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Universal approximators for multi-objective direct policy search in water reservoir management problems: a comparative analysis

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The optimal operation of water resources systems is a wide and challenging problem due to non-linearities in the model and the objectives, high dimensional state-control space, and strong uncertainties in the hydroclimatic regimes. The application of classical optimization techniques (e.g., SDP, Q-learning, gradient descent-based algorithms) is strongly limited by the dimensionality of the system and by the presence of multiple, conflicting objectives.

This study presents a novel approach which combines Direct Policy Search (DPS) and Multi-Objective Evolutionary Algorithms (MOEAs) to solve high-dimensional state and control space problems involving multiple objectives. DPS, also known as parameterization-simulation-optimization in the water resources literature, is a simulation-based approach where the reservoir operating policy is first parameterized within a given family of functions and, then, the parameters optimized with respect to the objectives of the management problem. The selection of a suitable class of functions to which the operating policy belong to is a key step, as it might restrict the search for the optimal policy to a subspace of the decision space that does not include the optimal solution. In the water reservoir literature, a number of classes have been proposed. However, many of these rules are based largely on empirical or experimental successes and they were designed mostly via simulation and for single-purpose reservoirs. In a multi-objective context similar rules can not easily inferred from the experience and the use of universal function approximators is generally preferred.

In this work, we comparatively analyze two among the most common universal approximators: artificial neural networks (ANN) and radial basis functions (RBF) under different problem settings to estimate their scalability and flexibility in dealing with more and more complex problems. The multi-purpose HoaBinh water reservoir in Vietnam, accounting for hydropower production and flood control, is used as a case study. Preliminary results show that the RBF policy parametrization is more effective than the ANN one. In particular, the approximated Pareto front obtained with RBF control policies successfully explores the full tradeoff space between the two conflicting objectives, while most of the ANN solutions results to be Pareto-dominated by the RBF ones.