# Tutorial: A Unified Framework for Optimization under Uncertainty

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Stochastic optimization is a fragmented field comprised of multiple communities from within operations research (stochastic programming, Markov decision processes, simulation optimization, decision analysis, bandit problems), computer science (reinforcement learning, bandit problems), optimal control (stochastic control, model predictive control, online computation), and applied mathematics (stochastic search). In this talk, I will identify the major dimensions of this rich class of problems, spanning static to fully sequential problems, offline and online learning (including so-called "bandit" problems), derivative-free and derivative-based algorithms, with attention given to problems with expensive function evaluations.

In this tutorial, I will give a common mathematical framework for modeling all of these problems using a single formulation. This framework consists of five fundamental elements (states, decisions/actions/ controls, exogenous information, transition function and objective function), and requires optimizing over policies, which is the major point of departure. We divide solution strategies for sequential problems ("dynamic programs") between stochastic search ("policy search") and policies based on lookahead approximations (which include both stochastic programming as well as value functions based on Bellman's equations). We further divide each of these two fundamental solution approaches into two subclasses, producing four (meta)classes of policies for approaching sequential stochastic optimization problems.

We use a simple energy storage example to demonstrate that each of these four classes may work best, as well as opening the door to a range of hybrid policies. The ultimate goal of the tutorial will be to put all of these problems into a single, elegant framework that makes it possible to draw on the entire spectrum of tools that have been developed in different settings. Every problem class, as well as the solution strategies, will be illustrated using actual applications.