Institute of Catastrophe Risk Management

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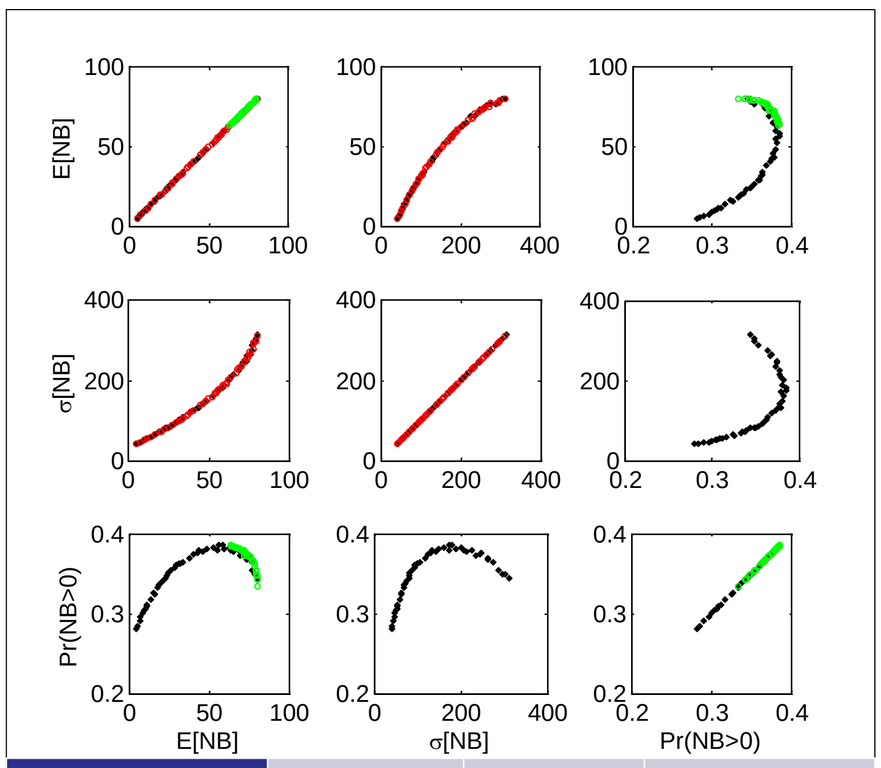
Multi-objective Stochastic Optimization for Flood Risk Management with Integrated Stochastic Surrogate and Genetic Algorithms

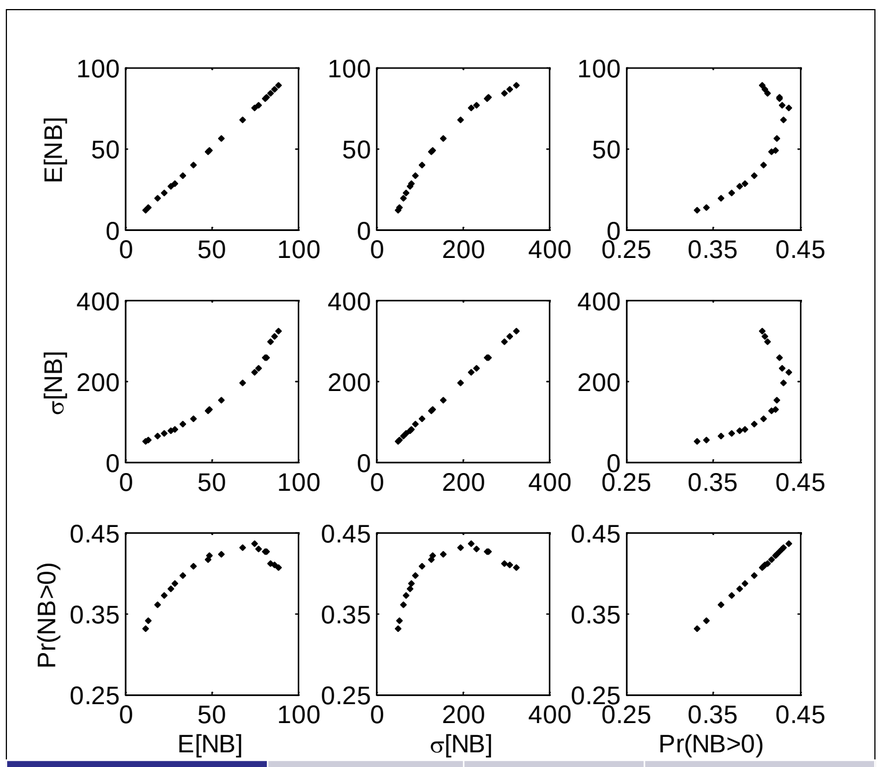
A multi-objective stochastic optimization model is developed to assist decision making problem for urban flood risk management under uncertainty. An evolutionary-based multi-objective optimization technique integrated with advanced stochastic surrogate modeling and advanced stochastic simulation algorithms is used to find the non-dominated flood risk management solutions that optimize conflicting objectives simultaneously. The proposed method is applied to Chester Creek Watershed, PA, and in future will be applied to other major cities/regions in Asia.

- **Decision Options**
  - New levee systems with levee height ranging from 5m to 10m
- **Decision Objectives**
  - Maximize the expectation of the annual net benefit, $E[NB]$
  - Minimize the standard deviation of annual net benefit, $\sigma[NB]$
  - Maximize the exceedance probability of the annual net benefit, $Pr[NB>0]$



Objective	max E[NB]	min σ[NB]	max Pr[NB>0]
Levee height (m)	7.48	5.00	6.28

Pareto optimal solutions of levee systems using MOSO



Objective	max E[NB]	min σ[NB]	max Pr[NB>0]
Levee height (m)	7.58	5.00	6.54

Pareto optimal solutions of levee systems using ISSMOSO

- **Multi-objective Stochastic Optimization (MOSO)**
  - Nondominated sorting genetic algorithm II
  - Generate a set of Pareto-optimal solutions containing all non-dominated solutions of levee system designs
- **Integrated Stochastic Surrogate & Multi-objective Stochastic Optimization (ISSMOSO)**
  - Stochastic surrogate is integrated with MOSO algorithm to significantly reduce the efforts required by computational demanding part of the original flood risk analysis models in MOSO

Results and Summaries:

- MOSO allows the consideration of a wide range of possible solutions regardless of how the criteria weights are assigned and provides information about all the potential and possible tradeoffs among the objectives
- The optimal solutions of ISSMOSO are comparable to the MOSO method in terms of accuracy
- ISSMOSO greatly reduces the computational effort of MOSO in flood risk management problems. Ongoing works include the integration performance with different types of stochastic surrogate models, cases with a larger number of random variables, design variables and stochastic objectives including resilience metrics the advancement of the proposed method, and the development of new methods

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