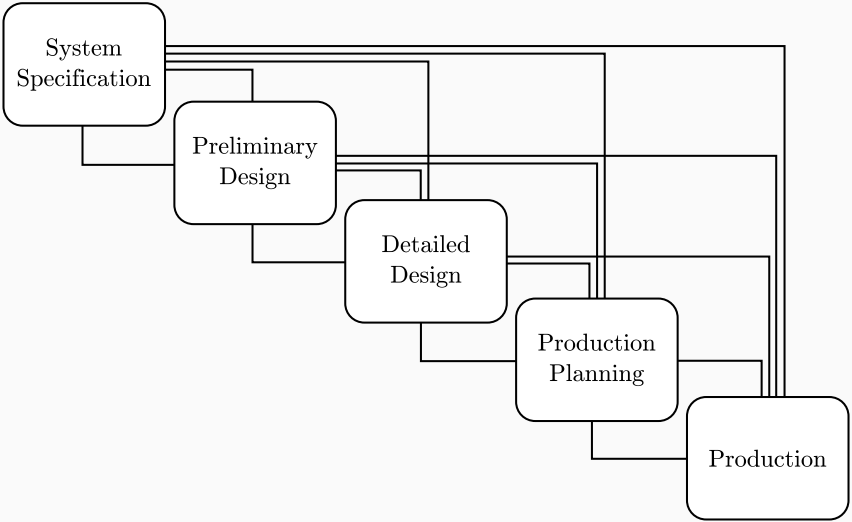
Overview of Engineering Design Optimization

What is Design Optimization?

Definition: Design Optimization

The systematic determination of an artifact's (or process's) design parameters in order to improve some objective(s) subject to constraints. Moreover, the response of the objective(s) and constraints due to changes in the design parameters are predicted using appropriate engineering analysis.

Where Does Design Optimization Fit?



Why Use Design Optimization?

Use optimization when, for example,

-
-
-

There is a trade-off!

What is Design Optimization?

Definition: Design Optimization

The systematic determination of an artifact's (or process's) design parameters in order to improve some objective(s) subject to constraints. Moreover, the response of the objective(s) and constraints due to changes in the design parameters are predicted using appropriate engineering analysis.

What are Design Variables/Parameters?

Definition: Design Variable (Design Parameter)

"A characteristic or property of an artifact or process, being designed, over which the designer has direct control." [MC00]

What is a Design Metric?

Definition: Design Metric

"A characteristic or property of an artifact or process, being designed, used to evaluate its performance." [MC00]

What is an Objective Function?

Definition: Objective Function

A design metric that is decreased (or increased) in order to improve the performance of an artifact or process

What about Constraints?

Definition: Constraint

A design metric that must take on a prescribed value, or remain within a prescribed range, in order for an artifact or process to be acceptable.

What Do We Mean By Engineering Analysis?

Definition: Engineering Analysis

A method that quantitatively models the relationship between the design variables (the inputs) and the design metrics (the outputs).

Finally, What Does Systematic Determination Mean?

This means that design optimization changes the design variables according to some algorithm.

- It does not change the variables based on experience or heuristics

Example: an algorithm with provable ability to improve the objective provided, under reasonable assumptions.

What is a Solution?
Global and Local Optima

What is a Solution to an Optimization Problem?

Before learning about optimization algorithms, we need to understand some optimization theory.

Consider the following statement:

$$\min_x f(x)$$

Global Minimizer

Definition: Global minimizer

A point x^* is a global minimizer if $f(x^*) \leq f(x)$ for all x.

Local Minimizer

Definition: Local minimizer

A point x^* is a local minimizer if there is a neighborhood $\mathcal{N}$ of x^* such that $f(x^*) \leq f(x)$ for all $x \in \mathcal{N}$.

Illustration of Global and Local Minimizers

References

A Messac and W Chen, *The engineering design discipline: is its confounding lexicon hindering its evolution?*, Journal of Engineering Valuation and Cost Analysis **3** (2000), 67–83.