بسم الله الرحمن الرحیم

Optimization at a Glance

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Outline

- Engineering Task
- Design
- Optimization
- Design Optimization
- Why do we need the optimization
- Forms of Struc. Opt.
- Optimization Methods

Engineering Task

We wish to produce the **best quality of life possible with the resources available.**

In **designing** new products, we must use design tools which provide the desired results in a timely and economical fashion.

Design

In the highly competitive world of today, it is no longer sufficient to **Design** a system that performs the required task satisfactorily.

It is essential to design the

Best System.

- Efficient
- Versatile (adaptable, multipurpose)
- Unique
- Cost-effective
- Durable
- ....

Optimization

- The concept of **Optimization** is intrinsically tied to humanity 's desire to excel.

مفهوم **بهینه سازی** ریشه در فطرت کمال جوی انسان دارد.

Vanderplaats(1984)

- **Optimization** is really a branch of applied mathematics.

Design Optimization

Any problem for which certain parameters need to be determined to satisfy constraints can be formulated as a

Design Optimization.

Why do we need the optimization?

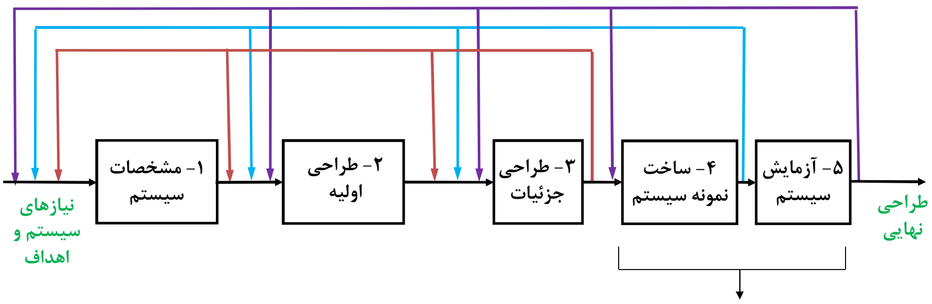
No. of Design Variables	No. of Choices for each	CPU time (s)	No. of Combin-ation	Total time
3	10	1/10	10^3	100s
10	10	10	10^{10}	10^{11}s or 32000 years

Range of Application of the Optimum Design

- The range of application of the optimum design methodology is almost **limitless**, constrained only by the imagination and ingenuity of the user.

Chapter 1- Introduction to Design

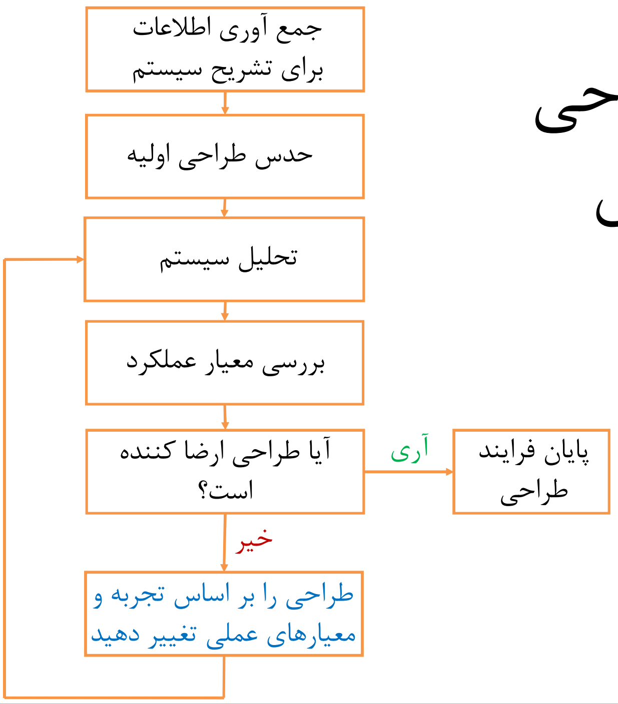
یک الگوی تکامل سیستم



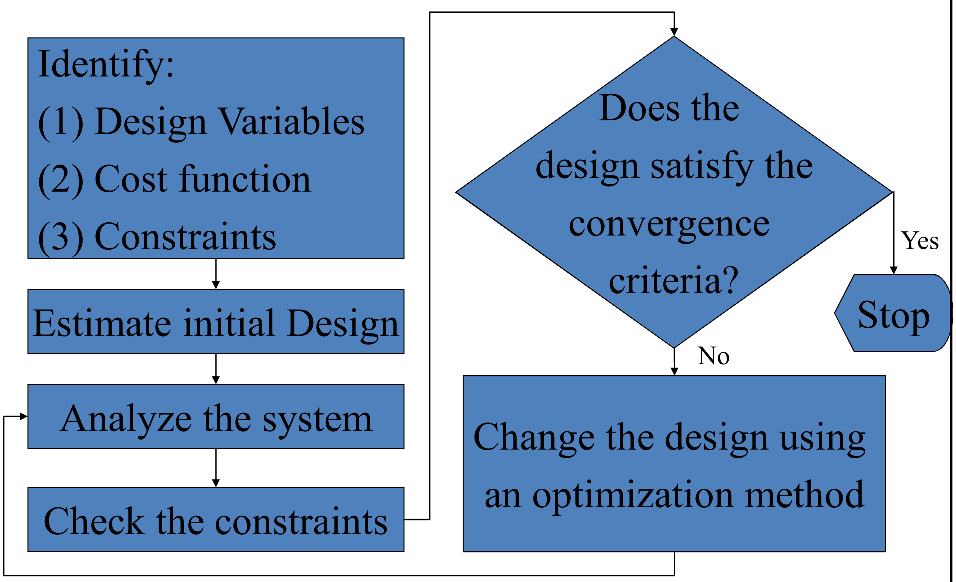
مربوط به تولید انبوه

طراحی قراردادی و بهین می‌تواند در هر یک از مراحل تکامل سیستم استفاده شود.

فرایند طراحی قراردادی



Optimum Design Process

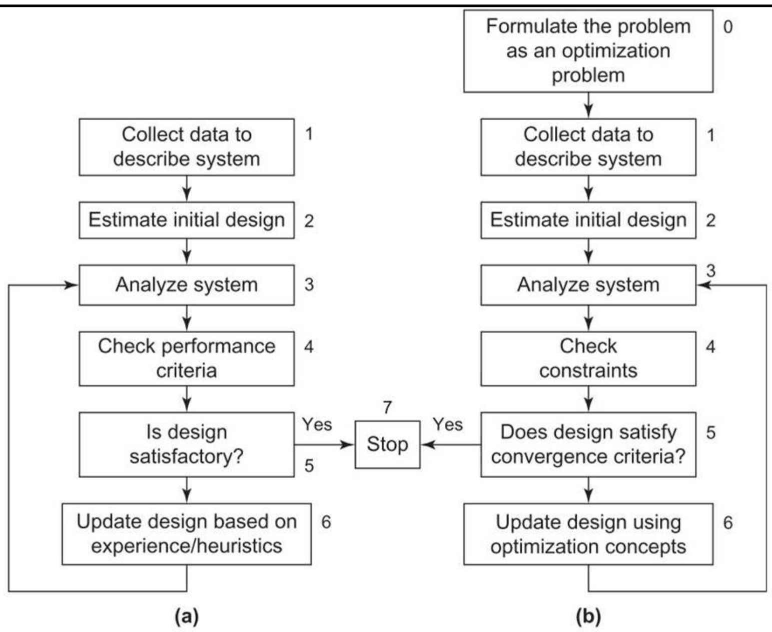


The optimist sees the glass half full.

The pessimist sees the glass half empty.

The optimization engineer sees the glass over designed.

Vanderplaats Research & Development, Inc.



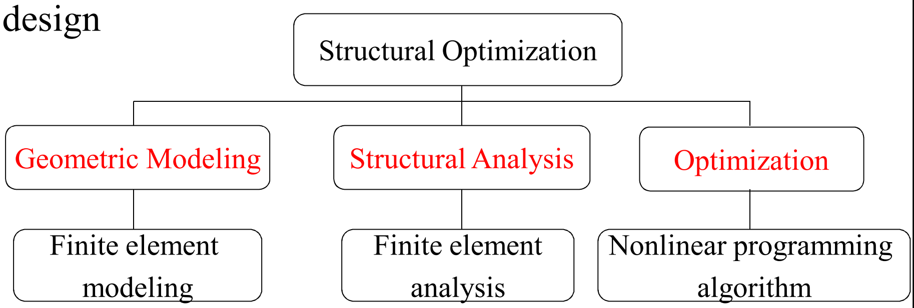
Comparison of (a) conventional design method and (b) optimum design method.

Structural Optimization

Structural optimization is an automated synthesis of a mechanical component based on structural properties.

For this optimization, we need:

- A geometric modeling tool to represent the shape
- A structural analysis tool to solve the problem
- An optimization algorithms to search for the optimum design



Forms of Structural Optimization

1- Size Optimization

Keeps a design's shape and topology unchanged while modifying specified dimensions of the design.

The object of size optimization is to find the appropriate combination of member sizes that meet some optimality objectives.

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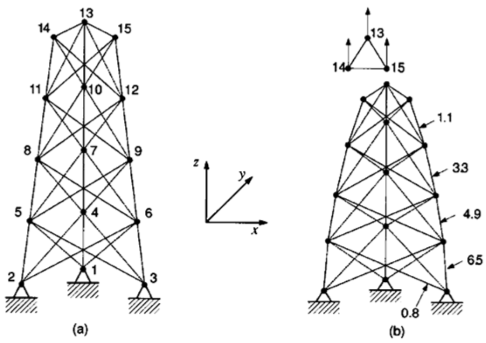
Size Optimization



•Size and configuration optimization of a truss, design variables are the cross sectional areas and nodal coordinates of the truss.

•The truss could also be optimized for material.

•The topology or connectivity of the truss is fixed.

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2- Topology Optimization

Topological optimization is a form of "shape" optimization, sometimes referred to as "layout" optimization.

Topology optimization is a mathematical approach that optimizes material layout within a given design space, for a given set of loads and boundary conditions such that the resulting layout meets a prescribed set of performance targets.

Using topology optimization, engineers can find the best concept design that meets the design requirements.

Topology optimization has been implemented through the use of finite element methods for the analysis, and optimization techniques based on the method of moving asymptotes, genetic algorithms, optimality criteria method, level sets, and topological derivatives.

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2- Topology Optimization(Cont'd)

The object of topology optimization is to have no restriction on the final form of the structure and to find the best use of material.

The traditional single criterion has been the Fully Stressed Design (FSD) where, ideally, all the material is at the same stress.

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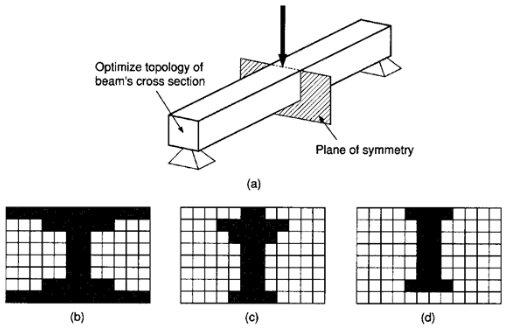
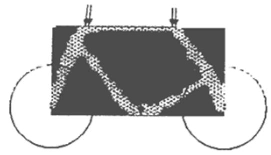
Topology Optimization





• Optimum shapes of the cross section of a beam for plastic (b), aluminum (c), and steel (d)

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3- Shape Optimization

In order to obtain a globally optimal shapes, topology must be also modified, allowing the creation of new boundaries.

The object of shape optimization is to find the best shape that will have the best stress outcome.

With shape optimization the topology of the structure is known.

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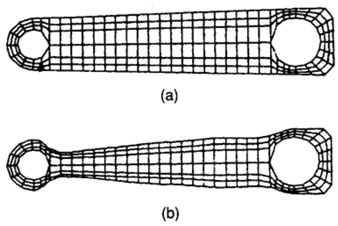
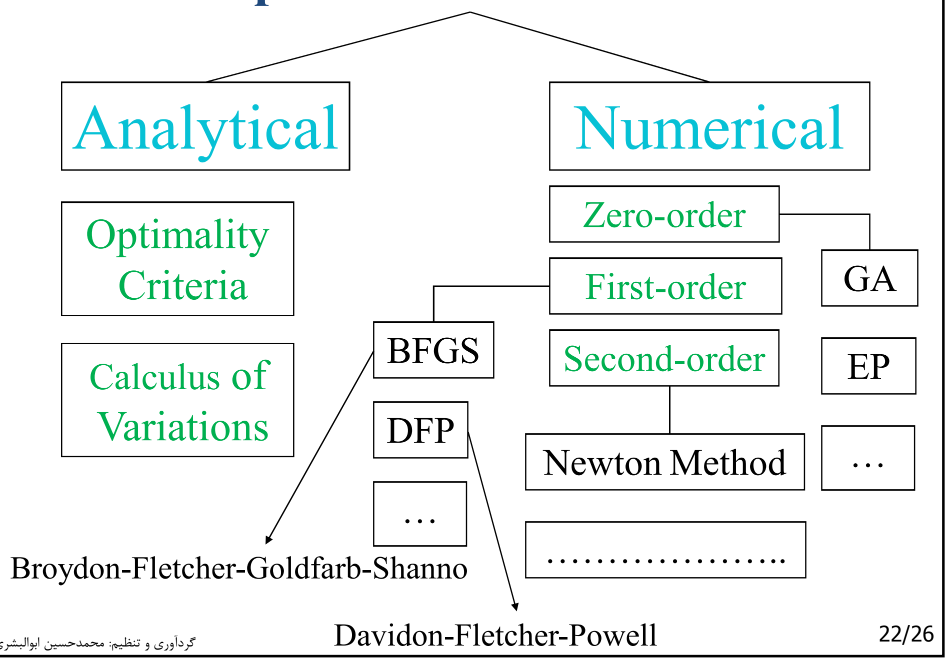
Shape Optimization



Shape optimization of a torque arm. Parts of the boundary are treated as design variables.

Optimization Methods



Methods for Structural Optimization

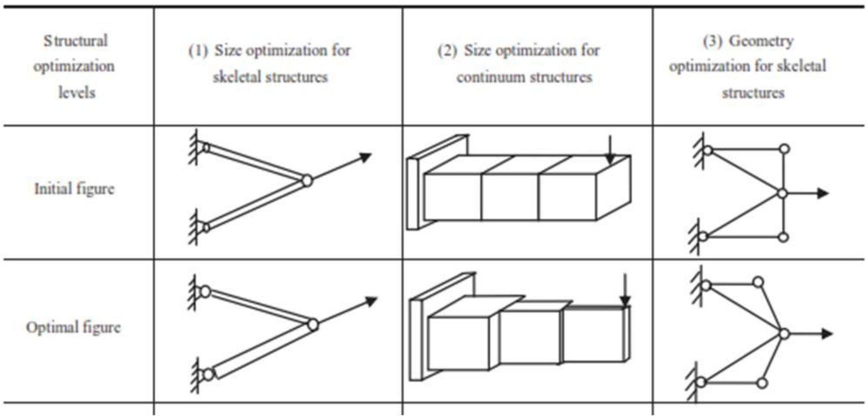
- Search (Vanderplaats, 1984)
- Optimality Criteria (Rozvany, 1989)
- Evolutionary Structural Optimization (Xie and Steven, 1997)

The structural optimization can be divided into three levels from low to high, according to the development levels. They can be described from engineering and mathematics, respectively:

Viewpoint	Low level	Middle level	High level
Engineering viewpoint	Cross section	Shape	Layout
Mathematical viewpoint	Size	Geometry	Topology

[1] Y. Sui, X. Peng, Modeling, Solving and Application for Topology Optimization of Continuum Structures, ICM Method Based on Step Function, Butterworth-Heinemann is an imprint of Elsevier, United Kingdom, 2018.

Levels of structural optimization



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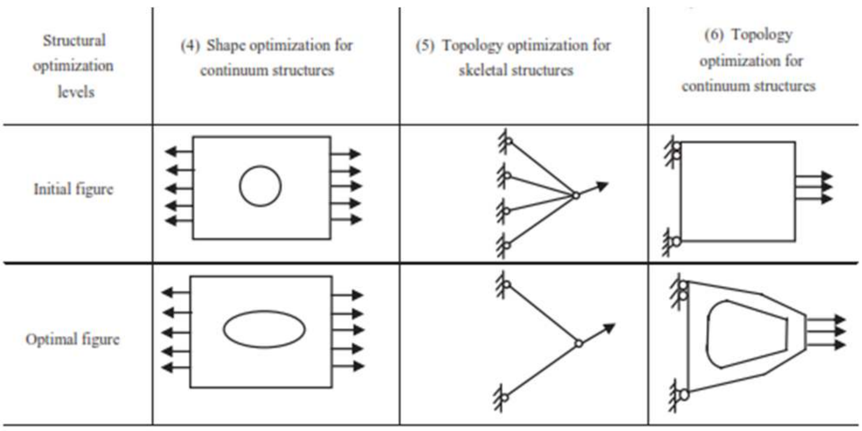
Levels of structural optimization



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