A Universal Framework for Sequential Decision Problems

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Sequential decision problems are an almost universal problem class, spanning dynamic resource allocation problems, control problems, optimal stopping/buy-sell problems, active learning problems, as well as two-agent games and multiagent problems. Application settings span engineering, the sciences, transportation, health services, medical decision making, energy, e-commerce and finance, but in this talk I will emphasize applications in transportation and logistics.

These problems have been addressed in the research literature using a variety of modeling and algorithmic frameworks, including (but not limited to) dynamic programming, stochastic programming, stochastic control, simulation optimization, stochastic search, approximate dynamic programming, reinforcement learning, model predictive control, and even multiarmed bandit problems.

I will present a universal modeling framework that can be used for *any* sequential decision problem in the presence of different sources of uncertainty. I use a “model first” strategy that optimizes over policies for making decisions. I will present four (meta)classes of policies that are the foundation of *any* solution approach that has ever been proposed for a sequential problem, either in the research literature or used in practice (including policies that have not been invented yet).

These ideas will be illustrated using applications in transportation, inventory planning, energy storage modeling, and laboratory experimentation. More illustrations are available in a teach-by-example book at <https://tinyurl.com/PowellSDAMbook/>.

I will close by making the case for teaching sequential decision analytics at both the undergraduate and graduate levels, including to students in fields centered on applications as well as methodology.