio, Clara Pizzuti

S8.8  Optimizing Cellular Automata through a Meta-model Assisted Memetic Algorithm  
      Donato D’Ambrosio, Rocco Rongo, William Spataro, Giuseppe A. Trunfio

S8.9  The Effect of the Set of Low-level Heuristics on the Performance of Selection Hyper-heuristics  
      M. Misir, K. Verbeeck, P. De Causmaecker, G. Vanden Berghe

S8.10  ACO on Multiple GPUs with CUDA for Faster Solution of QAPs  
       Shigeyoshi Tsutsui

S8.11  Collective Robot Navigation using Diffusion Limited Aggregation  
       Jonathan Mullins, Bernd Meyer, Aiguo Patrick Hu

S8.12  Evolutionary 3D-Shape Segmentation using Satellite Seeds  
       Kai Engel, Heinrich Müller
As soon as you arrive in Taormina, you will feel the magical, mythical atmosphere spread all around which has enchanted visitors from all over the world for yeas. Settled on a hill of the Monte Tauro, Taormina dominates two grand, sweeping bays below and on the southern side, the top of Mount Etna, the European highest active volcano, often capped with snow, offering to the visitors a breathtaking, dramatic and memorable view over almost one hundred miles of Mediterranean sea.

Taormina seems to be born as a tourist resort since past times, when ancient people like the Sicels, Greeks, Romans Byzantines, Saracens, Arabs, Norman and Spaniards chose it as their residential site thanks to its favourable position, mild climate and magic atmosphere. Nowadays, visitors can still find fine examples of Taormina's golden times: the splendid Greek Theatre, the Roman "Naumachiae", the 13th century Cathedral of Saint Nicolò, the 14th century Palazzo Corvaja, the 16th century Palace of the Dukes of Saint Stefano, the public gardens, the "Ancient Abbey" (Badia Vecchia) and many others.

Social Tour at Greek Theatre

The most significant monument in Taormina is the ancient theatre, not just because of its artistic and historical values but also because of its unique position. The view from here is called *panoramaet par excellence* and is definitely worth experiencing when you come to Sicily.

Second in size only to the Theatre in Syracuse, the Greek Theatre in Taormina although was built during Hellenic times in the 3rd to 2nd centuries BC, it was completely reconstructed and extended 300 years later by the Romans and used for gladiatorial shows. The theatre is situated at the very top of a hill, levelled for the purpose, using the natural incline of the valley for the "cavea": the auditorium seating.

The backdrop view would doubtless have added splendid dramatic impact to past productions.

The remains of a small temple stand on the side of the theatre. Remnants of an arcade, once leading to the theatre, stand at the top of the auditorium. Scenery consisted of nine columns, raised and placed in their original positions during the theatre's restoration in the Eighteen Hundreds.
The majestic panorama, combined with a spectacular view of Etna and the Calabrian mountains, renders this hollowed out hill a natural stage, as well as a stage for natural beauty.

**Getting Around**

Travelling in Sicily by comfortable buses is a very smart idea: they are fast, reliable and cheap and take the traveller almost everywhere. Taormina has its own bus terminal right in the town centre. Frequent buses (“Interbus”) run from Palermo, Catania (airport included) and Messina. Moreover, there are connections from Rome and Amalfi (Interbuisness), Bari, Brindisi (ferries from Greece) and Taranto (Etna).

Cheaper transportation might be possible by sharing car service. The SAT group (http://www.satgroup.it/) arranges transfer service between Catania Airport and Taormina.
Registration Desk
The registration desk is located in the conference centre of the Hotel. It is open from 8:00 of September 1 until the last day of the conference. During the conference you can find someone of the organization that can be help you on whatever you need.

Lunch and Coffee Break
Lunch, coffee and soft drinks during the breaks are included in the conference fee. The Coffee break takes place in the beautiful terrace of the Hotel Villa Didoro where you can see together sea and the Etna volcano. The lunch takes place in the main restaurant of the Hotel.

Instructions for Poster Presenters
Each poster session starts with a short plenary introduction of the presented papers in 20 minutes, and it takes place in the main conference room. During this short plenary introduction, the session chair summarizes the main results of each paper.

The poster presenters should set up their poster on their assigned poster boards 15 minutes before each poster session. During that, each presenter shall stand next to the own poster in order to talk and answering about his/her work.

Please don't forget to remove your poster after the closure of your session.

Wi-Fi Access
The conference room, as well as the posters room, offer to all participants a free wireless internet access. During the registration desk we will give you all needed access information.