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Robust Parameter Design

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Objectives

Robust parameter design creates designs insensitive to the variation of specific inputs.

Better to change the design than to control the inputs.

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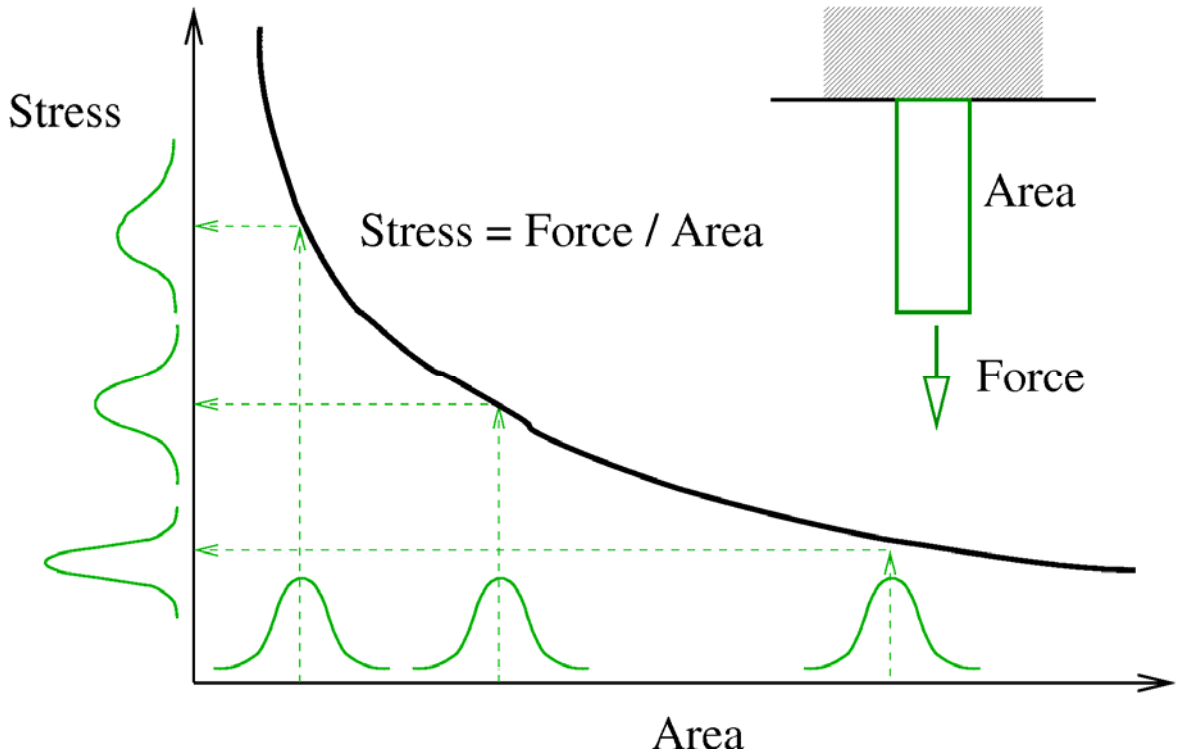
Robustness

Search for a flat part of design space



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Variables

Two sets of variables:

- Noise variables
- Control (normal) variables

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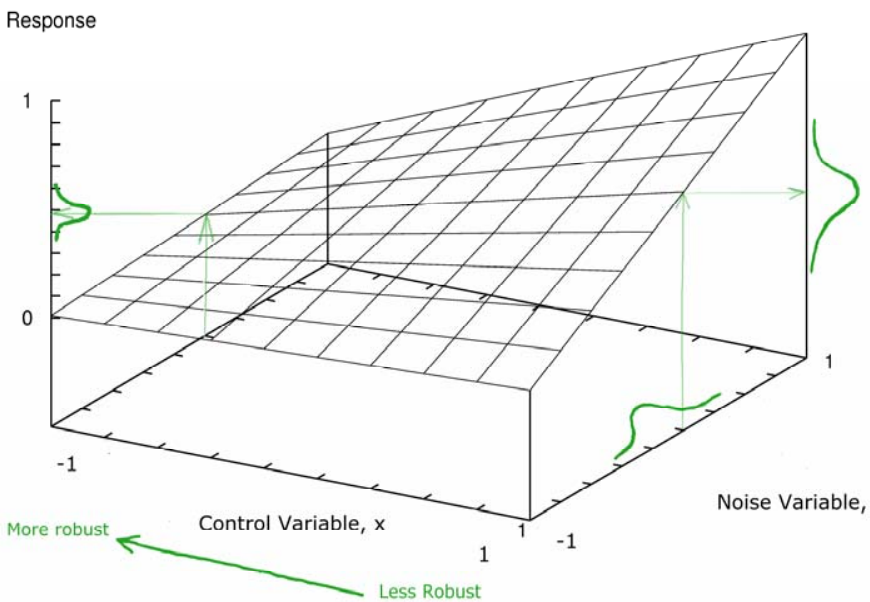
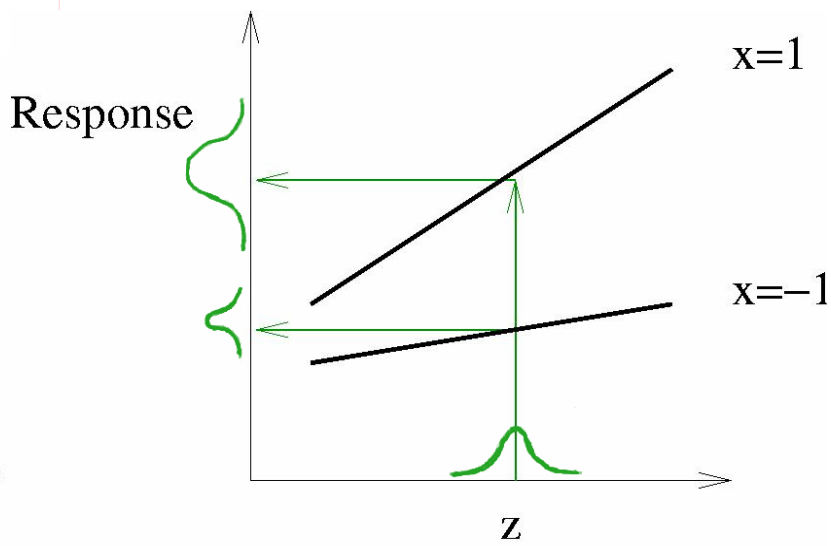
Robustness

Control variables are adjusted to minimize the effect of the noise variables.





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Dual Response Surface

Control variables **x**

Noise variables **z** with $Var(\mathbf{z}) = \sigma_z^2 \mathbf{I}_{r_z}$

Response $y(x,z)$

$$E_z[y(x,z)] = \beta + x'\beta + x'\beta x$$

$$Var_z[y(x,z)] = \sigma_z^2 l'(x) l(x) + \sigma^2$$

With $Var(\mathbf{z}) = \sigma_z^2 \mathbf{I}_{r_z}$ $\quad l(x) = \dfrac{\partial y(x,z)}{\partial z}$

Search direction for $Var(\mathbf{z})$: $\dfrac{\partial^2 y(x,z)}{\partial x \partial z}$

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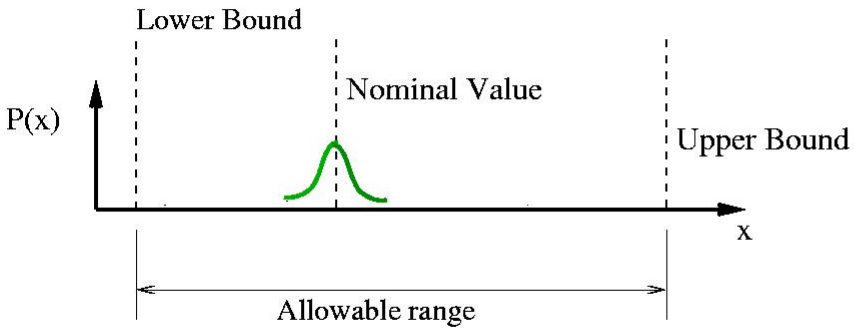
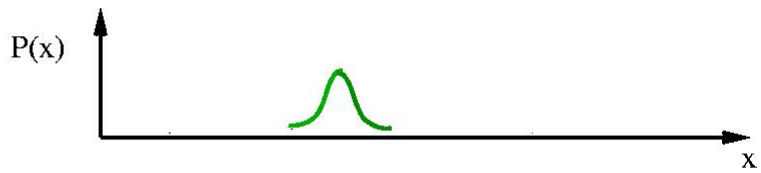
LS-OPT: Variables

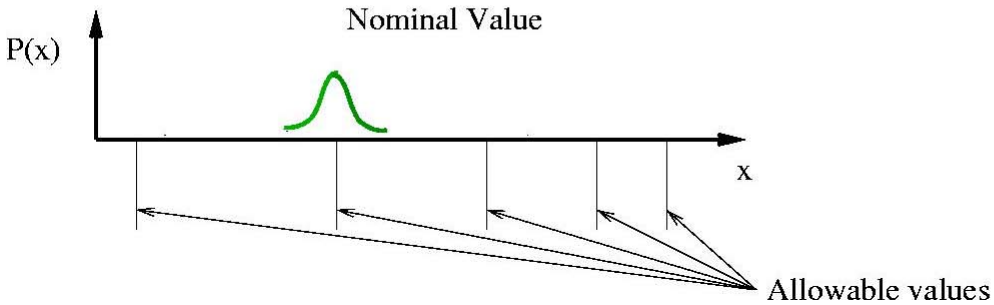
Design Variable



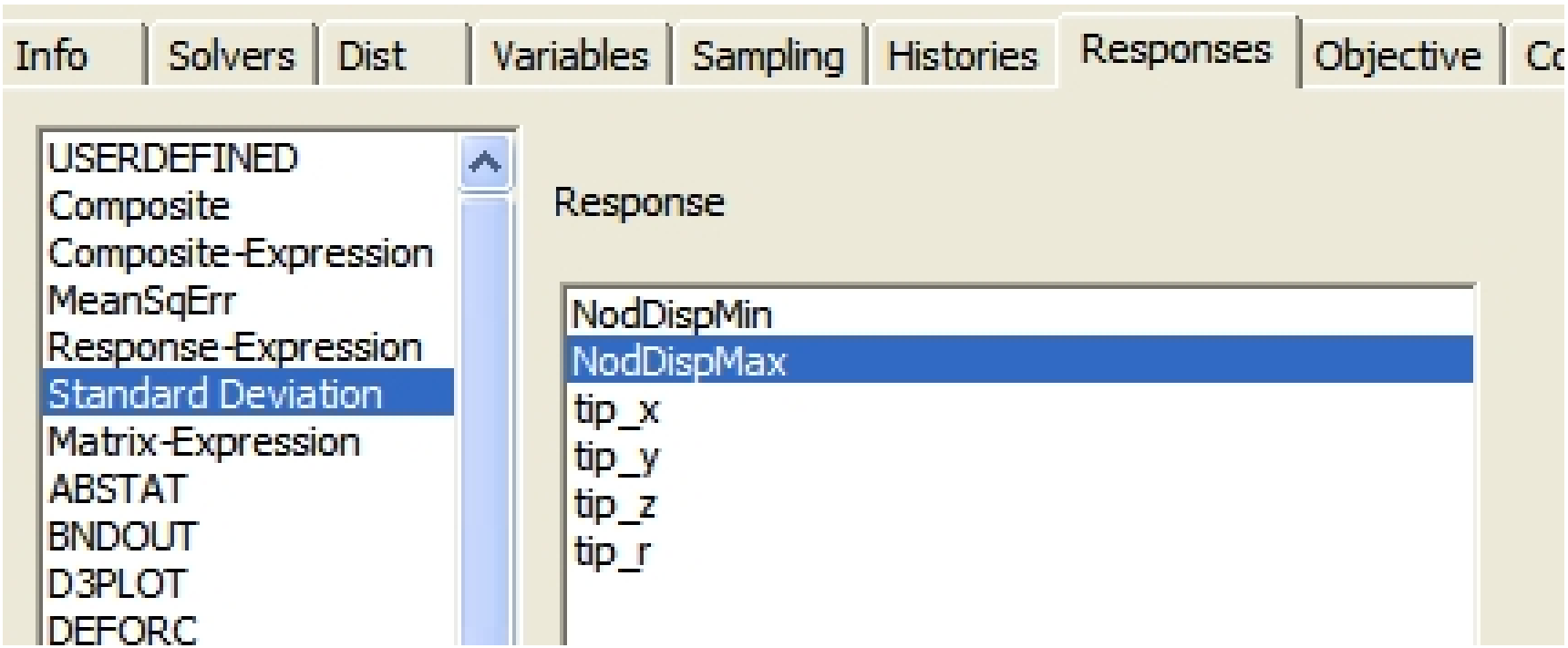
Noise Variable



Discrete Variable



LS-OPT: Response



composite 'var x11' noise 'x11'

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Experimental design

Interaction terms must be included.

Objective and constraints

Variation can be an objective or a constraint.

Use multi-criteria design to described bigger-is-better etc.

Variable screening

Interaction terms must be considered.

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Execution Speed

Variance computed analytically for responses surfaces.

But computed numerically for neural nets and composites.

Chained composites in conjunction with neural nets are numerically very intensive.

Use response surfaces if speed is a problem.

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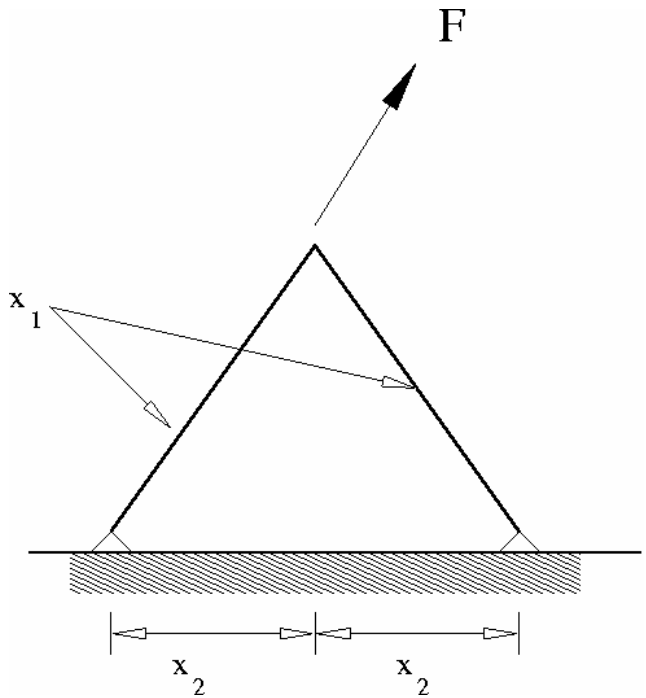
Example

Two-bar truss



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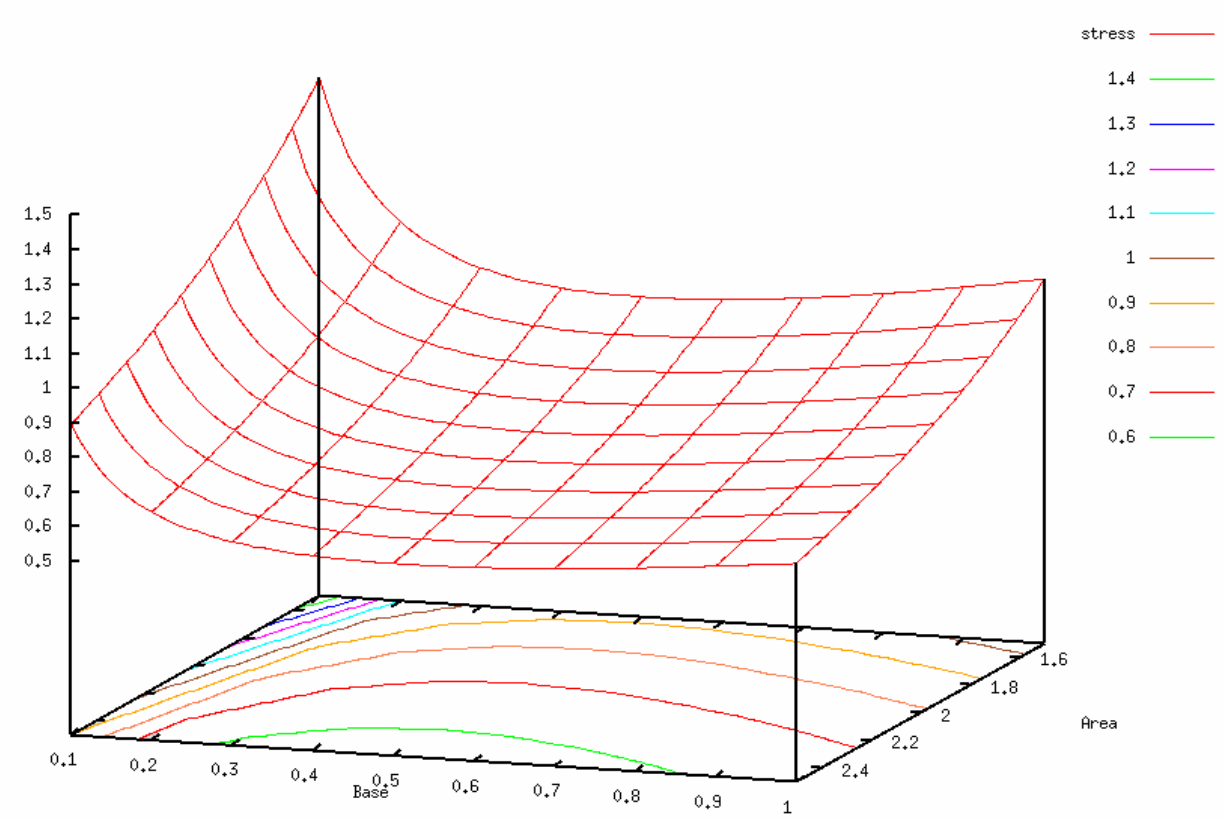
Response Surface

Stress response



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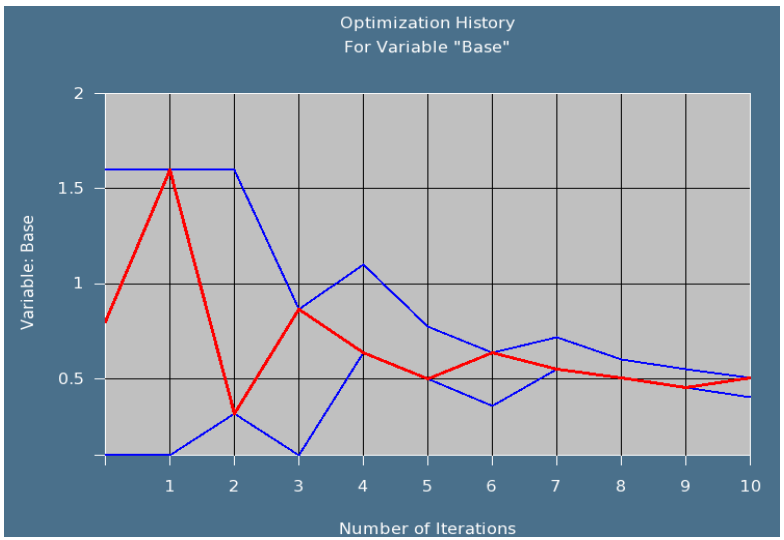
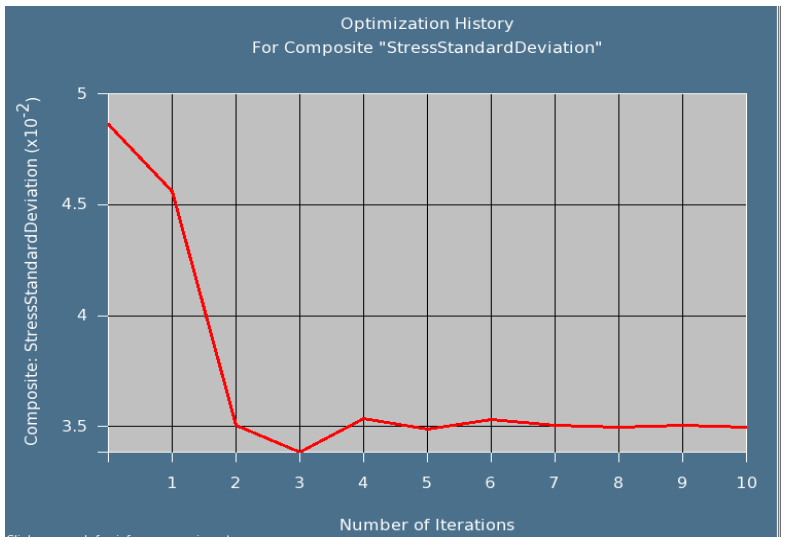
Optimization histories

Base



Std Dev of stress



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Summary

Creates design insensitive to variation of inputs (noise variables).

Adjust control variables to find design with lowest derivative with respect to noise variables.

Interaction terms are important.