ORPA-AFROS Inter-disciplinary Summer School

OASIS'2022, 4-7 July 2022

https://bbb.univ-avignon.fr/b/ser-xgs-ol9-ric

OASIS Concept

OASIS schools are proposed by the African Federation of Operations Research (OR) Societies (AFROS : afrosocieties.org) and the Operational Practice in Africa Group (ORPA : orpa-group.org). Motivated by the fact that OR is by essence multidisciplinary, we propose a series of plenary talks, given by leading academics or industrials, on interdisciplinary research directions using operations research methods. OASIS schools aim to overview problems, concepts, solution methodologies, research directions integrating OR with other disciplines. They are tailored both for beginners of a subject, and for experienced researchers interested in introductive presentations not directly in the scope of their research.

2022 Topic
Operations Research (OR) and Artificial Intelligence (AI)

The 2022 school will expose methodologies at the boundary of OR and AI. It will focus on modern integrative approaches historically treated separately despite of many common points. The presentations may belong to the following research classes :

1. Search Methodologies : Search methodologies are a set of techniques designed to find optimal, or near-optimal, solutions to optimization problems. The school will review modern approaches using OR and AI techniques.
2. Optimization and Machine Learning : Learning a model consists, in many cases, of solving an optimization problem than can be formulated as a mathematical program. The school will present recent advances in this class. Machine learning approaches in Mathematical Programming will also be considered.
3. Various Applications using OR and AI techniques

Speakers

- Fred Glover, Chief Scientific Officer, Entanglement, Inc., Gary Kochenberger, Chief Optimization Officer, Entanglement, Inc.. Title : New Advances for Quantum-Inspired Optimization.
- El Ghazali Talbi, Professor, University of Lille and INRIA. Title : Machine learning in metaheuristics.
- Sébastien Le Digabel, Professor, Polytechnique Montréal. Title : Blackbox optimization with the MADS algorithm and the NOMAD software.
- Bubaccar Bah, Associate Professor and Head of Data Science, Medical Research Council Unit The Gambia (MRCG), London School of Hygiene & Tropical Medicine (LSHTM) and German Research Chair in Mathematics of Data Science, African Institute for Mathematical Sciences (AIMS) South Africa. Title : Divide-and-Conquer Equation Learning with R-square and Bayesian Model Evidence.

Organizers and Contacts

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AFROS
AFRICAN FEDERATION OF OPERATIONS RESEARCH SOCIETIES

ORPA

Planning

Monday 4th July 2022, 12h-13h30 GMT, Fred Glover and Gary Kochenberger, « New Advances for Quantum-Inspired Optimization »

In recent years, we have discovered that a mathematical formulation known as QUBO, an acronym for a Quadratic Unconstrained Binary Optimization problem, can embrace an exceptional variety of important optimization problems found in industry, science, and government. The QUBO model has emerged as an underpinning of the quantum computing areas known as quantum annealing and digital annealing and has become a subject of study in neuromorphic computing. Through these connections, QUBO models lie at the heart of experimentation carried out with quantum computers developed by D-Wave Systems and neuromorphic computers developed by IBM. We illustrate the process of reformulating important optimization problems as QUBO models through a series of explicit examples. We disclose the unexpected advantages of modeling a wide range of problems in a form that differs from the linear models classically adopted in the optimization community. We then go farther by describing important QUBO-Plus and PUBO models (where "P" stands for "Polynomial") that go beyond QUBO models to embrace a wide range of additional important applications. Each step of generating such models is illustrated in detail by simple numerical examples, to highlight the convenience of using these models in numerous settings. We describe recent algorithmic innovations that offer a fertile avenue for integrating classical and quantum computing and for applying these models. These innovations, embodied in software made available through Entanglement, Inc., have produced an ability to solve dramatically larger problems and to obtain significantly better solutions than software being offered through D-Wave, IBM, Microsoft, Fujitsu and other groups pursuing this area. Some of the major applications addressed with these innovations include those in : Classical Combinatorial Optimization, Financial Services, Transportation Manufacturing, Pharmaceuticals and Related, Network and Energy, Machine learning.

Tuesday 5th July 2022, 12h-13h30 GMT, El Ghazali Talbi, « Machine learning in metaheuristics ».

Abstract : During the past few years, research in applying machine learning (ML) to design efficient, effective, and robust metaheuristics has become increasingly popular. Many of those machine learning-supported metaheuristics have generated high-quality results and represent state-of-the-art optimization algorithms. Although various appproaches have been proposed, there is a lack of a comprehensive survey and taxonomy on this research topic. In this tutorial, we will investigate different opportunities for using ML into metaheuristics. We define uniformly the various ways synergies that might be achieved. A detailed taxonomy is proposed according to the concerned search component: target optimization problem and low-level and high-level components of metaheuristics. Our goal is also to motivate researchers in optimization to include ideas from ML into metaheuristics. We identify some open research issues in this topic that need further in-depth investigations.

Wednesday 6th July 2022, 15h-16h30 GMT, Sébastien Le Digabel, « Blackbox optimization with the MADS algorithm and the NOMAD software ».

Abstract: NOMAD is a free software package for blackbox optimization. It implements the mesh adaptive direct search (MADS), a derivative-free optimization algorithm. NOMAD is designed to solve industrial problems, and therefore it includes several practical features such as constraints and the possibility of processing several objectives, noisy evaluations, etc. This presentation introduces derivative-free and blackbox optimization, the MADS algorithm and the practical use of NOMAD. Realistic test cases will also be discussed, with emphasis on the optimization of the hyperparameters of neural networks, for which NOMAD is naturally adapted thanks to its ability to consider categorical variables.

Thrusday 7th July 2022, 12h-13h30 GMT, Bubaccar Bah, « Divide-and-Conquer Equation Learning with R-square and Bayesian Model Evidence ».

Abstract : Deep learning is a powerful method for tasks like predictions and classification, but lacks interpretability and analytic access. Instead of fitting up to millions of parameters, an intriguing alternative for a wide range of problems would be to learn the governing equations from data. Resulting models would be concise, parameters can be interpreted, the model can adjust to shifts in data, and analytic analysis allows for extra insights. Common challenges are model complexity identification, stable feature selection, expressivity, computational feasibility, and scarce data. In our work, the mentioned challenges are addressed by combining existing methods in a novel way. We choose multiple regression as a framework and argue how a surprisingly large space of model equations can be captured. For feature selection, we exploit the computationally cheap coefficient of determination (R-square) to loop through millions of models, and by using a divide-and-conquer strategy, we are able to rule out remaining models in the equation class. Final model selection is achieved by exact values of the Bayesian model evidence with empirical priors, which is known to identify suitable model complexity without relying on mass data. Random polynomials and the chaotic Lorenz system are used as examples.