Studying Decision Making in the Face of Uncertainty

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In almost every field, decision makers are often required to make important choices in the face of uncertainty. For instance, a financial portfolio manager must make investment decisions without being certain of asset returns. A medical doctor must prescribe a treatment without being totally certain about a patient's response to that particular treatment. An electricity grid system operator must select a set of generators to be switched on without fully knowing what the consumer demand will be and what the state of the transmission lines are. An airline makes pricing and scheduling decisions while facing an uncertain demand. Today's world of free markets, fast communication links, and availability of vast amounts of data makes the study of decision making under uncertainty or dynamic optimization extremely important.

Uncertainty in a decision-making problem is usually modeled in one of two ways: either by a probability distribution in a stochastic model or by an uncertainty set in a robust model. A stochastic model estimates probability distributions of potential outcomes by allowing for random variation in one or more inputs over time. While a stochastic model might be a good approximation of reality, the resulting optimization problem is often very difficult to solve even approximately. On the other hand, a robust model can be solved efficiently in most cases but is considered too conservative to be useful in practice as it optimizes over the worst case.

Vineet Goyal works to address a fundamental question about the relationship between these two diametrically opposite paradigms. His research focuses on providing justification for robust and other tractable approaches as a practical method to solve dynamic optimization problems. His work shows that under fairly general assumptions, the robust optimization approach provides a good approximation of the stochastic problem in many cases.

Goyal's current work focuses on analyzing the performance of various tractable approaches such as affine policies (also referred to as linear decision rules) and piecewise affine policies for dynamic optimization problems. His goal is to better understand the trade-off between tractability and performance of various approaches. This is a fundamental question and has potential for significant impact given the wide applicability of dynamic optimization.

Goyal is especially interested in applications in electricity markets where dynamic optimization is very applicable with an increasing concentration of renewable sources of generation that have a highly uncertain generation capacity. He also applies this research to problems associated with revenue management and inventory management.

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