RT-181: A Model of Design as a Sequential Decision Process

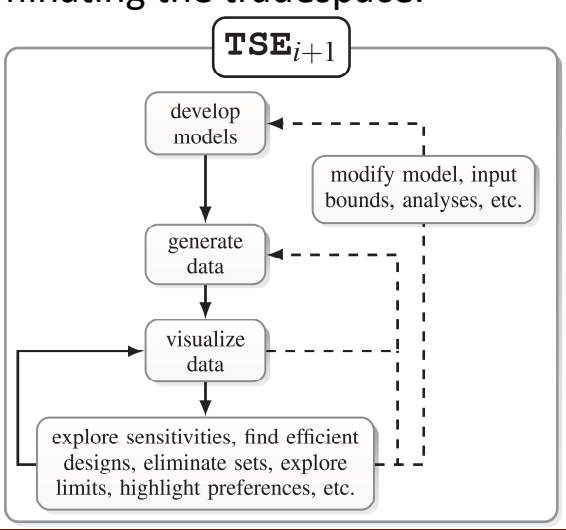
Simon W Miller & Michael A Yukish

SYSTEMS ENGINEERING RESEARCH CENTER

PennState Applied Research Laboratory

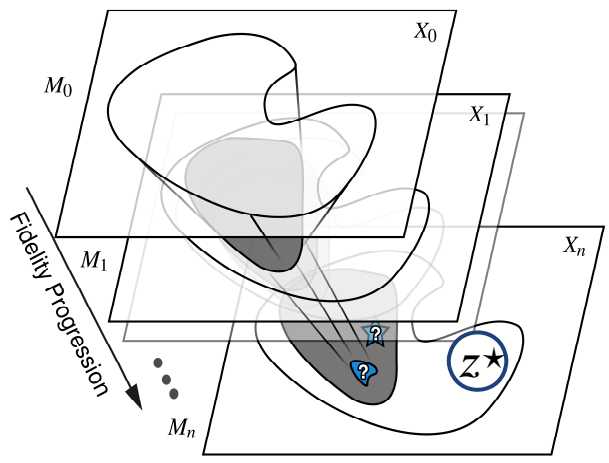
Research Task / Overview

to treat design as a ***Sequential Decision Process*** whereby models are used to continually refine the design space with mathematical guarantees on discriminating the tradespace.



Goals & Objectives

- we seek to formally define design when viewed as a sequential decision process using:
  1. bounding models
  2. dominance criteria
  3. optimal modeling policy

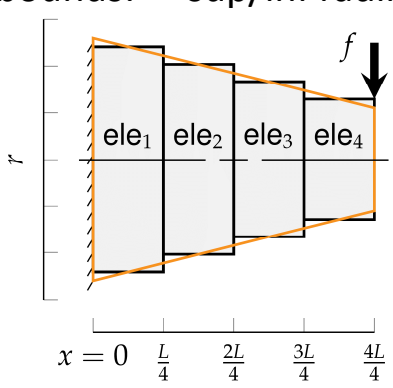


Data & Analysis

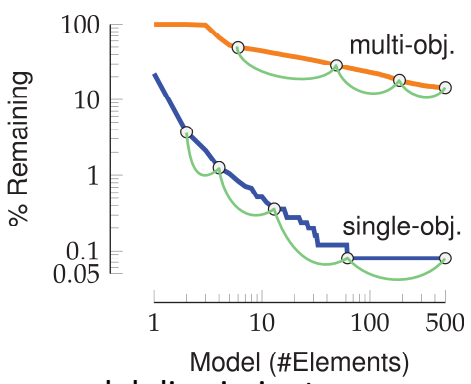
a ***bounding model*** provides two-sided estimate to a function by restricting the form of the lower fidelity models as

$$g_i^{\ell}(x) \leq \min_{Y} h(x,y) \leq g_i^{u}(x)$$

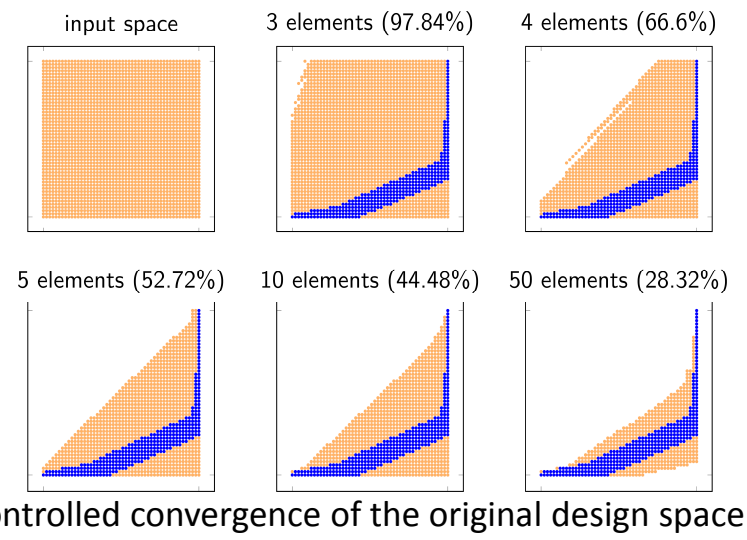
example: 2 parameter 1D FEA problem
fidelity: discretization of the cylindrical body
objective: minimize mass and tip deflection
bounds: sup/inf radii per element



problem domain



model discriminatory power and optimal policies $\mathcal{P}^\star$



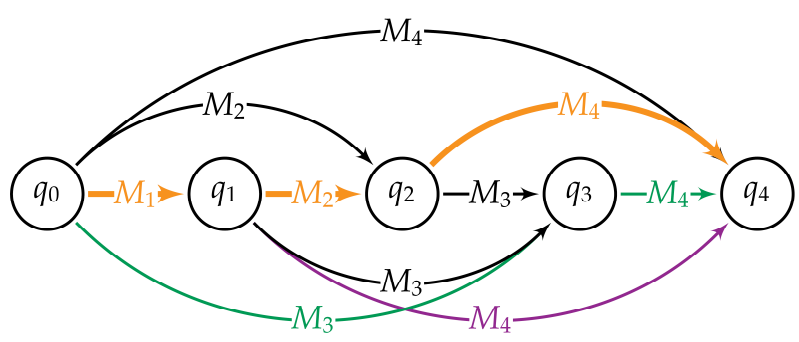
controlled convergence of the original design space the non-dominated set with after modeling effort

Cost savings from optimal policy compared to one-shot exploration: $c_{so} = 0.99, \quad c_{mo} = 0.74$

Methodology

<u>The Formal Model</u>

- tradespace Z
- model set $M = \{M_1, \ldots, M_m\}$
- consideration sets $\{Z_0, \ldots, Z_m\}$
- ideal point $z^\star$
- cost $c(i,j)$ of using M_j to move from Z_i to Z_j
- modeling policy $\mathcal{P} = \{M_{p1}, M_{p2}, \ldots, M_{pm}\}$

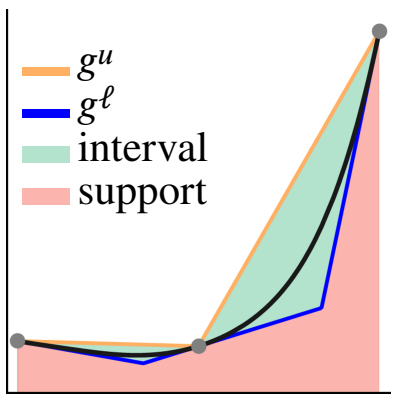


Model Sequencing

Future Research

- extension to general function forms

convex functions
- interpolation generates the ***upper bound***
- tangent planes at points provide function support and the ***lower bound***



Contacts/References

Simon W Miller swm154@arl.psu.edu
Michael A Yukish may106@arl.psu.edu
Penn State Applied Research Laboratory

Miller, S.W., Yukish, M.A., & Simpson, T.W., 2017, "Design as a sequential decision process: A method for reducing design set space Using models to bound objectives", *Structural and Multidisciplinary Optimization*

Unal, M., Miller, S.W., Chhabra, J.P.S., Warn, G.W., Yukish, M.A., & Simpson, T.W., 2017, "A sequential decision process for the system-level design of structural frames", *Structural and Multidisciplinary Optimization*