Chemical Engineering
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Scalable Decision-Making for Energy Systems: A Graph-Structured Optimization Approach

Sungho Shin

Postdoctoral Researcher
Argonne National Laboratory

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4:00pm Reception

The global community is facing the grand challenge of decarbonizing energy infrastructures to combat climate change. Unfortunately, substantial technical challenges appear in the planning, design, and operation of these systems; these include the presence of uncertainties (e.g., renewable energy sources, weather events, asset failures) and the complex, heterogeneous nature of energy networks. Optimization problems involved in these decision-making practices can have billions of variables and constraints and embed complex physical models, making it impossible to handle with existing approaches. To address these challenges, we need to develop (i) mathematical modeling abstractions that facilitate the navigation of complex systems and (ii) scalable solution algorithms that can handle such complex problems. In this talk, I will introduce a new optimization paradigm that can help address these challenges: graph-structured optimization. This paradigm expresses optimization problems as graphs, allowing for a unified treatment of a wide range of decision-making problems, including those that embed uncertainty, multi-scale spatiotemporal phenomena, and networks. We will explain how this paradigm facilitates modeling and the discovery of general properties for optimization problems. Specifically, we will introduce a powerful property that we call exponential decay of sensitivity; this property explains how data perturbations (e.g., disturbances) propagate through the graph structure of optimization problems and provides important insights that enable the creation of scalable algorithms and guide system design. We conclude the talk by discussing the implications of our results in the planning, design, and operation of future energy systems and the open challenges.

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