RELIABILITY-BASED DESIGN OPTIMIZATION OF LARGE-SCALE COMPLEX SYSTEMS

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INTRODUCTION
Input $X \in \mathbb{R}^d$ → COMPLEX SYSTEM → Output $y(X) \in \mathbb{R}$

- $X = (X_1, \ldots, X_d) \in \mathbb{R}^d$ → random variables
- $d = (d_1, \ldots, d_d) \in \mathbb{D} \subset \mathbb{R}^d$ → design parameters

- Reliability-based Design Optimization (RBDO)
  - $\min_{(X,d)} \{ y(X,d) \} \quad \text{s.t.} \quad h_i(X,d) = b_i \quad (i = 1, \ldots, m)$

- Robust Design Optimization (RDO)
  - $\min_{(X,d)} \{ y(X,d) \} \quad \text{s.t.} \quad h_i(X,d) = b_i, \quad \sigma_i(X,d) \leq \varepsilon_i, \quad i = 1, \ldots, m$

STASTICAL MOMENTS & SENSITIVITIES

- Two Important Properties of Polynomial Basis
  - $E_0 \{ \phi_{n,d}(X_0) \phi_{n,d}(X_0) \} = 1$
  - $E_0 \{ \phi_{n,d}(X_0) \phi_{n,d}(X_0) \} = 0 \quad \text{if} \quad n \neq n'$

- Second-Moment Statistics
  - $E_0 \{ \phi_{n,d}(X_0) \phi_{n,d}(X_0) \} = \sum_{1 \leq i < j \leq n} \sum_{a \neq b} C_{i,j}^2(d)$

- Score Functions
  - $\frac{\partial E_0 \{ y(X) \}}{\partial d_{k}} = \sum_{j=1}^{m} \frac{\partial b_j}{\partial d_{k}} \cdot \frac{\partial E_0 \{ y(X) \}}{\partial b_j}$

- Design Sensitivities
  - $\frac{\partial E_0 \{ y(X) \}}{\partial a_{k}} = \sum_{j=1}^{m} \frac{\partial b_j}{\partial a_{k}} \cdot \frac{\partial E_0 \{ y(X) \}}{\partial b_j}$

ROBUST DESIGN OPTIMIZATION

- Multipoint Single-Step PDD
  - $\min_{(X,d)} \{ y(X,d) \} \quad \text{s.t.} \quad h_i(X,d) = b_i, \quad \sigma_i(X,d) \leq \varepsilon_i, \quad i = 1, \ldots, m$

RESULTS

- Optimal Bracket Designs

BROADER IMPACT

- Improved design of civil, automotive, and aerospace infrastructures
- Application to design optimization and reliability-based design optimization

PUBLICATIONS