CAD/CAM (21-342)

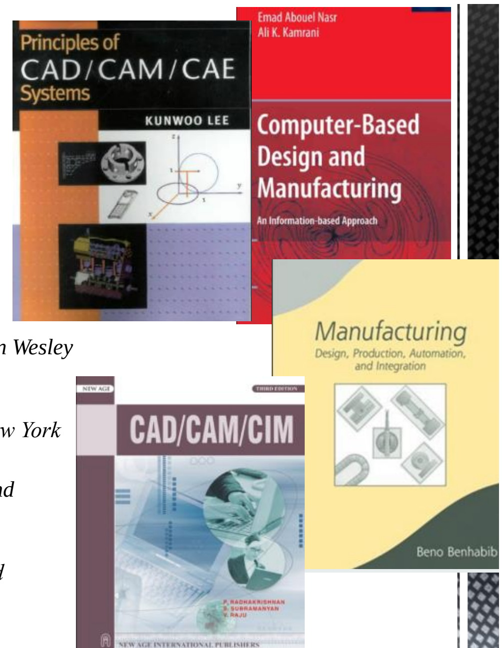
Advanced Manufacturing Laboratory
Department of Industrial Engineering
Sharif University of Technology

Session # 10

Course Description

- Instructor
  - Omid Fatahi Valilai, Ph.D. Industrial Engineering Department, Sharif University of Technology
  - Email: FValilai@sharif.edu , Tel: 6616-5706
  - Website: Sharif.edu/~fvalilai
- Class time
  - Saturday- Monday 10:30-12:00
- Course evaluation
  - Mid-term (25%)
  - Final exam (40%)
  - Quiz (5%)
  - Exercise (30%)

Course Description *(Continued ...)*



- *Mid-term session:*
  - *Monday: 8th Ordibehesht 1393, 10:30 ~ 12:30*
- *Final Exam:*
  - *Saturday: 24th Khordad 1393, 15:00 ~ 17:30*
- *Reference:*
  - *Lee, Kunwoo; "Principles of CAD/CAM/CAE systems", 1999, Addsion Wesley*
  - *Abouel Nasr, Emad; Kamrani, Ali K.; "Computer-Based Design and Manufacturing: An Information-Based Approach", 2007, Springer, New York*
  - *Benhabib, Beno; "Manufacturing: Design, Production, CAD/CAM, and Integration", 2003, Marcel Dekker Inc, New York*
  - *Radhakrishnan, P.; Subramanian, S.; Raju, V.; "CAD/CAM/CIM", 3rd edition, 2005, New age international (P) limited publishers, New York*

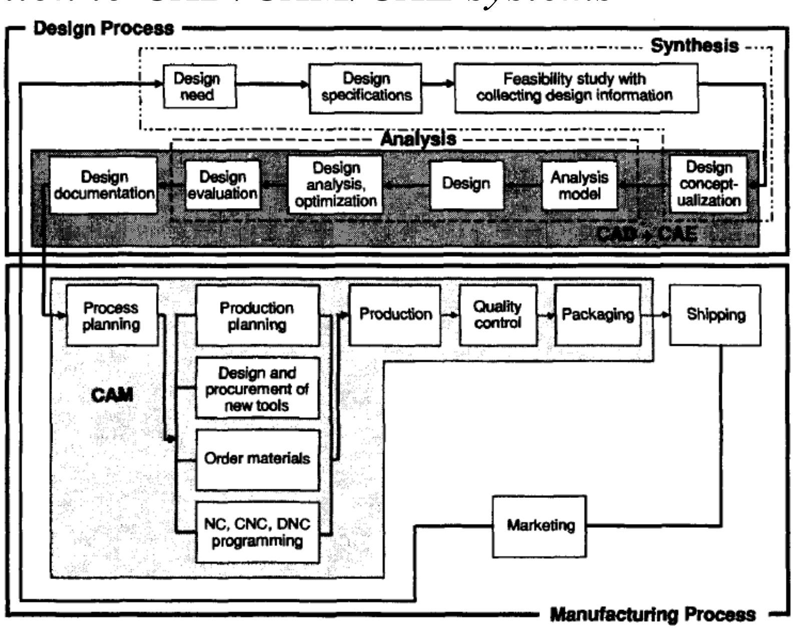
Course Description *(Continued..)*

- *Contents:*
  - *Introduction to CAD/CAM/CAE systems* *(5 sessions)*
  - *Components of CAD/CAM/CAE systems* *(2 sessions)*
  - *Geometric modeling systems* *(3 sessions)*
  - *Optimization in CAD* *(5 sessions)*
  - *Rapid prototyping and manufacturing* *(3 sessions)*
  - *Virtual engineering* *(2 sessions)*
  - *Product Life Cycle Cost Model* *(2 sessions)*
  - *Computer-Based Design and Features/Methodologies of Feature Representations* *(5 sessions)*
  - *Feature-Based Process Planning and Techniques* *(3 sessions)*
  - *Collaborative Engineering* *(2 sessions)*

Course Description *(Continued..)*

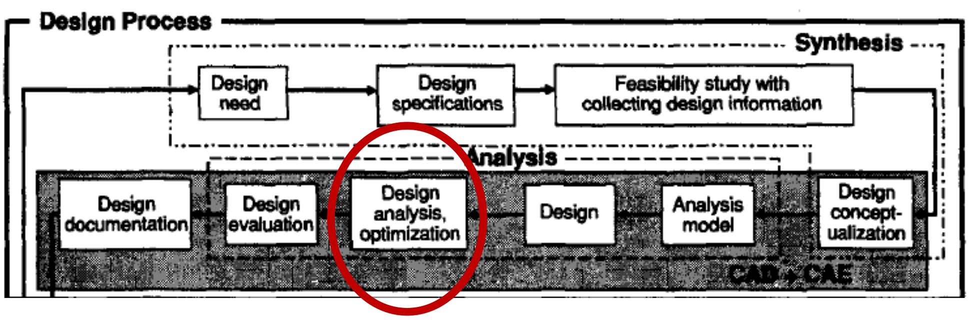
- *Contents:*
  - *Optimization in CAD* *(5 sessions)*
    - *Optimization of optimization problems*
    - *Treatments of constraints*
    - *Search models*
    - *Simulated annealing*
    - *Genetic algorithms*
    - *Structural optimization*

Introduction to CAD/CAM/CAE systems



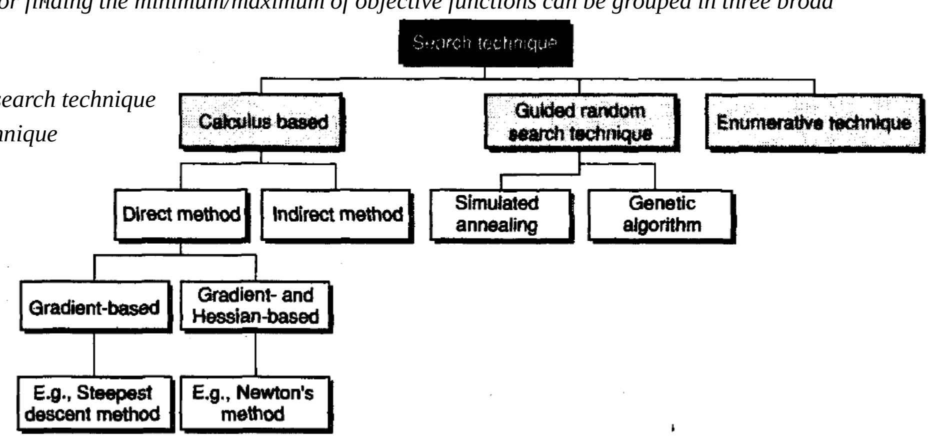
Geometric modeling systems

- *Optimization in CAD*



Geometric modeling systems

- *Optimization in CAD*
  - *Search techniques for finding the minimum/maximum of objective functions can be grouped in three broad classes:*
    - *Calculus based*
    - *Guided random search technique*
    - *Enumerative technique*



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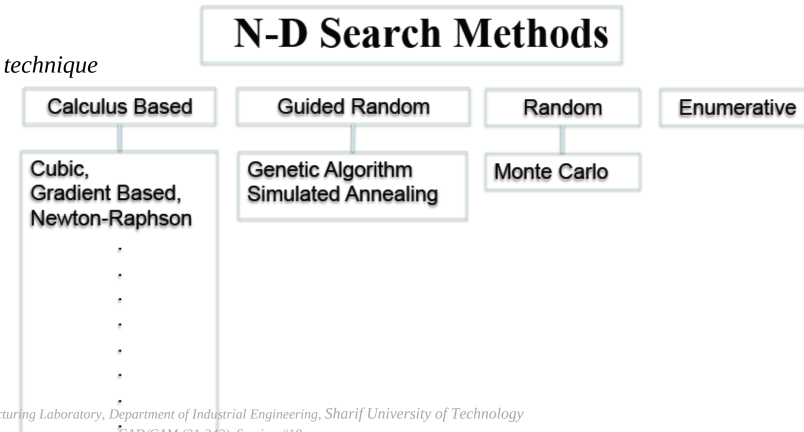
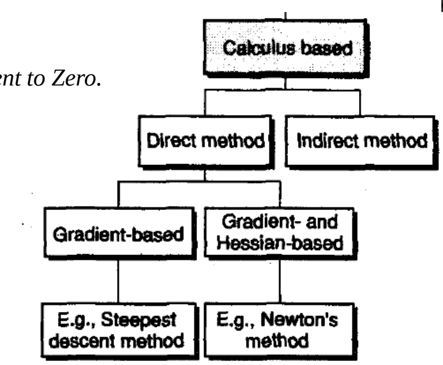


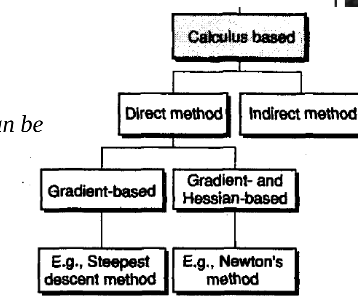
Geometric modeling systems

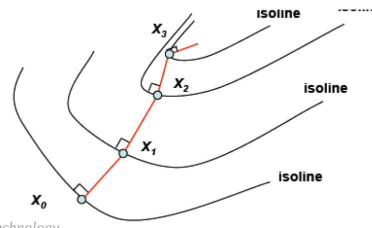
- *Optimization in CAD*
  - *Search techniques for finding the minimum/maximum of objective functions can be grouped in three broad classes:*
    - *Calculus based*
      - *Indirect method: knowing the objective function set the gradient to Zero.*
      - *Direct Methods:*
        - *Steepest Descent method*
        - *Different flavors of Newton methods*



Geometric modeling systems

- Optimization in CAD
  - *Search techniques for finding the minimum/maximum of objective functions can be grouped in three broad classes:*
    - *Calculus based*
      - *Indirect method: knowing the objective function set the gradient to Zero.*
      - *Direct Methods:*
        - *Steepest Descent method*
        - *The gradient of a scalar field is a vector field which points in the direction of the greatest rate of increase of the scalar field, and whose magnitude is the greatest rate of change*



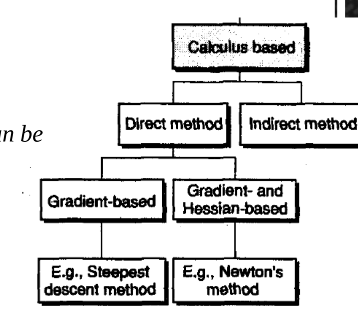


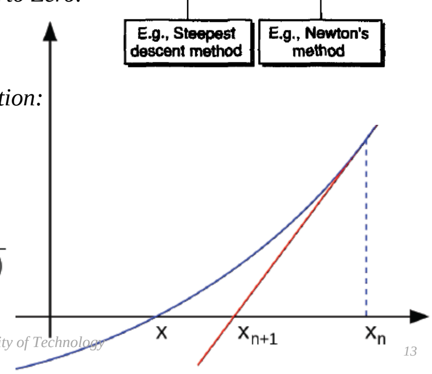
Gradient always normal to isoline

Geometric modeling systems

- Optimization in CAD
  - *Search techniques for finding the minimum/maximum of objective functions can be grouped in three broad classes:*
    - *Calculus based*
      - *Indirect method: knowing the objective function set the gradient to Zero.*
      - *Direct Methods:*
        - *The Newton-Raphson method is defined by the recurring relation:*

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$





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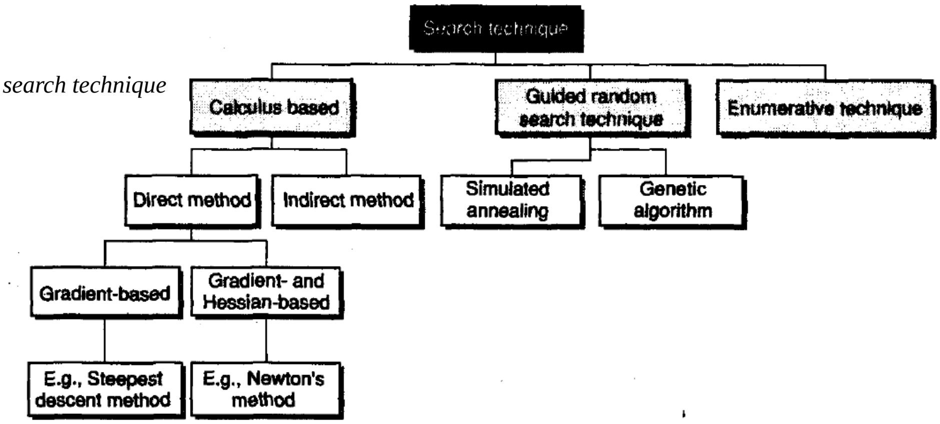
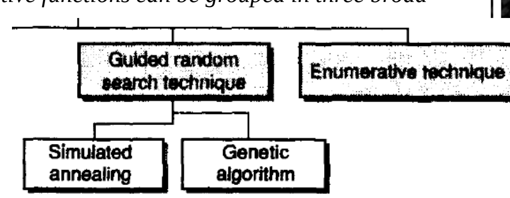


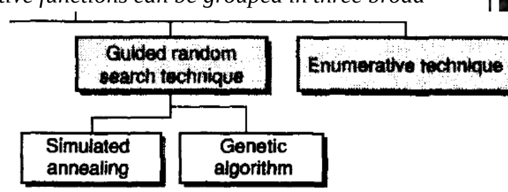
Geometric modeling systems

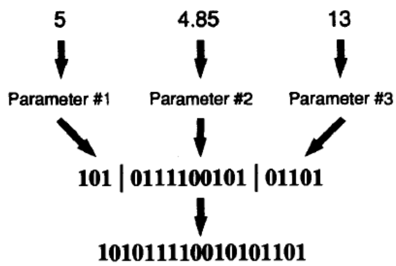
- *Optimization in CAD*
  - *Search techniques for finding the minimum/maximum of objective functions can be grouped in three broad classes:*
    - *Calculus based*
    - *Guided random search technique*
      - *Genetic algorithm*
        - *Valid for discrete variables*
        - *One of the best "all purposes" search method.*
        - *Emulates the genetic evolution due to the "survival of the fittest"*
        - *Each variable value >a GENE, a binary string value in the variable range*
        - *Vector variables X> a CHROMOSOME, a concatenation of a random*
        - *combinations of Genes (strings) one per type (one value per variable). A Chromosome (Xi) is a point in the X domain and is also defined as genotype.*
        - *Objective Function F(X)>phenotype. F(Xi) is a point in the Objective Function domain corresponding to Xi .*



Geometric modeling systems

- Optimization in CAD
  - Search techniques for finding the minimum/maximum of objective functions can be grouped in three broad classes:
    - Calculus based
    - Guided random search technique
      - Genetic algorithm





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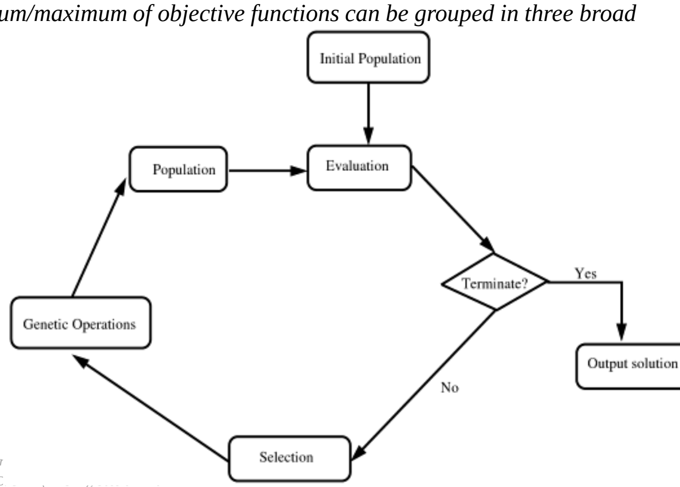
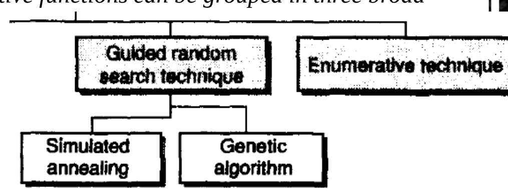


Geometric modeling systems

- Optimization in CAD
  - Search techniques for finding the minimum/maximum of objective functions can be grouped in three broad classes:
    - Calculus based
    - Guided random search technique
      - Simulated annealing



- The name and inspiration come from annealing

in metallurgy, a technique involving heating and controlled cooling of a material to increase the size of its crystals and reduce their defects.

The slow cooling gives them more chances of finding configurations with lower internal energy than the initial one.

Geometric modeling systems

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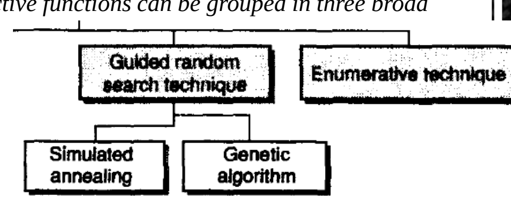

- In the simulated annealing (SA) method, each point s of the search space is analogous to a state of some physical system, and the function E(s) to be minimized is analogous to the internal energy of the system in that state. The goal is to bring the system, from an arbitrary initial state, to a state with the minimum possible energy.

Geometric modeling systems

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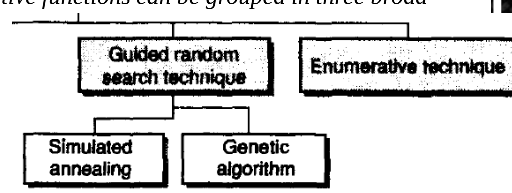
      - *Simulated annealing*



- *By analogy with this physical process, each step of the SA algorithm attempts to replace the current solution by a random solution (chosen according to a candidate distribution, often constructed to sample from solutions near the current solution).*
- *The new solution may then be accepted with a probability that depends both on the difference between the corresponding function values and also on a global parameter T (called the temperature), that is gradually decreased during the process*

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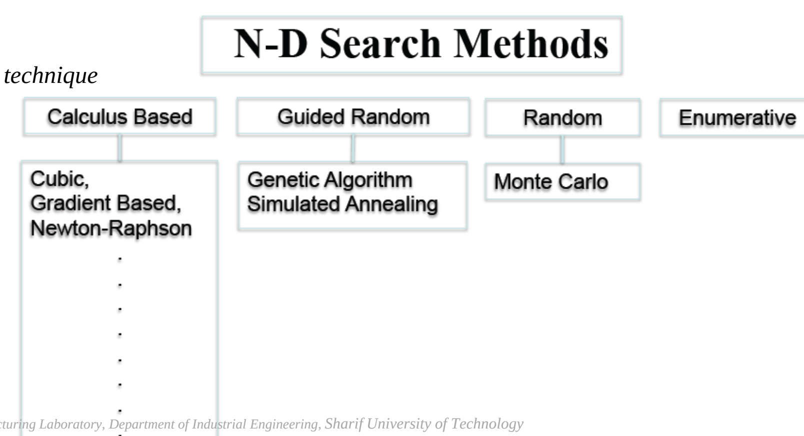

Geometric modeling systems

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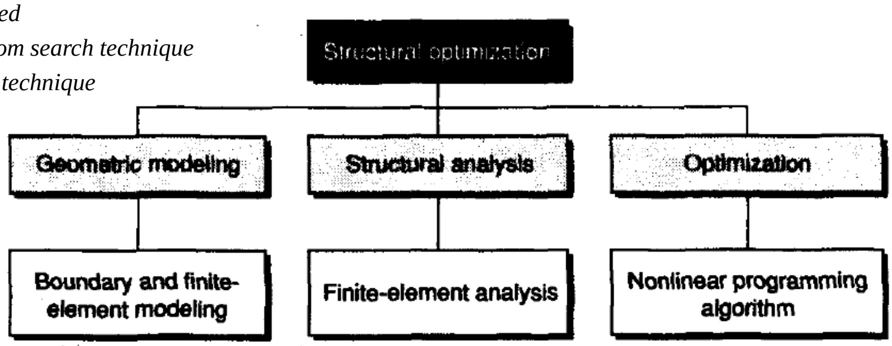
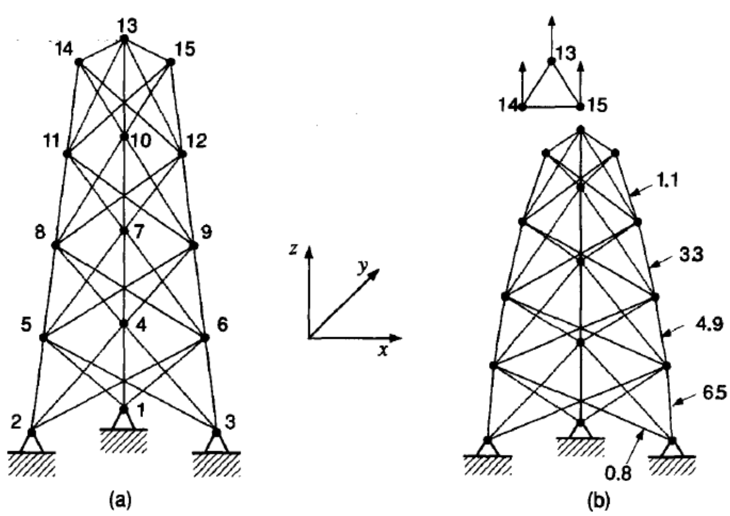


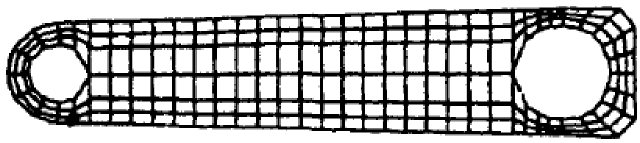
Geometric modeling systems

- *Optimization in CAD*
  - *Structural Optimization*
    - *Sizing Optimization*

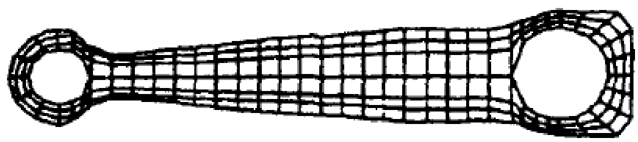


Geometric modeling systems

- Optimization in CAD
  - Structural Optimization
    - Shape Optimization



(a)



(b)