Learning and Intelligent OptimizatioN conference

Microsoft Technology Center, Paris

January 16-20, 2012

Conference Pre-Proceedings

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Foreword

This LION conference (**L**earning and **I**ntelligent **O**ptimizatio**N**) is the sixth of a series of conferences that target the interface between Optimization and Machine Learning, and the ever increasing success of these events witnesses the growing interest of the scientific community for this research area today, as confirmed by the 109 submissions from 39 different countries that we received for this edition. We want to thank here all these authors for submitting some of their best work to LION'6.

Of these 109 submissions, there were 78 long papers and 21 short papers presenting original work, and 10 papers presenting work that had already been published. Due to this very high pressure, and the single track format of the conference, we have chosen to give room to original works in front of already published works, regardless of the quality of the papers, and apologize toward the authors of these papers for that.

Out of these 99 original submission, 24 papers were accepted as long papers (hence an **acceptance rate of 31%**), and 30 papers were accepted as short papers (19 that had been submitted as long papers, and 5 that had been submitted as short papers). All papers were assigned to 3 independent reviewers, and received at least 2 reviews. Note that the papers submitted to the Special Sessions were assigned by the Special Session Chairs, except the ones that were authored by some of the Session Chairs, that were handled by the Conference Chairs, to ensure the anonymity of the reviewers (similarly, papers authored by one of the conference co-chair were handled by the other co-chair and one member of the Steering Committee, unknown by the authors). We wish to heartily thank here all the reviewers (not anonymous any more, see next pages) for their hard and timely work, emphasizing the importance of such peer review, the best (if not only) way we know today to ensure a review process as fair as possible.

Because LION is a unique occasion for people from different research communities, the conference is single track (no parallel sessions) and the program leaves room for interactions among attendees with long coffee breaks. For the same reason, though the presentations of long paper (resp. short papers) are scheduled with 25mn (resp. 15mn) slots, the presentations themselves must not be longer than 20mn (resp. 12mn), allowing time for questions and discussions. The session chairs will be very strict on respecting these constraints.

The final program of the conference (see later) also include 3 invited talks, who will present forefront research results and frontiers, and 3 tutorial talks, who will help even more bringing together the different component of LION community. We wish to thank all these speakers who will focus on different aspects of LION themes, and thus contribute to a better view and understanding of Intelligent Optimization at large.

Beside the authors, the reviewers, and the invited speakers, there are other people who made this event possible whom we wish to thank now: Pierre-Louis Xech (Microsoft France), for arranging the venue at Microsoft France Technology center, and smoothening many small details that would otherwise have become incredibly time-consuming, Pietro Zanoni (Reactive Search), Inc., for setting up and diligently maintaining the conference Web site, Mireille Moulin (INRIA Saclay Île-de-France, Finance dpt), for taking care of all the financial details with efficiency and flexibility, Esther Slamitz (INRIA Saclay Île-de-France, Events dpt) for looking up and planning all local arrangements, Emmanuelle Perrot (INRIA Saclay Île-de-France, Communication dpt) for providing many goodies, ... including the printing of this booklet, Chantal Girodon (INRIA Rocquencourt, Conferences & Seminars Office) for managing the registration system.

Finally, we would like to thank our sponsors, Microsoft Research, Microsoft France, and INRIA Saclay Île-de-France, for their financial help to keep the registration fees at reasonable cost.

We hope you will enjoy a great conference,

Paris, January 2012
Youssef Hamadi (Microsoft Research Cambridge) and Marc Schoenauer (INRIA Saclay Île-de-France)
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Zhu Zhu, Université de Picardie

Program

Monday, January 16., 2011

11:30-13:30 : *Welcome and (free) lunch*

13:30-15:30 : **TUTORIAL TALK**: Addressing Numerical Black-Box Optimization: CMA-ES
Anne Auger and Nikolaus Hansen, INRIA Saclay

15:30-16:00 : *Coffee break* Hall

16:00-18:05 : *CHESC*
Chairs: Gabriela Ochoa and Matthew Hyde

A Non-Adaptive Stochastic Local Search Algorithm for the CHeSC 2011 Competition (25mn),
Franco Mascia, Thomas Stützle ***15 PDF***

A Vehicle Routing Domain for the HyFlex Hyper-heuristics Framework (25mn),
James Walker, Gabriela Ochoa, Michel Gendreau, Edmund Burke ***15 PDF***

A new Hyperheuristic Algorithm for Cross Domain Search Problems (15mn),
Andreas Lehrbaum, Nysret Musliu ***16 PDF***

A Hyper-heuristic Inspired by Pearl Hunting (15mn),
C.Y. Chan, Fan Xue, W.H. Ip, C.F. Cheung ***16 PDF***

Five Phase and Genetic Hive Hyper-heuristics for the Cross-Domain Search (15mn),
T. Cichowicz, M. Drozdowski, M. Frankiewicz, G. Pawlak, F. Rytwinski, J. Wasilewski ***17 PDF***

An Intelligent Hyper-heuristic Framework for CHeSC 2011 (15mn),
Mustafa Misir, Katja Verbeeck, Patrick De Causmaecker, Greet Vanden Berghe ***17 PDF***

Evaluation of a family of reinforcement learning cross-domain optimization heuristics (15mn),
Luca Di Gaspero, Tommaso Urli ***17 PDF***

18:05-20:00 : *Welcome reception and cocktail*

Tuesday, January 17., 2011

09:30-10:30 : **INVITED TALK**: Optimization problems and algorithms for the high-level control of dynamic systems
Gérard Verfaillie, ONERA

10:30-11:00 : *Coffee break*

11:00-12:00 : *MAXSAT*
Chair: Felip Manya

Lower Bounds and Upper Bounds for MaxSAT (15mn),
Federico Heras, Antonio Morgado, Joao Marques-Silva ***18 PDF***

Natural Max-SAT encoding of Min-SAT (15mn),
Adrian Kügel ***18 PDF***

Counter Implication Restart for Parallel SAT Solvers (15mn),
Tomohiro Sonobe, Mary Inaba ***18 PDF***

Clause Sharing in Parallel MaxSAT (15mn),
Ruben Martins, Vasco Manquinho, Inês Lynce ***19 PDF***

12:10-13:15 : *Tree Search*
Chair: Gérard Verfaillie

Iterative-Deepening Search with On-line Tree Size Prediction (25mn),
Ethan Burns, Wheeler Ruml ***19 PDF***

Evaluating Tree-Decomposition Based Algorithms for Answer Set Programming (25mn),
Michael Morak, Nysret Musliu, Reinhard Pichler, Stefan Rümmele, Stefan Woltran ***20 PDF***

Improving exploration in Upper Confidence Trees (15mn),
Adrien Couetoux, Olivier Teytaud, Hassen Doghmen ***20 PDF***

13:30-14:30 : *Lunch* Microsoft cafeteria

14:30-15:10 : *Tree Search cont'd*

Application of the Nested Rollout Policy Adaptation Algorithm to the Traveling Salesman Problem with Time Windows (25mn),
Tristan Cazenave, Fabien Teytaud ***20 PDF***

A Tree Search Approach to Sparse Coding (15mn),
Rui Rei, João P. Pedroso, Hideitsu Hino, Noboru Murata ***21 PDF***

15:25-16:30 : *Biological applications (BIO)*
Chairs: Clarisse Dhaenens and Laetitia Jourdan

Minimizing Time when Applying Bootstrap to Contingency Tables Analysis of Genome-Wide Data (25mn),
Francesco Sambo, Barbara Di Camillo ***21 PDF***

Community Detection in Social and Biological Networks using Differential Evolution (25mn),
Guanbo Jia, Zixing Cai, Mirco Musolesi, Yong Wang, Dan Tennant, Ralf Weber, John Heath, Shan He ***22 PDF***

Brain cine-MRI Sequences Registration using B-spline Free-Form Deformations and MLSDO Dynamic Optimization Algorithm (15mn),
Julien Lepagnot, Amir Nakib, Hamouche Oulhadj, Patrick Siarry ***22 PDF***

16:30-17:00 : *Coffee break*

17:00-18:30 : *Automatic Parameter Tuning*
Chair: Thomas Stützle

Automatically Configuring Algorithms for Scaling Performance (25mn),
James Styles, Holger Hoos, Martin Mueller ***23 PDF***

Parallel Algorithm Configuration (25mn),
Frank Hutter, Holger Hoos, Kevin Leyton-Brown ***23 PDF***

Quantifying Homogeneity of Instance Sets for Algorithm Configuration (25mn),
Marius Schneider, Holger H. Hoos ***24 PDF***

Determining the Characteristic of Difficult Job Shop Scheduling Instances for a Heuristic Solution Method (15mn),
Helga Ingimundardottir, Thomas Philip Runarsson ***24 PDF***

Wednesday, January 18., 2011

09:30-10:30 : **INVITED TALK**: Autonomous Search
Frédéric Saubion, Université d'Angers

10:30-11:00 : *Coffee break*

11:00-12:25 : *Parallelism*
Chair: Enrique Alba

Learning Algorithm Portfolios for Parallel Execution (25mn),
Xi Yun, Susan Epstein ***24 PDF***

Toward Autonomous Search with Island Models (15mn),
Adrien Goëffon, Frédéric Lardeux ***25 PDF***

Influence of the Migration Period in Parallel Distributed GAs for Dynamic Optimization (15mn),
Yesnier Bravo, Gabriel Luque, Enrique Alba ***25 PDF***

Expected improvements for the asynchronous parallel global optimization of expensive functions : potentials and challenges (15mn),
Janis Janusevskis, Rodolphe Le Riche, David Ginsbourger ***25 PDF***

Parallel GPU Implementation of Iterated Local Search for the Travelling Salesman Problem (15mn),
Audrey Delévacq, Pierre Delisle, Michaël Krajecki ***26 PDF***

12:25-13:15 : *Other approaches*

Quasi-Elementary Landscapes and Superpositions of Elementary Landscapes (25mn),
Darrell Whitley, Francisco Chicano ***26 PDF***

Optimization by l1-constraining a Markov Fitness Modelling (25mn),
Gabriele Valentini, Luigi Malagò, Matteo Matteucci ***27 PDF***

13:30-14:30 : *Lunch* Microsoft cafeteria

14:30-16:30 : *Multi-Objective Optimization*
Chair: Dimo Brockhoff

A Study on Large Population MOEA Using Adaptive Epsilon-Box Dominance and Neighborhood Recombination for Many-objective Optimization (25mn),
Naoya Kowatari, Akira Oyama, Hernan Aguirre, Kiyoshi Tanaka ***27 PDF***

Bounding the Effectiveness of Hypervolume-based (mu+lambda)-Archiving Algorithms (25mn),
Tamara Ulrich, Lothar Thiele ***28 PDF***

Adaptive Control of the Number of Crossed Genes in Many-Objective Evolutionary Optimization (15mn),
Hiroyuki Sato, Carlos Coello, Hernan Aguirre, Kiyoshi Tanaka ***28 PDF***

An Approach to Instantly Use Single-objective Results for Multi-objective Evolutionary Combinatorial Optimization (15mn),
Christian Grimme, Joachim Lepping ***29 PDF***

An Efficient Meta-heuristic based on Self-control Dominance Concept for a Bi-objective Re-entrant Scheduling Problem with Outsourcing (15mn),
Atefeh Moghaddam, Farouk Yalaoui, Lionel Amodeo ***29 PDF***

Effect of SMS-EMOA Parameterizations on Hypervolume Decreases (15mn),
Leonard Judt, Olaf Mersmann, Boris Naujoks ***29 PDF***

16:30-17:00 : *Coffee break*

17:00-18:00 : *Evolutionary Algorithms*
Chair: Darrell Whitley

Effects of Speciation on Evolution of Neural Networks In Highly Dynamic Environments (15mn),
Peter Krcah ***30 PDF***

Evolutionary Optimization for Algebraic Geometry: Design of Robust Runge–Kutta Methods (15mn),
Ivan Martino, Giuseppe Nicosia ***30 PDF***

Learning the Neighborhood with the Linkage Tree Genetic Algorithm (15mn),
Dirk Thierens, Peter Bosman ***31 PDF***

Implicit Model Selection based on Variable Transformations in Estimation of Distribution (15mn),
Emanuele Corsano, Davide Cucci, Luigi Malagò, Matteo Matteucci ***31 PDF***

20:00-23:00 : *Conference Banquet* Boat trip on the River Seine

Thursday, January 19., 2011

09:30-10:30 : **INVITED TALK**: Surrogate-Assisted Evolutionary Optimisation: Past, Present and Future
Yaochu Jin, Nature-Inspired Computing and Engineering Group, Department of Computing, University of Surrey, UL

10:30-11:00 : *Coffee break*

11:00-13:15 : *Local Search, Simulated Annealing*
Chair: Frank Hutter

High-Dimensional Model-Based Optimization Based on Noisy Evaluations of Computer Games (25mn),
Mike Preuss, Tobias Wagner, David Ginsbourger ***32 PDF***

Local Search and the Traveling Salesman Problem: A Feature-Based Characterization of Problem Hardness (25mn),
Olaf Mersmann, Bernd Bischl, Jakob Bossek, Heike Trautmann, Markus Wagner, Frank Neumann ***32 PDF***

Parameter-Optimized Simulated Annealing for Application Mapping on Networks-on-Chip (25mn),
Bo Yang, Liang Guang, Tero Säntti, Juha Plosila ***33 PDF***

Hybridizing Reactive Tabu Search with Simulated Annealing (15mn),
Stefan Voß, Andreas Fink ***33 PDF***

Constraint-Based Local Search for the Costas Array Problem (15mn),
Daniel Diaz, Florian Richoux, Philippe Codognet, Yves Caniou, Salvador Abreu ***33 PDF***

A Comparison of Operator Utility Measures for On-line Operator Selection in Local Search (15mn),
Nadarajen Veerapen, Jorge Maturana, Frédéric Saubion ***34 PDF***

Bayesian optimization using sequential Monte Carlo (15mn),
Romain Benassi, Julien Bect, Emmanuel Vazquez ***34 PDF***

13:30-14:30 : *Lunch*

14:30-16:30 : **TUTORIAL TALK**: Intelligent Optimization with Submodular Functions
Andreas Krause, ETH Zurich

16:30-17:00 : *Coffee break*

17:00-18:25 : *Combinatorial Optimisation*
Chair: Roberto Battiti

A Learning Optimization Algorithm in Graph Theory (25mn),
Gilles Caporossi, Pierre Hansen ***35 PDF***

A Math-heuristic Dantzig-Wolfe Algorithm for the Capacitated Lot Sizing Problem (25mn),
Marco Caserta, Stefan Voß ***36 PDF***

Fast permutation learning (25mn),
Tony Wauters, Katja Verbeeck, Patrick De Causmaecker, Greet Vanden Berghe ***36 PDF***

Friday, January 20., 2011

09:30-11:30 : **TUTORIAL TALK**: Symmetry in Mathematical Programming
Leo Liberti, Ecole Polytechnique

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

12:00-13:05 :
Monte-Carlo Tree Search
Chair: Michèle Sebag

Pilot, Rollout and Monte Carlo Tree Search Methods for Combinatorial Optimization (25mn),
Thomas Runarsson, Marc Schoenauer, Michèle Sebag ***34 PDF***

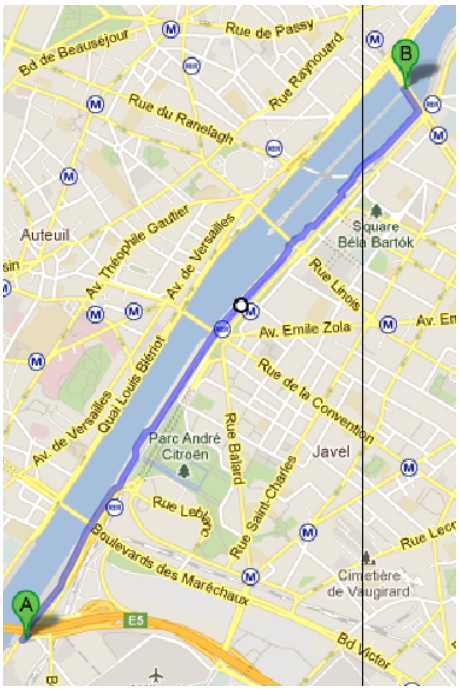
Combining Myopic Optimization and Tree Search: Application to MineSweeper (25mn),
Olivier Teytaud, Michèle Sebag ***35 PDF***

Monte Carlo Methods for Preference Learning (15mn),
Paolo Viappiani ***35 PDF***

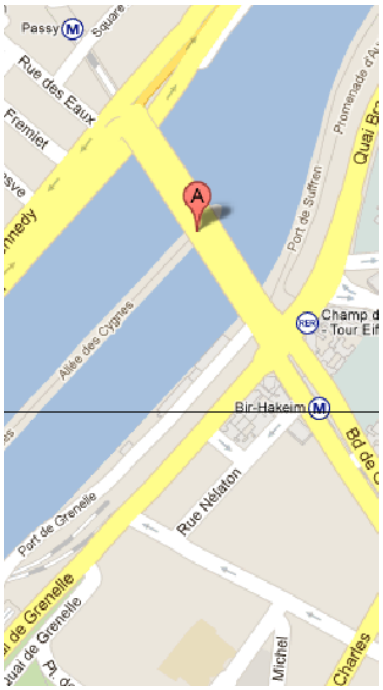
13:30-14:30 : *Closing and Lunch*

Social Event, Wednesday January 18., 20h

Boarding on boat **Capitaine Fracasse**
Allée des Cygnes, in the middle of Pont Bir-Hakeim
Metro line 6, station "Bir-Hakeim" or "Passy"
RER line C, station "Champ de Mars - Tour Eiffel"



Walking from conference venue (37mn)



Boarding place

Invited talks

Optimization problems and algorithms for the high-level control of dynamic systems
Gérard Verfaillie
ONERA, France

Abstract: The high-level control of dynamic systems, such as aircraft, airports, air traffic, or spacecraft, consists in deciding at each control step on which action(s) to be performed as a function of current observations and objectives. Successive decisions must entail that the dynamics of the controlled system satisfies user objectives as best as possible. To do so, a usual approach, inspired from the Model Predictive Approach in Automatic Control consists at each control step in (i) collecting current observations and objectives (ii) solving a deterministic planning problem over a given horizon ahead, (iii) extracting the first action from the best plan produced, (iv) applying it, and (v) considering the next step. From the optimization point of view, this implies to be able to solve quickly many successive similar planning problems over a sliding horizon, maybe not in an optimal way. I will try to present and illustrate this approach and to explain the potential impact of learning techniques.

Short bio: Graduated from école Polytechnique (Paris) in 1971 and from SUPAéRO (French national engineering school in aeronautics and space, Computer science specialization, Toulouse) in 1985, Gérard Verfaillie is now Research supervisor at ONERA (The French Aerospace Lab). His research activity is related to models, methods, and tools for combinatorial optimization and constrained optimization, especially for planning and decision-making.

Autonomous Search
Frédéric Saubion
Université d'Angers, France

Abstract: Decades of innovations in combinatorial problem solving have produced better and more complex algorithms. These new methods are better since they can solve larger problems and address new application domains. They are also more complex, which means that they are hard to reproduce and often harder to fine tune to the peculiarities of a given problem. This last point has created a paradox where efficient tools became out of reach for practitioners. Autonomous search represents a new research field defined to precisely address the above challenge. Its major strength and originality consist in the fact that problem solvers can now perform self-improvement operations based on analysis of the performances of the solving process – including short-term reactive reconfiguration and long-term improvement through self-analysis of the performance, offline tuning and online control, and adaptive control and supervised control. Autonomous search "crosses the chasm" and provides engineers and practitioners with systems that are able to autonomously self-tune their performance while effectively solving problems. In this talk, we review existing works and we attempt to classify the different paradigms that have been proposed during past years to build more autonomous solvers. We also draw some perspectives and futures directions.
Short bio: Frédéric Saubion coheads the Metaheuristics, Optimization and Applications team at the Université d'Angers (France); his research topics include hybrid and adaptive evolutionary algorithms and applications of metaheuristics to various domains such as information retrieval, nonmonotonic reasoning and biology. `www.info.univ-angers.fr/pub/saubion`

Surrogate-Assisted Evolutionary Optimisation: Past, Present and Future

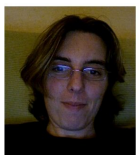
Yaochu Jin
Nature-Inspired Computing and Engineering Group, Department of Computing,
University of Surrey, UK

Abstract: Surrogate-assisted (or meta-model based) evolutionary computation uses efficient computational models, often known as surrogates or meta-models, for approximating the fitness function in evolutionary algorithms. Research on surrogate-assisted evolutionary computation began over a decade ago and has received considerably increasing interest in recent years. Very interestingly, surrogate-assisted evolutionary computation has found successful applications not only in solving computationally expensive single- or multi-objective optimization problems, but also in addressing dynamic optimization problems, constrained optimization problems and multi-modal optimization problems. This talk provides an up-to-date overview of the history and recent developments in surrogate-assisted evolutionary computation and suggests a few future trends in this research area.

Short bio: Yaochu Jin received the B.Sc., M.Sc., and Ph.D. degrees from Zhejiang University, China, in 1988, 1991, and 1996, respectively, and the Dr.-Ing. Degree from Ruhr University Bochum, Germany, in 2001. He is a Professor of Computational Intelligence and Head of the Nature Inspired Computing and Engineering (NICE) Group, Department of Computing, University of Surrey, UK. He was a Principal Scientist with the Honda Research Institute Europe in Germany. His research interests include understanding evolution, learning and development in biology and bio-inspired approaches to solving engineering problems. He (co)authored over 130 peer-reviewed journal and conference papers. He is an Associate Editor of BioSystems, IEEE Transactions on Neural Networks, IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on Nanobioscience, and IEEE Computational Intelligence Magazine. He has delivered over ten Plenary/Keynote speeches at international conferences on multi-objective machine learning, computational modeling of neural development, morphogenetic robotics and evolutionary design optimization. He is the General Chair of the 2012 IEEE Symposium on Computational Intelligence in Bioinformatics and Computational Biology. He presently chairs the Intelligent System Applications Technical Committee of the IEEE Computational Intelligence Society. Professor Jin is a Fellow of BCS and Senior Member of IEEE.

Tutorial talks

Addressing Numerical Black-Box Optimization: CMA-ES



Anne Auger and Nikolaus Hansen
INRIA Saclay Île-de-France

Abstract: Evolution Strategies (ESs) and many continuous domain Estimation of Distribution Algorithms (EDAs) are stochastic optimization procedures that sample a multivariate normal (Gaussian) distribution in the continuous search space, $\mathbb{R}^n$. Many of them can be formulated in a unified and comparatively simple framework. This introductory tutorial focuses on the most relevant algorithmic question: how should the parameters of the sample distribution be chosen and, in particular, updated in the generation sequence? First, two common approaches for step-size control are reviewed, one-fifth success rule and path length control. Then, Covariance Matrix Adaptation (CMA) is discussed in depth: rank-one update, the evolution path, rank-mu update. Invariance properties and the interpretation as natural gradient descent are touched upon. In the beginning, general difficulties in solving non-linear, non-convex optimization problems in continuous domain are revealed, for example non-separability, ill-conditioning and ruggedness. Algorithmic design aspects are related to these difficulties. In the end, the performance of the CMA-ES is related to other well-known evolutionary and non-evolutionary optimization algorithms, namely BFGS, DE, PSO,...

Short bios: Anne Auger is a permanent researcher at the French National Institute for Research in Computer Science and Control (INRIA). She received her diploma (2001) and PhD (2004) in mathematics from the Paris VI University. Before to join INRIA, she worked for two years (2004-2006) at ETH in Zurich. Her main research interest is stochastic continuous optimization including theoretical aspects and algorithm designs. She is a member of ACM-SIGECO executive committee and of the editorial board of Evolutionary Computation. She has been organizing the biannual Dagstuhl seminar "Theory of Evolutionary Algorithms" in 2008 and 2010. Nikolaus Hansen is researcher at The French National Institute for Research in Computer Science and Control (INRIA). He received a Ph.D. in civil engineering in 1998 from the Technical University Berlin under Ingo Rechenberg. Before joining INRIA, he has been working in applied artificial intelligence and in genomics, and he has been researching in evolutionary computation and computational science at the Technical University Berlin and the ETH Zurich. His main research interests are learning and adaptation in evolutionary computation and the development of algorithms applicable in practice. He has been a main driving force behind the development of CMA-ES over many years.

Intelligent Optimization with Submodular Functions

Andreas Krause
ETH Zurich, Switzerland

Abstract: In recent years, submodularity, a discrete analogue of convexity, has emerged as very useful in a variety of machine learning problems. Similar to convexity, submodularity allows to efficiently find provably (near-) optimal solutions. In this tutorial, I will introduce the notion of submodularity, discuss examples and properties of submodular functions, and review algorithms for submodular optimization. I will also cover recent extensions to the online (no-regret) and adaptive (closed-loop) setting. A particular focus will be on relevant applications such as active learning and optimized information gathering, ranking and algorithm portfolio optimization.
Short bio: Andreas Krause received his Diplom in Computer Science and Mathematics from the Technical University of Munich, Germany (2004) and his Ph.D. in Computer Science from Carnegie Mellon University (2008). He joined the California Institute of Technology as an assistant professor of computer science in 2009, and is currently assistant professor in the Department of Computer Science at the Swiss Federal Institute of Technology Zurich. His research is in adaptive systems that actively acquire information, reason and make decisions in large, distributed and uncertain domains, such as sensor networks and the Web. Dr. Krause is a 2010 Kavli Frontiers Fellow, and received an NSF CAREER award, the Okawa Foundation Research Grant recognizing top young researchers in telecommunications, as well as awards at several premier conferences (AAAI, KDD, IPSN, ICML, UAI) and the ASCE Journal of Water Resources Planning and Management.

Symmetry in Mathematical Programming

Leo Liberti
Ecole Polytechnique, Palaiseau, France

Abstract: This tutorial will introduce some basic concepts about group theory and how it applies to mathematical programming. We shall give an overview of the main existing research streams on this subjects, and then discuss the latest developments. We shall show how to put together existing computational tools (GAP, AMPL, CPLEX, Couenne, Rose, kept together using shell scripts) in order to automatically detect and exploit symmetry in a given mathematical programming instance.
Short bio: Leo Liberti received his PhD in 2004 from Imperial College, London. He then obtained a postdoctoral fellowship at Politecnico di Milano, and has been at LIX, Ecole Polytechnique ever since 2006, where he is an associate professor. He co-founded (and currently heads) the System Modelling and Optimization (SYSMO) team, he is co-director of the Optimization and Sustainable Development (OSD) Microsoft-CNRS sponsored chair, and is vice-president of the Computer Science department. He is Editor-in-Chief of 4OR, and holds associate editorships with several international journals (DAM, JOGO, ITOR, EURJCO, CMS). He has published more than 100 papers on mathematical programming and optimization techniques and applications.

List of Abstracts

A Non-Adaptive Stochastic Local Search Algorithm for the CHeSC 2011 Competition

Franco Mascia, Thomas Stützle

Session *CHESC*

In this work,we present our submission for the Cross-domain Heuristic Search Challenge 2011. We implemented a randomised but non-adaptive stochastic local search algorithm consisting of several algorithm schemata that have been offline-tuned on four sample problem domains. Our algorithm ranked seventh in the competition results. In this paper, we present the results obtained after a more careful tuning, and a different combination of algorithm schemata included in the final algorithm design. This improved version would rank fourth in the competition.

Link to the PDF file

A Vehicle Routing Domain for the HyFlex Hyper-heuristics Framework

James Walker, Gabriela Ochoa, Michel Gendreau, Edmund Burke

Session *CHESC*

HyFlex (Hyper-heuristics Flexible framework) is a software framework allowing development of domain independent search heuristics (hyper-heuristics), and testing across multiple problem domains. This framework was used as a base for the first 'Cross-domain Heuristic Search Challenge', a research competition that attracted significant international attention. In this paper, we present one of the problems that was used as a hidden domain in the competition, namely, the capacitated vehicle routing problem with time windows. The domain implements a data structure and objective function for the vehicle routing problem, as well as many state-of- the-art low-level heuristics (search operators) of several types. The domain is tested using two adaptive variants of a multiple-neighborhood iterated local search algorithm that operate in a domain independent fashion, and therefore can be considered as hyper-heuristics. Our results confirm that adding adaptation mechanisms improve the performance of hyper-heuristics. It is our hope that this new and interesting problem domain can be used to promote research within hyper-heuristics, adaptive operator selection, adaptive multi-meme algorithms, and autonomous control for search algorithms.

Link to the PDF file

Hyper-Heuristic Based on Iterated Local Search Driven by Evolutionary Algorithm

Jiri Kubalik

Session *CHESC*

This paper proposes an evolutionary-based iterative local search hyper-heuristic approach called Iterated Search Driven by Evolutionary Algorithm Hyper-Heuristic (ISEA). Two versions of this algorithm, ISEA-chesc and ISEA-adaptive, that differ in the re-initialization scheme are presented. A performance of the two algorithms was experimentally evaluated on six hard optimization problems using the HyFlex experimental framework and the algorithms were compared with algorithms that took part in the CHeSC 2011 challenge. Achieved results are very promising, the ISEA-adaptive placed second among all competition algorithms. It also shows how important for good performance of this iterated local search hyper-heuristic is the re-initialization strategy.

Link to the PDF file

A new Hyperheuristic Algorithm for Cross Domain Search Problems

Andreas Lehrbaum, Nysret Musliu

Session *CHESC*

This paper describes a new hyperheuristic algorithm that performs well over a variety of different problem classes. A novel method for switching between working on a single solution and a pool of solutions is proposed. This method is combined with an adaptive strategy that guides the selection of the underlying low-level heuristics throughout the search. The algorithm was implemented based on the HyFlex framework and was submitted as a candidate for the Cross-Domain Heuristic Search Challenge 2011.

Link to the PDF file

A Hyper-heuristic Inspired by Pearl Hunting

C.Y. Chan, Fan Xue, W.H. Ip, C.F. Cheung

Session *CHESC*

Pearl Hunter is an inspired hyper-heuristic. Pearl Hunter employs "snorkeling" actions to propose promising solutions for the "scuba dive." An off-line learning process finds the best portfolio of low-level heuristics, and the environment of "diving" is determined from reactions of local search. The algorithm was tested on the HyFlex framework. Three new best-known solutions for personnel scheduling problems have been found.

Link to the PDF file

Five Phase and Genetic Hive Hyper-heuristics for the Cross-Domain Search

Tomasz Cichowicz, Maciej Drozdowski, Michal Frankiewicz, Grzegorz Pawlak, Filip Rytwinski, Jacek Wasilewski

Session *CHESC*

In this paper we present two hyper-heuristics: Five Phase approach (5Ph) and Genetic Hive (GH), developed for the Cross-Domain Heuristic Search Challenge held in 2011. Development paths of the algorithms and testing methods imposed by the competition rules are outlined. Performance of both methods is studied. Useful and interesting experience in construction of the hyper-heuristics are presented. Conclusions and recommendations for the future advancement of hyper-heuristic methodologies are discussed.

Link to the PDF file

An Intelligent Hyper-heuristic Framework for CHeSC 2011

Mustafa Misir, Katja Verbeeck, Patrick De Causmaecker, Greet Vanden Berghe

Session *CHESC*

The present study proposes a new selection hyper-heuristic providing several adaptive features to cope with the requirements of managing different heuristic sets. The approach suggested provides an intelligent way of selecting heuristics, determines effective heuristic pairs and adapts the parameters of certain heuristics online. In addition, an adaptive list-based threshold accepting mechanism has been developed. It enables deciding whether to accept or not the solutions generated by the selected heuristics. The resulting approach won the first Cross Domain Heuristic Search Challenge against 19 high-level algorithms. The detailed empirical results concerning the behaviour of the hyper-heuristic and its sub-mechanisms will be presented at the conference.

Link to the PDF file

Evaluation of a family of reinforcement learning cross-domain optimization heuristics

Luca Di Gaspero, Tommaso Urli

Session *CHESC*

In our participation to the Cross-Domain Heuristic Search Challenge we developed an approach based on Reinforcement Learning for the automatic selection of problem-specific low-level heuristics across different problem domains. Since the amount of information available to the algorithms according to the competition rules is rather limited, we tested different memory models and learning criteria to improve the results of the learning procedure. In this paper we report our design choices and a comparison of the different family of algorithms we developed.

Link to the PDF file

Lower Bounds and Upper Bounds for MaxSAT

Federico Heras, Antonio Morgado, Joao Marques-Silva

Session *MAXSAT*

This paper presents several ways to compute lower bounds and upper bounds for MaxSAT based on calling a SAT solver. Preliminary results indicate that (i) the bounds obtained are of high quality, (ii) the use of a SAT solver can enhance the performance of SLS in structured instances and (iii) the bounds may boost the search of MaxSAT solvers on some benchmarks.

Link to the PDF file

Natural Max-SAT encoding of Min-SAT

Adrian Kügel

Session *MAXSAT*

We show that there exists a natural encoding which transforms Min-SAT instances into Max-SAT instances. Unlike previous encodings, this natural encoding keeps the same variables, and the optimal assignment for the Min-SAT instance is identical to the optimal assignment of the corresponding Max-SAT instance. In addition to that the encoding can be generalized to the Min-SAT variants with clause weights and hard clauses. We conducted experiments which give evidence that our encoding is practically relevant, as Min-2-SAT instances can be solved much faster by transforming them to Max-SAT and using a Max-SAT solver than by using the best Min-SAT solver directly.

Link to the PDF file

Counter Implication Restart for Parallel SAT Solvers

Tomohiro Sonobe, Mary Inaba

Session *MAXSAT*

A portfolio approach has become the mainstream for parallel SAT solvers, making diversification of the search for each process more important. In the SAT Competition 2011, we proposed a novel restart method called counter implication restart (CIR), for sequential solvers and won gold and silver medals with CIR. CIR enables SAT solvers to change the search spaces drastically after a restart. In this paper, we propose an adaptation of CIR to parallel SAT solvers to provide better diversification. Experimental results indicate that CIR provides good diversification and its overall performance is very competitive with state-of-the-art parallel solvers.

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Clause Sharing in Parallel MaxSAT

Ruben Martins, Vasco Manquinho, Inês Lynce

Session *MAXSAT*

In parallel MaxSAT solving, sharing learned clauses is expected to help to further prune the search space and boost the performance of a parallel solver. However, not all learned clauses should be shared since it could lead to an exponential blow up in memory and to sharing many irrelevant clauses. The main question is which learned clauses should be shared among the different threads. This paper reviews the existing heuristics for sharing learned clauses, namely, static and dynamic heuristics. Moreover, a new heuristic for clause sharing is presented based on freezing shared clauses. Shared clauses are only incorporated into the solver when they are expected to be useful in the near future. Experimental results show the importance of clause sharing and that the freezing heuristic outperforms other clause sharing heuristics.

Link to the PDF file

Iterative-Deepening Search with On-line Tree Size Prediction

Ethan Burns, Wheeler Ruml

Session *Tree Search*

The memory requirements of best-first graph search algorithms such as A* often prevent them from solving large problems. The best-known approach for coping with this issue is iterative deepening, which performs a series of bounded depth-first searches. Unfortunately, iterative deepening only performs well when successive cost bounds visit a geometrically increasing number of nodes. While it happens to work acceptably for the classic sliding tile puzzle, IDA* fails for many other domains. In this paper, we present an algorithm that adaptively chooses appropriate cost bounds on-line during search. During each iteration, it learns a model of the search tree that helps it to predict the bound to use next. Our search tree model has three main benefits over previous approaches: 1) it will work in domains with real-valued heuristic estimates, 2) it can be trained on-line, and 3) it is able to make predictions with only a small number of training examples. We demonstrate the power of our improved model by using it to control an iterative-deepening A* search on-line. While our technique has more overhead than previous methods for controlling iterative-deepening A*, it can give more robust performance by using its experience to accurately double the amount of search effort between iterations.

Link to the PDF file

Evaluating Tree-Decomposition Based Algorithms for Answer Set Programming

Michael Morak, Nysret Musliu, Reinhard Pichler, Stefan Rümmele, Stefan Woltran

Session *Tree Search*

A promising approach to tackle intractable problems is given by a combination of decomposition methods with dynamic algorithms. One such decomposition concept is tree decomposition. However, several heuristics for obtaining a tree decomposition exist and, moreover, also the subsequent dynamic algorithm can be laid out differently. In this paper, we provide an experimental evaluation of this combined approach when applied to reasoning problems in propositional answer set programming. More specifically, we analyze the performance of three different heuristics and two different dynamic algorithms, an existing standard version and a recently proposed algorithm based on a more involved data structure, but which provides better theoretical runtime. The results suggest that a suitable combination of the tree decomposition heuristics and the dynamic algorithm has to be chosen carefully. In particular, we observed that the performance of the dynamic algorithm highly depends on certain features (besides treewidth) of the provided tree decomposition. Based on this observation we apply supervised machine learning techniques to automatically select the dynamic algorithm depending on the features of the input tree decomposition.

Link to the PDF file

Improving exploration in Upper Confidence Trees

Adrien Couetoux, Olivier Teytaud, Hassen Doghmen

Session *Tree Search*

In the standard version of the UCT algorithm, in the case of a continuous set of decisions, the exploration of new decisions is done through blind search. This can lead to very inefficient exploration, par- ticularly in the case of large dimension problems, which often happens in energy management problems, for instance. In an attempt to use the information gathered through past simulations to better explore new de- cisions, we propose a method named Blind Value (BV). It only requires the access to a function that randomly draws feasible decisions. We also implement it and compare it to the original version of continuous UCT. Our results show that it gives a significant increase in convergence speed, in dimensions 12 and 80.

Link to the PDF file

Application of the Nested Rollout Policy Adaptation Algorithm to the Traveling Salesman Problem with Time Windows

Tristan Cazenave, Fabien Teytaud

Session *Tree Search cont'd*

In this paper, we are interested in the minimization of the travel cost of the traveling salesman problem with time windows. In order to do this minimization we use a Nested Rollout Policy Adaptation (NRPA) algorithm. NRPA has multiple levels and maintains the best tour at each level. It consists in learning a rollout policy at each level. We also show how to improve the original algorithm with a modified rollout policy that helps NRPA to avoid time windows violations.

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A Tree Search Approach to Sparse Coding

Rui Rei, João P. Pedroso, Hideitsu Hino, Noboru Murata

Session *Tree Search cont'd*

Sparse coding is an important optimization problem with numerous applications. In this paper, we describe the problem and commonly used pursuit methods, and propose a best-first tree search algorithm employing multiple queues for unexplored tree nodes. We assess the effectiveness of our method in an extensive computational experiment, proving its superiority over the considered methods even for modest computational time.

Link to the PDF file

Minimizing Time when Applying Bootstrap to Contingency Tables Analysis of Genome-Wide Data

Francesco Sambo, Barbara Di Camillo

Session *Biological applications (BIO)*

Bootstrap resampling is starting to be frequently applied to contingency tables analysis of Genome-Wide SNP data, to cope with the bias in genetic effect estimates, the large number of false positive associations and the instability of the lists of SNPs associated with a disease. The bootstrap procedure, however, increases the computational complexity by a factor B, where B is the number of bootstrap samples.

In this paper, we study the problem of minimizing time when applying bootstrap to contingency tables analysis and propose two levels of optimization of the procedure. The first level of optimization is based on an alternative representation of bootstrap replicates, bootstrap histograms, which is exploited to avoid unnecessary computations for repeated subjects in each bootstrap replicate. The second level of optimization is based on an ad-hoc data structure, the bootstrap tree, exploited for reusing computations on sets of subjects which are in common across more than one bootstrap replicate. The problem of finding the best bootstrap tree given a set of bootstrap replicates is tackled with best improvement local search. Different constructive procedures and local search operators are proposed to solve it.

The two proposed levels of optimization are tested on a real Genome-Wide SNP dataset and both are proven to significantly decrease computation time.

Link to the PDF file

Community Detection in Social and Biological Networks using Differential Evolution

Guanbo Jia, Zixing Cai, Mirco Musolesi, Yong Wang, Dan Tennant, Ralf Weber, John Heath, Shan He

Session *Biological applications (BIO)*

The community detection in complex networks is an important problem in many scientific fields, from biology to sociology. This paper proposes a new algorithm, Differential Evolution based Community Detection (DECD), which employs a novel optimization algorithm, differential evolution (DE) for detecting communities in complex networks. DE uses network modularity as the fitness function to search for an optimal partition of a network. Based on the standard DE crossover operator, we design a modified binomial crossover to effectively transmit some important information about the community structure in evolution. Moreover, a biased initialization process and a clean-up operation are employed in DECD to improve the quality of individuals in the population. One of the distinct merits of DECD is that, unlike many other community detection algorithms, DECD does not require any prior knowledge about the community structure, which is particularly useful for its application to real-world complex networks where prior knowledge is usually not available. We evaluate DECD on several artificial and real-world social and biological networks. Experimental results show that DECD has very competitive performance compared with other state-of-the-art community detection algorithms.

Link to the PDF file

Brain cine-MRI Sequences Registration using B-spline Free-Form Deformations and MLSDO Dynamic Optimization Algorithm

Julien Lepagnot, Amir Nakib, Hamouche Oulhadj, Patrick Siarry

Session *Biological applications (BIO)*

In this paper, a dynamic optimization algorithm is used to assess the deformations of the wall of the third cerebral ventricle in the case of a brain cine-MR imaging. In this method, a nonrigid registration process is applied to a 2D+t cine-MRI sequence of a region of interest. In this paper, we propose to use a B-spline Free-Form deformation model. The registration process consists of optimizing an objective function that can be considered as a dynamic function. Thus, a dynamic optimization algorithm, called MLSDO, is used to accomplish this task. The obtained results are compared to those of several well-known static optimization algorithms. This comparison shows the relevance of using a dynamic optimization algorithm to solve this kind of problems, and the efficiency of MLSDO.

Link to the PDF file

Automatically Configuring Algorithms for Scaling Performance

James Styles, Holger Hoos, Martin Mueller

Session *Automatic Parameter Tuning*

Automated algorithm configurators have been shown to be very effective for finding good configurations of high performance algorithms for a broad range of computationally hard problems. As we show in this work, the standard protocol for using these configurators is not always effective. We propose a simple and computationally inexpensive modification to this protocol and apply it to state-of-the-art solver for two prominent problems, TSP and computer Go playing, where the standard protocol is unable or unlikely to yield performance improvements, and one problem, mixed integer programming, where the standard protocol is known to be effective. We show that our new protocol is able to find configurations between 5% and 75% better than the standard protocol within the same time budget.

Link to the PDF file

Parallel Algorithm Configuration

Frank Hutter, Holger Hoos, Kevin Leyton-Brown

Session *Automatic Parameter Tuning*

State-of-the-art algorithms for solving hard computational problems often expose many parameters whose settings critically affect empirical performance. Manually exploring the resulting combinatorial space of parameter settings is often tedious and unsatisfactory. Automated approaches for finding good parameter settings are becoming increasingly prominent and have recently lead to substantial improvements in the state of the art for a variety of computationally challenging problems. Automated algorithm configuration is typically very costly, involving many thousands of invocations of the algorithm to be configured. Here, we study the extent to which parallel computing can come to the rescue. We compare straightforward parallelization by multiple independent runs with a more sophisticated method of parallelizing the model-based configuration procedure SMAC. Empirical results for configuring the MIP solver CPLEX demonstrate that near-optimal speedups can be obtained with up to 16 parallel workers, and that 64 workers can still accomplish challenging configuration tasks that previously took 2 days in 1-2 hours. Overall, we show that our methods make effective use of large-scale parallel resources and thus substantially expand the practical applicability of algorithm configuration.

Link to the PDF file

Quantifying Homogeneity of Instance Sets for Algorithm Configuration

Marius Schneider, Holger H. Hoos

Session *Automatic Parameter Tuning*

Automated configuration procedures play an increasingly prominent role in realising the performance potential inherent in highly parametric solvers for a wide range of computationally challening problems. However, these configuration procedures have difficulties when dealing with inhomogenous instance sets, where the relative difficulty of problem instances varies between configurations of the given parametric algorithm. In the literature, instance set homogeneity has been assessed using qualitative, visual criterion based on heat maps. Here, we introduce two quantitative measures of homogeneity and empirically demonstrate these to be consistent with the earlier qualitative criterion. We also show that according to our measures, homogeneity increases when partitioning instance set by means of clustering based on observed runtimes and that the performance of a prominent automatic algorithm configurator increases on the resulting, more homogenous subsets.

Link to the PDF file

Determining the Characteristic of Difficult Job Shop Scheduling Instances for a Heuristic Solution Method

Helga Ingimundardottir, Thomas Philip Runarsson

Session *Automatic Parameter Tuning*

Many heuristic methods have been proposed for the job-shop scheduling problem. Different solution methodologies outperform other depending on the particular problem instance under consideration. Therefore, one is interested in knowing how the instances differ in structure and determine when a particular heuristic solution is likely to fail and explore in further detail the causes. In order to achieve this, we seek to characterise features for different difficulties. Preliminary experiments show there are different significant features that distinguish between easy and hard JSSP problem, and that they vary throughout the scheduling process. The insight attained by investigating the relationship between problem structure and heuristic performance can undoubtedly lead to better heuristic design that is tailored to the data distribution under consideration.

Link to the PDF file

Learning Algorithm Portfolios for Parallel Execution

Xi Yun, Susan Epstein

Session *Parallelism*

Portfolio-based solvers are both effective and robust, but their promise for parallel execution with constraint satisfaction solvers has received relatively little attention. This paper proposes an approach that constructs algorithm portfolios intended for parallel execution based on a combination of case-based reasoning, a greedy algorithm, and three heuristics. Empirical results show that this method is efficient, and can significantly improve performance with only a few additional processors. On problems from solver competitions, the resultant algorithm portfolios perform nearly as well as an oracle.

Link to the PDF file

Toward Autonomous Search with Island Models

Adrien Goëffon, Frédéric Lardeux

Session *Parallelism*

In this paper we propose an original approach in designing autonomous algorithms. We define a dynamic island model which aims to dynamically select local search operators within a classical evolutionary algorithm. Each local search operator is assigned to an island, in a fully connected topology. Selection of operators is simulated by migration steps, whose policies depend on a learning process. The efficiency of this approach is assessed in comparing, for the One-Max Problem, theoretical and ideal results to those obtained by the dynamic island model. Experiments show that the model has the expected behavior.

Link to the PDF file

Influence of the Migration Period in Parallel Distributed GAs for Dynamic Optimization

Yesnier Bravo, Gabriel Luque, Enrique Alba

Session *Parallelism*

Many real-world optimization problems present a dynamic behavior that challenges the performance of the standard Genetic Algorithm (GA) due to its panmictic population strategy. Several approaches have been proposed to tackle this limitation. However, one of the barely studied domains has been the parallel distributed GA (dGA), characterized by decentralizing the population in islands communicating through migrations of individuals. In this article, we analyze the influence of themigration period in the behavior of the dGA for dynamic environments. Results show how to adjust this parameter for addressing different change severities in a comprehensive set of dynamic test-bed functions.

Link to the PDF file

Expected improvements for the asynchronous parallel global optimization of expensive functions : potentials and challenges

Janis Janusevskis, Rodolphe Le Riche, David Ginsbourger

Session *Parallelism*

Sequential sampling strategies based on Gaussian processes are now widely used for the optimization of problems involving costly simulations. But Gaussian processes can also generate parallel optimization strategies. The current article presents a new, parameter free, asynchronous parallel expected improvement criterion for optimization. An estimation of the criterion, which mixes Monte Carlo sampling and analytical bounds, is proposed. Linear speed-ups are measured on uni-dimensional functions.

Link to the PDF file

Parallel GPU Implementation of Iterated Local Search for the Travelling Salesman Problem

Audrey Delévacq, Pierre Delisle, Michaël Krajecki

Session *Parallelism*

The purpose of this paper is to propose effective parallelization strategies for the Iterated Local Search (ILS) metaheuristic on Graphics Processing Units (GPU). We consider the decomposition of the 3-opt local search procedure and the associated data structures on the GPU processing hardware and memory structure. Two resulting algorithms are extensively evaluated and compared on both speedup and solution quality on a state-of-the-art Fermi GPU architecture. Solving instances of the Travelling Salesman Problem ranging from 100 to 3038 cities, we report speedups of up to 6.02 with solution quality similar to the original sequential implementation. The proposed experimental study highlights the combined influence of metaheuristic parameters, GPU technical configuration, memory structures and parallelization granularity on the obtained level of performance.

Link to the PDF file

Quasi-Elementary Landscapes and Superpositions of Elementary Landscapes

Darrell Whitley, Francisco Chicano

Session *Other approaches*

There exists local search landscapes where the evaluation function is an eigenfunction of the graph Laplacian that corresponds to the neighborhood structure of the search space. Problems that display this structure are called “Elementary Landscapes" and they have a number of special mathematical properties. The term “Quasi-elementary landscapes" is introduced to describe landscapes that are “almost" elementary; in quasi-elementary landscapes there exists some efficiently computed “correction" that captures those parts of the neighborhood structure that deviate from the normal structure found in elementary landscapes. The “shift" operator, as well as the “3-opt" operator for the Traveling Salesman Problem landscapes induce quasi-elementary landscapes. A local search neighborhood for Max-Clique is also quasi-elementary. Finally, we show that landscapes which are a superposition of 2 elementary landscapes are also quasi-elementary in structure.

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Optimization by l1-constraining a Markov Fitness Modelling

Gabriele Valentini, Luigi Malagò, Matteo Matteucci

Session *Other approaches*

When the function to be optimized is characterized by a limited and unknown number of interactions among variables, a context that applies to many real world scenario, it is possible to design optimization algorithms based on such information. Estimation of Distribution Algorithms learn a set of interactions from a sample of points and encode them in a probabilistic model. The latter is then used to sample new instances. In this paper, we propose a novel approach to estimate the Markov Fitness Model used in DEUM. We combine model selection and model fitting by solving an ℓ_1-constrained linear regression problem. Since candidate interactions grow exponentially in the size of the problem, we first reduce this set with a preliminary coarse selection criteria based on Mutual Information. Then, we employ ℓ_1-regularization to further enforce sparsity in the model, estimating its parameters at the same time. Our proposal is analysed against the 3D Ising Spin Glass function, a problem known to be NP-hard, and it outperforms other popular black-box meta-heuristics.

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A Study on Large Population MOEA Using Adaptive Epsilon-Box Dominance and Neighborhood Recombination for Many-objective Optimization

Naoya Kowatari, Akira Oyama, Hernan Aguirre, Kiyoshi Tanaka

Session *Multi-Objective Optimization*

Multi-objective evolutionary algorithms are increasingly being investigated to solve many-objective optimization problems. However, most algorithms recently proposed for many-objective optimization cannot find Pareto optimal solutions with good properties on convergence, spread, and distribution. Often, the algorithms favor one property at the expense of the other. In addition, in some applications it takes a very long time to evaluate solutions, which prohibits running the algorithm for a large number of generations. In this work to obtain good representations of the Pareto optimal set we investigate a large population MOEA, which employs adaptive epsilon-box dominance for selection and neighborhood recombination for variation, using a very short number of generations to evolve the population. We study the performance of the algorithm on some functions of the DTLZ family, showing the importance of using a larger populations to search on many-objective problems and the effectiveness of employing adaptive epsilon-box dominance and neighborhood recombination that take into account the characteristics of many-objective landscapes.

Link to the PDF file

Bounding the Effectiveness of Hypervolume-based (mu+lambda)-Archiving Algorithms

Tamara Ulrich, Lothar Thiele

Session *Multi-Objective Optimization*

In this paper, we study bounds for the α-approximate effectiveness of non-decreasing $(\mu+\lambda)$-archiving algorithms that optimize the hypervolume. A $(\mu+\lambda)$-archiving algorithm defines how μ individuals are to be selected from a population of μ parents and λ offspring. It is non-decreasing if the μ new individuals never have a lower hypervolume than the μ original parents. An algorithm is α-approximate if for any optimization problem and for any initial population, there exists a sequence of offspring populations for which the algorithm achieves a hypervolume of at least $1/\alpha$ times the maximum hypervolume.

Bringmann and Friedrich (GECCO 2011, pp. 745–752) have proven that all non-decreasing, locally optimal $(\mu+1)$-archiving algorithms are $(2+\epsilon)$-approximate for any $\epsilon > 0$. We extend this work and substantially improve the approximation factor by generalizing and tightening it for any choice of λ to $\alpha = 2-(\lambda-p)/\mu$ with $\mu = q\cdot\lambda - p$ and $0 \leq p \leq \lambda - 1$. In addition, we show that $1+\frac{1}{2\lambda}$ is a lower bound on α, i.e. there are optimization problems where one can not get closer than a factor of $1/\alpha$ to the optimal hypervolume.

Link to the PDF file

Adaptive Control of the Number of Crossed Genes in Many-Objective Evolutionary Optimization

Hiroyuki Sato, Carlos Coello, Hernan Aguirre, Kiyoshi Tanaka

Session *Multi-Objective Optimization*

When we solve many-objective optimization problems (MaOPs) by multi-objective evolutionary algorithms (MOEAs), genetic diversity of solutions in the population significantly increases to explore the true Pareto optimal solutions distributed in broad region of decision variable space. To realize effective genetic operation in MaOPs, crossover controlling the number of crossed genes (CCG) has been proposed. CCG controls the number of crossed genes by using an user-defined parameter alpha. CCG with small alpha significantly improves the search performance of MOEA in MaOPs by restricting the number of crossed genes small. However, to achieve high search performance by using CCG, we have to find out an appropriate parameter alpha by conducting many experiments. To improve the usability of CCG, in this work we propose an adaptive CCG which dynamically controls the parameter alpha during the solutions search in a single run of the algorithm. Through performance verification, we show that the values of alpha controlled by the adaptive CCG is converged to an appropriate value even when the adaptation is started from any initial values. Also we show the adaptive CCG achieves around 80

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An Approach to Instantly Use Single-objective Results for Multi-objective Evolutionary Combinatorial Optimization

Christian Grimme, Joachim Lepping

Session *Multi-Objective Optimization*

Standard dominance-based multi-objective evolutionary algorithms offer a general approach for solving problems that involve more than one objective. However, they only hardly allow to integrate problem knowledge without redesigning the approach as a whole. Thus, we present and evaluate a flexible alternative approach based on an abstraction from predator prey interplay: Each predator represents a different objective and they collectively hunt for prey solutions, which have to adapt to all threats to survive. Coupling special heuristics to predators allows to integrate expert knowledge, e.g., from single-objective problem solutions. For the parallel machine scheduling domain, we first show that the combination of problem knowledge principally leads to better trade-off approximations than produced by the standard class of algorithms, especially NSGA-2. Second, in a more detailed evaluation we show how the incremental integration of existing problem knowledge gradually improves the algorithm's performance.

Link to the PDF file

An Efficient Meta-heuristic based on Self-control Dominance Concept for a Bi-objective Re-entrant Scheduling Problem with Outsourcing

Atefeh Moghaddam, Farouk Yalaoui, Lionel Amodeo

Session *Multi-Objective Optimization*

We study a two-machine re-entrant flowshop scheduling problem in which the jobs have strict due dates. In order to be able to satisfy all customers and avoid any tardiness, scheduler decides which job shall be outsourced and find the best sequence for in-house jobs. Two objective functions are considered: minimizing total completion time for in-house jobs and minimizing outsource cost for others. Since the problem is NP-hard, an efficient genetic algorithm based on self-control dominance concept with adaptive generation size is proposed. Non-dominated solutions are compared with classical NSGA-II regarding different metrics. The results prove the efficiency of the proposed algorithm.

Link to the PDF file

Effect of SMS-EMOA Parameterizations on Hypervolume Decreases

Leonard Judt, Olaf Mersmann, Boris Naujoks

Session *Multi-Objective Optimization*

As shown in previous work, it is possible for the SMS-EMO algorithm to experience decreases in dominated hypervolume w.r.t. a global reference point. We now study the influence of the SMS-EMOA parameter settings on number and amount of the observed decreases de- rived from results of multiple runs. We show that the number of decreases drop and the number of increases rise with a higher population size. In addition, a positive correlation between mean increase and mean decrease can be observed. Our findings further indicate a substantial impact of the mutation operators on the number and amount of decreases.

Link to the PDF file

Effects of Speciation on Evolution of Neural Networks In Highly Dynamic Environments

Peter Krcah

Session *Evolutionary Algorithms*

Using genetic algorithms for solving dynamic optimization problems is an important area of current research. One approach to this problem is to use multiple populations evolving concurrently, each tracking a different optimum of the fitness function. In this work, we investigate effects of speciation in NeuroEvolution of Augmenting Topologies (NEAT), a well-known method for evolving neural network topologies, on problems with dynamic fitness function. NEAT uses speciation as a method of maintaining diversity in the population and protecting new, poorly-adapted solutions against competition. We show that NEAT outperforms non-speciated genetic algorithm (GA) not only on problems with static fitness function (as demonstrated by previous works), but also on dynamic problems, where the optimum of the fitness function moves gradually between generations. We also demonstrate that NEAT fails to achieve better performance on problems where the optimum moves rapidly. We propose a novel method called DynNEAT, which extends NEAT by changing the size of each species based on its historical performance. We demonstrate that DynNEAT outperforms both NEAT and non-speciated GA on problems with rapidly moving optimum, while it achieves performance similar to NEAT on problems with static or slowly moving optimum.

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Evolutionary Optimization for Algebraic Geometry: Design of Robust Runge–Kutta Methods

Ivan Martino, Giuseppe Nicosia

Session *Evolutionary Algorithms*

This research work presents a new evolutionary optimization algorithm, EVO-RUNGE-KUTTA in theoretical mathematics with important applications in scientific computing. We illustrate the application of EVO-RUNGE-KUTTA, a two-phase optimization algorithm using a multicriteria approach, to a problem of pure algebra, the study of the parameterization of an algebraic variety, an important open problem in algebra. The problem is really complicated, hence excluding some particular cases, to find a global solution for the problem of the parameterization of an algebraic variety is an open problem. Results show the design and optimization of particular algebraic varieties, the Runge-Kutta methods of order q. The mapping between algebraic geometry and evolutionary optimization is direct, and we expect that many open problems will be modelled as searches and design for methods having specific properties.

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Learning the Neighborhood with the Linkage Tree Genetic Algorithm

Dirk Thierens, Peter Bosman

Session *Evolutionary Algorithms*

Stochastic local search algorithms typically explore a predefined neighborhood of promising solutions. In this paper we discuss the use of learning the neighborhood during the search. Specifically, we discuss the Linkage Tree Genetic Algorithm (LTGA), a population-based, stochastic local search algorithm that learns the neighborhood by identifying the problem variables that have a high mutual information in a population of good solutions. The LTGA builds each generation a linkage tree using a hierarchical clustering algorithm. The distance measure for the clustering is an information theoretical measure, called the variation of information. Each node in the tree represents a specific cluster of problem variables that are supposed to be linked together. When generating new solutions, these linked variables specify the neighborhood where the LTGA searches for better solutions by sampling values for these problem variables from the current population. To demonstrate the use of learning the neighborhood in this way we experimentally compare iterated local search (ILS) with the LTGA on a hard discrete problem, the nearest-neighbor NK-landscape problem with maximal overlap. Results show that the LTGA is indeed significantly superior to the ILS, proving that learning the neighborhood during the search can lead to a considerable gain in search performance.

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Implicit Model Selection based on Variable Transformations in Estimation of Distribution

Emanuele Corsano, Davide Cucci, Luigi Malagò, Matteo Matteucci

Session *Evolutionary Algorithms*

In this paper we address the problem of model selection in Estimation of Distribution Algorithms from a novel perspective. The classic approach in the literature is based on the choice of a model selection algorithm from the machine learning literature, able to identify explicitly the interactions among the variables in the problem. Instead, we perform an implicit model selection by transforming the variables and choosing a low dimensional model in the space of the new variables. We show how the choice of a proper transformation corresponds to the identification of a good model for the selected sample able to capture the correlations in the selected sample, without explicitly evaluate them. We apply such paradigm in an Estimation of Distribution algorithm and we introduce a novel algorithm called I-FCA, which makes use of the independence model in the transformed space, yet being able to recover higher order interactions among the original variables. We evaluated the performance of the algorithm in solving well known benchmarks in a black-box context and compared with other popular EDAs. Preliminary results show the viability of this approach and its effectiveness in problems with higher-order interactions.

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High-Dimensional Model-Based Optimization Based on Noisy Evaluations of Computer Games

Mike Preuss, Tobias Wagner, David Ginsbourger

Session *Local Search, Simulated Annealing*

Most publications on surrogate models have focused either on the prediction quality or on the optimization performance. It is still unclear whether the prediction quality is indeed related to the suitability for optimization. Moreover, most of these studies only employ low-dimensional problems. There are no results for popular surrogate models, such as kriging, for high-dimensional ($n > 10$) noisy problems. In this paper, we analyze both aspects by comparing different surrogate models on the noisy 22-dimensional car setup optimization problem, based on both, prediction quality and optimization performance. In order not to favor specific properties of the model, we run two conceptually different modern optimization methods on the surrogate models, CMA-ES and BOBYQA. It appears that kriging and random forests are very good modeling techniques with respect to both, prediction quality and suitability for optimization algorithms.

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Local Search and the Traveling Salesman Problem: A Feature-Based Characterization of Problem Hardness

Olaf Mersmann, Bernd Bischl, Jakob Bossek, Heike Trautmann, Markus Wagner, Frank Neumann

Session *Local Search, Simulated Annealing*

With this paper we contribute to the understanding of the success of 2-opt based local search algorithms for solving the traveling salesman problem (TSP). Although 2-opt is widely used in practice, it is hard to understand its success from a theoretical perspective. We take a statistical approach and examine the features of TSP instances that make the problem either hard or easy to solve. As a measure of problem difficulty for 2-opt we use the approximation ratio that it achieves on a given instance. Our investigations point out important features that make TSP instances hard or easy to be approximated by 2-opt.

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Parameter-Optimized Simulated Annealing for Application Mapping on Networks-on-Chip

Bo Yang, Liang Guang, Tero Säntti, Juha Plosila

Session *Local Search, Simulated Annealing*

Application mapping is an important issue in designing systems based on many-core networks-on-chip (NoCs). Simulated Annealing (SA) has been often used for searching for the optimized solution of application mapping problem. The parameters applied in SA algorithm jointly control the annealing schedule and have great impact on the performance of SA algorithm. The optimized parameters should be selected in a systematic way for each particular mapping problem, instead of using an identical set of empirical parameters for all problems. In this work, we refine the general SA algorithm by introducing new parameters dedicated to the application mapping problem. We apply another optimization algorithm, simplex method, to generate optimized parameters for the SA algorithm. The experiment shows that with optimized parameters, we can get a 237 times speedup of the SA algorithm, compared to an existing work where the empirical values are used for setting parameters. For the set of benchmarks, the proposed parameter-optimized SA algorithm achieves the same communication energy consumption using less than 1

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Hybridizing Reactive Tabu Search with Simulated Annealing

Stefan Voß, Andreas Fink

Session *Local Search, Simulated Annealing*

Reactive Tabu Search aims at the automatic adaptation of the tabu list length. The idea is to increase the tabu list length when the tabu memory indicates that the search is revisiting formerly traversed solutions. Once too many repetitions are encountered, an escape meachanism constituting a random walk is an essential part of the method. We propose to replace this random walk by a controlled simulated annealing. Excellent results are presented for various combinatorial optimization problems.

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Constraint-Based Local Search for the Costas Array Problem

Daniel Diaz, Florian Richoux, Philippe Codognet, Yves Caniou, Salvador Abreu

Session *Local Search, Simulated Annealing*

The Costas Array Problem is a highly combinatorial problem linked to radar applications. We present in this paper its detailed modeling and solving by Adaptive Search, a constraint-based local search method. Experiments have been done on both sequential and parallel hardware up to several hundreds of cores. Performance evaluation of the sequential version shows results outperforming previous implementations, while the parallel version shows nearly linear speedups w.r.t. the sequential one, for instance 120 for 128 cores and 230 for 256 cores.

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A Comparison of Operator Utility Measures for On-line Operator Selection in Local Search

Nadarajen Veerapen, Jorge Maturana, Frédéric Saubion

Session *Local Search, Simulated Annealing*

This paper investigates the adaptive selection of operators in the context of Local Search. The performance of the operators in terms of solution quality and distance of the candidate solution from the search trajectory is considered. The utility of each operator is then computed from these two criteria. A number of utility measures based on the Pareto dominance relationship and the relative distances between the operators are proposed and evaluated on Quadratic Assignment Problem instances using an implied or static target balance between exploitation and exploration. A refined algorithm with an adaptive target balance is then examined.

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Bayesian optimization using sequential Monte Carlo

Romain Benassi, Julien Bect, Emmanuel Vazquez

Session *Local Search, Simulated Annealing*

We consider the problem of optimizing a real-valued continuous function f using a Bayesian approach, where the evaluations of f are chosen sequentially by combining prior information about f, which is described by a random process model, and past evaluation results. The main difficulty with this approach is to be able to compute the posterior distributions of quantities of interest which are used to choose evaluation points. In this article, we decide to use a Sequential Monte Carlo (SMC) approach.

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Pilot, Rollout and Monte Carlo Tree Search Methods for Combinatorial Optimization

Thomas Runarsson, Marc Schoenauer, Michèle Sebag

Session *Monte-Carlo Tree Search*

Greedy heuristics may be attuned by looking ahead for each possible choice, in an approach called the rollout or Pilot method. These methods may be seen as meta-heuristics that can enhance (any) heuristic solution, by repetitively modifying a master solution: similarly to what is done in game tree search, better choices are identified using lookahead, based on solutions obtained by repeatedly using a greedy heuristic. This paper first illustrates how the Pilot method improves upon some simple well known dispatch heuristics for the job-shop scheduling problem. The Pilot method is then shown to be a special case of the more recent Monte Carlo Tree Search (MCTS) methods: Unlike the Pilot method, MCTS methods use random completion of partial solutions to identify promising branches of the tree. The Pilot method and two simple versions of MCTS, respectively using the MAX-k-arm bandit algorithm and the ε-greedy exploration paradigms, are then compared within the same framework, consisting of 300 scheduling problems of varying sizes with fixed-budget of rollouts. Results demonstrate that MCTS reaches better or same results as the Pilot methods in this context.

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Combining Myopic Optimization and Tree Search: Application to MineSweeper

Olivier Teytaud, Michèle Sebag

Session *Monte-Carlo Tree Search*

Many reactive planning tasks are tackled by optimization combined with shrinking horizon: the problem is simplified to a non-reactive optimization problem, based on the available information at the current time step and an estimate of future behavior, and the simplified problem is updated at each time step thanks to new information. This is in particular suitable when fast off-the-shelf components are available for the simplified problem - optimality *stricto sensu* is not possible, but good results are obtained at a reasonnable computational cost for highly untractable problems. As machines get more powerful, it makes sense however to go beyond the inherent limitations of this approach. Yet, a brute-force solving of the complete problem is often impossible; we here propose a methodology for embedding a solver inside a consistent reactive planning solver.

Our methodology consists in embedding the solver in an Upper-Confidence-Tree algorithm, both in the nodes and as a Monte-Carl o simulator. We show the mathematical consistency of the approach, and then we apply it to a classical success of the myopic approach: the MineSweeper game.

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Monte Carlo Methods for Preference Learning

Paolo Viappiani

Session *Monte-Carlo Tree Search*

Utility elicitation is an important component of many applications, as decision support systems and recommender systems. Such systems query the users about their preferences and give recommendations based on the system's belief about the utility function.

Critical to these applications is the acquisition of prior distribution about the utility parameters, and the possibility of real time Bayesian inference. In this paper we consider Monte Carlo methods for these problems.

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A Learning Optimization Algorithm in Graph Theory

Gilles Caporossi, Pierre Hansen

Session *Combinatorial Optimisation*

Using a heuristic optimization module based upon the Variable Neighborhood Search (VNS), the system AutoGraphiX's main feature is to find extremal or near extremal graphs, i.e., graphs that minimize or maximize an invariant. From the so obtained graphs, conjectures are found either automatically or interactively. Most of the features of the system relies on the optimization that must be efficient but the variety of problems handled by the system makes the tuning of the optimizer difficult to achieve. We propose a learning algorithm that is trained during the optimization of the problem and provides better results than all the algorithms previously used for that purpose.

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A Math-heuristic Dantzig-Wolfe Algorithm for the Capacitated Lot Sizing Problem

Marco Caserta, Stefan Voß

Session *Combinatorial Optimisation*

The multi-item multi-period capacitated lot sizing problem with setups (CLST) is a well known optimization problem with wide applicability in real-world production planning problems. Based on a recently proposed Dantzig-Wolfe approach we present a novel math-heuristic algorithm for the CLST. The major contribution of this paper lies in the presentation of an algorithm that exploits exact techniques (Dantzig-Wolfe) in a metaheuristic fashion, in line with the novel trend of math-heuristic algorithms. To the best of the authors' knowledge, it is the first time that such technique is employed within a metaheuristic framework, with the aim of tackling challenging instances in short computational time.

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Fast permutation learning

Tony Wauters, Katja Verbeeck, Patrick De Causmaecker, Greet Vanden Berghe

Session *Combinatorial Optimisation*

Permutations occur in a great variety of optimization problems, such as routing, scheduling and assignment problems. The present paper introduces the use of learning automata for the online learning of good quality permutations. Several centralized and decentralized methods using individual and common rewards are presented. The performance, memory requirement and scalability of the presented methods is analyzed. Results on well known benchmark problems show interesting properties. It is also demonstrated how these techniques are successfully applied to multi-project scheduling problems.

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