EXTENDED ABSTRACT ONLY

Advances in exploratory modeling for assessing uncertain cumulative impacts

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Abstract: Many of the challenges society is facing involve a network of actors with different resources and heterogeneous power relations that has to coordinate their actions, while the system relating decision alternatives to consequences is both complex and subject to uncertainty. The complexity is due to non-linear cross-scale interactions among various sub-systems. Uncertainty exists about the current state of the system, the possible ways in which the future might unfold and how this affects the system. Moreover, the various actors often have diverging understandings of the system and the uncertainties, while also disagreeing on the relevant values that should be considered in decision-making. Examples of such decision problems can be found in many domains such as energy transitions, flood risk management, infrastructure planning, supply chain management, and climate adaptation. These decision problems have been described as wicked, as ill-structured, or as societal messes.

Offering model-based support for decision-making on societal challenges entails coming to grips with the multi-actor character of decision making, as well as the intrinsic uncertainty and complexity of the system. Over the last decade, under the label of decision-making under deep uncertainty, a novel paradigm for developing and using models has emerged in response to the perceived failure of existing approaches in offering meaningful model-based decision support on uncertain complex multi-actor decision problems. This paradigm entails a shift from using models to try to predict the future, towards using models to explore thousands of scenarios. In evaluating the performance of candidate strategies, rather than using some decision analytic approach for aggregating the various outcomes of interest into a single measure of goodness, this paradigm places a strong emphasis on Pareto optimality. Focusing on Pareto optimality allows doing justice to the plurality of values actually at stake in decision-making on societal challenges.

The uncertainty, complexity, and multiplicity of values intrinsic to decision-making on societal challenges preclude the possibility of developing a single true representation of the system of interest. Instead, analysts have to develop and use a set of models that encompasses the uncertainty, while being constrained by available data and knowledge. A single model drawn from the set is not a prediction. Rather, it is a computational experiment that reveals how the real world system would behave if the assumptions made in the experiment about the various uncertainties were correct. Such a what-if experiment in isolation is typically not that informative, other than suggesting the plausibility of its outcomes. Instead, exploratory modeling aims to support reasoning and decision-making on the basis of large sets of computational experiments. Thus exploratory modeling involves searching through the space of possible experiments using many-objective optimization algorithms, and sampling over the space using design of experiments and global sensitivity analysis techniques.

In this talk, I will introduce a general taxonomy of exploratory modeling approaches, illustrate this taxonomy using a stylized toy case, and demonstrate it with an in depth real-world case focused on the resilience of the multi-modal transport model of Bangladesh to natural hazards.

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