

Simulation-Based Design under Uncertainty

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Integrated **DE**sign **A**utomation **L**aboratory (*IDEAL*)

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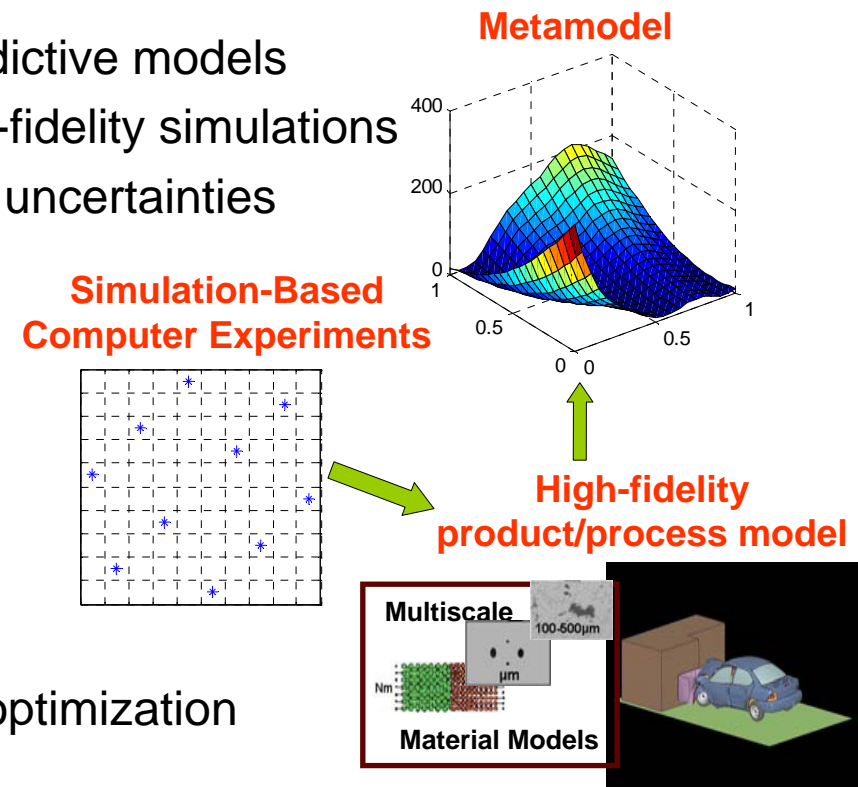


Simulation Based Design under Uncertainty

- Built upon the advancement of simulation-based engineering science (SBES)
- Challenges
 - Uncertainty quantification of predictive models
 - Huge computational cost of high-fidelity simulations
 - Incorporating various sources of uncertainties

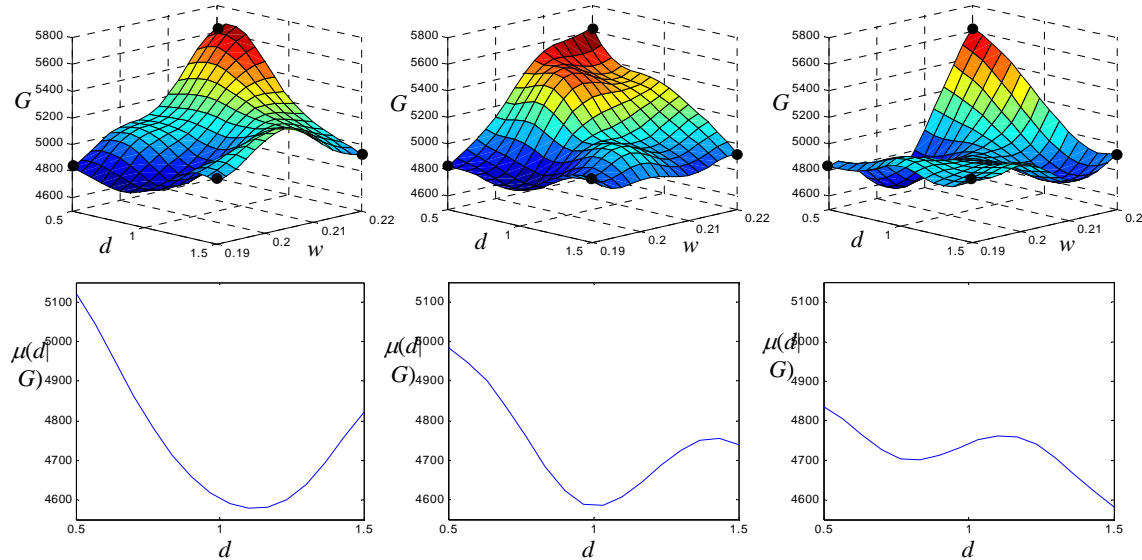
Research Topics

- Optimal computer experiments
- Sequential sampling
- Statistical (global) sensitivity analysis
- Variable-fidelity optimization
- Quantification of model uncertainty
- Sequential approach to probabilistic optimization
- Stochastic Multiscale design

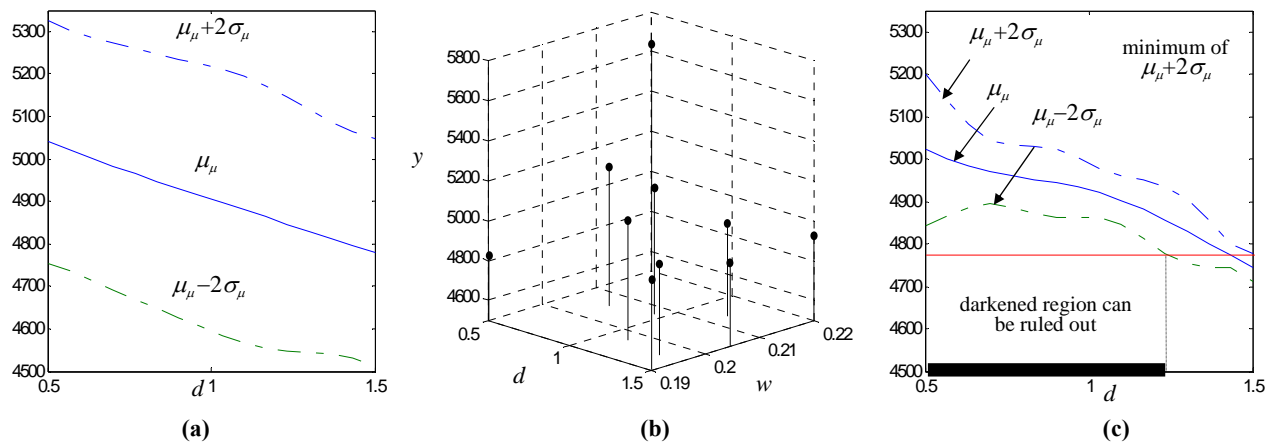


A Bayesian Treatment of Uncertainty in Simulation-Based Robust Design

Uncertainty in robust design objective due to lack of simulations



Quantifying the effects of simulation uncertainty to guide sampling of both design and noise variables



NSF 0758557, PI: D. Apley; co-PI: W. Chen, J. Cao



Model Uncertainty Quantification and Validation

Computer Model

Experimental Error $\varepsilon \sim N(0, \sigma_\varepsilon^2 \mathbf{I})$

$$\underbrace{y^e(\mathbf{x})}_{\text{Physical Experiments}} = \underbrace{y^m(\mathbf{x}, \boldsymbol{\theta})}_{\text{Model Inadequacy}} + \underbrace{\delta(\mathbf{x}) + \varepsilon}_{\text{Prediction mean and confidence interval}}$$

Physical Experiments

Model Inadequacy

— Prediction mean
 Prediction confidence interval

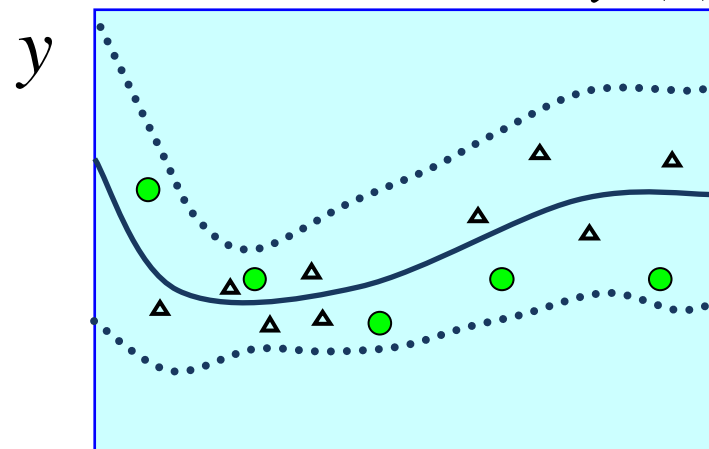
- $\boldsymbol{\theta}$ - Uncertain computer model parameters
- \mathbf{x} - Input variables

Goal: Obtain prediction at untested points with uncertainty quantification

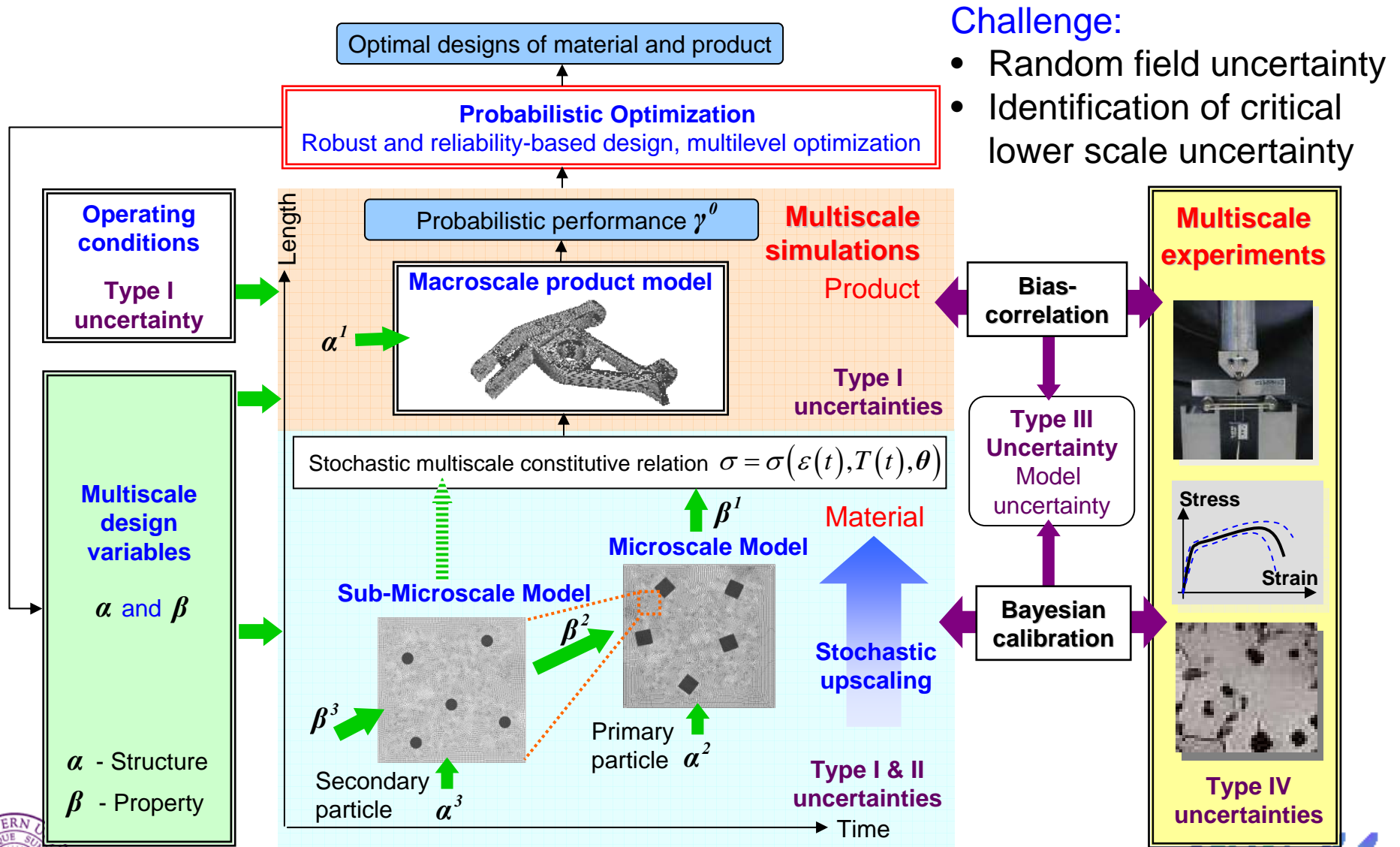
Challenge:

- Identifiability of calibration and bias correction
- Bayesian analysis for large dimension problems

- Computer experiments $y^m(\mathbf{x}, \boldsymbol{\theta})$
- Physical experiments $y^e(\mathbf{x})$



Stochastic Multiscale Computational Design



NSF 0928320, PI: W. Chen; co-PIs: W.K. Liu, C. Brinson

