Geophysical Research Abstracts
Vol. 18, EGU2016-11908-1, 2016
EGU General Assembly 2016

Scalable multi-objective control for large scale water resources systems under uncertainty

Matteo Giuliani (1), Julianne Quinn (2), Jonathan Herman (3), Andrea Castelletti (1,4), and Patrick Reed (2)

(1) Politecnico di Milano, Dept. Electronics, Information, and Bioengineering, Milano, Italy (matteo.giuliani@polimi.it), (2) Department of Civil and Environmental Engineering, Cornell University, Ithaca, NY., (3) Department of Civil and Environmental Engineering, University California Davis, CA., (4) Institute of Environmental Engineering, ETH Zurich, Zurich, Switzerland.

The use of mathematical models to support the optimal management of environmental systems is rapidly expanding over the last years due to advances in scientific knowledge of the natural processes, efficiency of the optimization techniques, and availability of computational resources. However, undergoing changes in climate and society introduce additional challenges for controlling these systems, ultimately motivating the emergence of complex models to explore key causal relationships and dependencies on uncontrolled sources of variability.
In this work, we contribute a novel implementation of the evolutionary multi-objective direct policy search (EMODPS) method for controlling environmental systems under uncertainty. The proposed approach combines direct policy search (DPS) with hierarchical parallelization of multi-objective evolutionary algorithms (MOEAs) and offers a threefold advantage: the DPS simulation-based optimization can be combined with any simulation model and does not add any constraint on modeled information, allowing the use of exogenous information in conditioning the decisions. Moreover, the combination of DPS and MOEAs prompts the generation or Pareto approximate set of solutions for up to 10 objectives, thus overcoming the decision biases produced by cognitive myopia, where narrow or restrictive definitions of optimality strongly limit the discovery of decision relevant alternatives. Finally, the use of large-scale MOEAs parallelization improves the ability of the designed solutions in handling the uncertainty due to severe natural variability.
The proposed approach is demonstrated on a challenging water resources management problem represented by the optimal control of a network of four multipurpose water reservoirs in the Red River basin (Vietnam). As part of the medium-long term energy and food security national strategy, four large reservoirs have been constructed on the Red River tributaries, which are mainly operated for hydropower production, flood control, and water supply. Numerical results under historical as well as synthetically generated hydrologic conditions show that our approach is able to discover key system tradeoffs in the operations of the system. The ability of the algorithm to find near-optimal solutions increases with the number of islands in the adopted hierarchical parallelization scheme. In addition, although significant performance degradation is observed when the solutions designed over history are re-evaluated over synthetically generated inflows, we successfully reduced these vulnerabilities by identifying alternative solutions that are more robust to hydrologic uncertainties, while also addressing the tradeoffs across the Red River multi-sector services.