

# 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	
<ul> <li>Mid-term</li> </ul>	(25%)
<ul> <li>Final exam</li> </ul>	(40%)
<ul> <li>Quiz</li> </ul>	(5%)
Exercise	(30%)

Emad Abouel Na Ali K. Kamrani

Computer-Based Design and

Manufacturing

Manufacturing

Principles of

CAD/CAM/CAE

KUNWOO LEE

CAD/CAM/CII

### Course Description (Continued ...)

- Mid-term session:
  - Monday: 8th Ordibehesht 1393, 10:30 ~ 12:30
- Final Exam:
  - Saturday: 24<sup>th</sup> 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

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### Course Description (Continued..)

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

### Course Description (Continued..)

Contents:

- Optimization in CAD
  - Optimization of optimization problems
  - Treatments of constraints
  - Search models
  - Simulated annealing
  - Genetic algorithms
  - Structural optimization

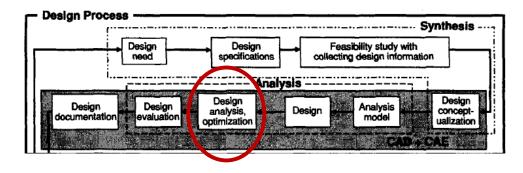
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## Introduction to CAD/CAM/CAE systems

Design Process				Sj	nthesis
	esign veed	Design specifications	Feasib collecting o	ility study with design information	
i		Analy	sis		
Design		Design analysis,	Design	Analysis model	Design concept-
occumentation	ovaluation	ptimization			ualization
			and the state of the second	S.C.M.S.C	Law Barris
Process	Production	Production	Quality	Packaging	Shipping
planning	planning				
CAM	Design and procurement of	,]][]			
	new tools				
	Order materials				
	۹ <b>ـــــ</b>				
	NC, CNC, DNC		Marke	ting	
	programming				
	alaria da cara anteria.				

(5 sessions)

### • Optimization in CAD



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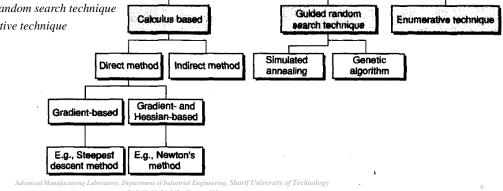
## Geometric modeling systems

#### Optimization in CAD

Search techniques for finding the minimum/maximum of objective functions can be grouped in three broad classes: Search technique



- Guided random search technique
- *Enumerative technique*



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### 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
     Calculus Based Guided Random Random

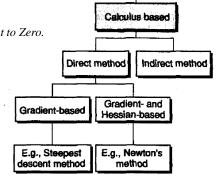
Enumerative technique	Calculus Based	Guided Random	Random	Enumerative
	Cubic, Credient Record	Genetic Algorithm	Monte Carlo	
	Gradient Based, Newton-Raphson	Simulated Annealing		
	,			
	,			
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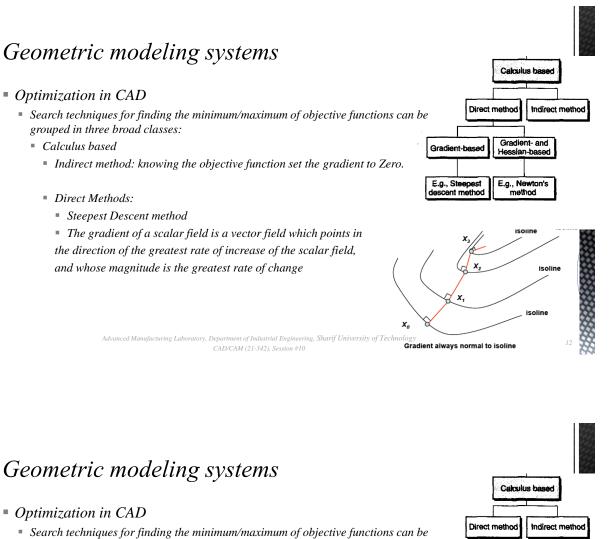
**N-D Search Methods** 

## Geometric modeling systems

#### Optimization in CAD

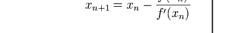
- Search techniques for finding the minimum/maximum of objective functions can be grouped in three broad classes:
  - Calculus based
    - Indirect method: knowing the objective function set the gradient to Zero.
    - Direct Methods:
      - Steepest Descent method
      - Different flavors of Newton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





- 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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Gradient- and

Hessian-based

E.g., Newton's method

x<sub>n</sub>

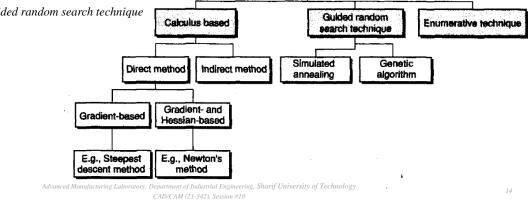
 $\mathbf{x}_{n+1}$ 

Gradient-based

E.g., Steepest descent method

### Optimization in CAD

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

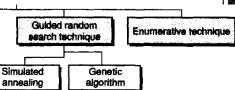


## Geometric modeling systems

#### 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.

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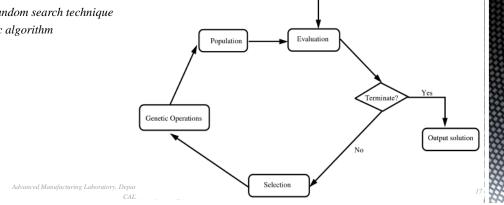


#### Geometric modeling systems Optimization in CAD Search techniques for finding the minimum/maximum of objective functions can be grouped in three broad classes: Guided random Calculus based Enumerative technique search technique Guided random search technique Genetic algorithm Genetic Simulated annealing algorithm 4.85 13 5 Parameter #2 Parameter #3 Parameter #1 101 | 0111100101 | 01101 10101111001010101101 harif University of Technology CAD/CAM (21-342), Session #10

## Geometric modeling systems

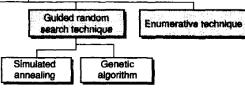
### Optimization in CAD

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



### 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.

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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

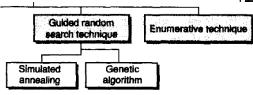
	random echnique	Enum	erative technique
Simulated annealing	Genetic		

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.



### Optimization in CAD

- Search techniques for finding the minimum/maximum of objective functions can be grouped in three broad classes:
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    - Simulated annealing

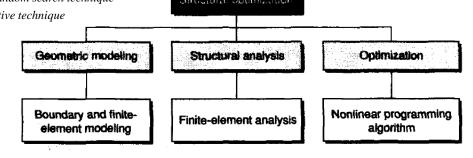


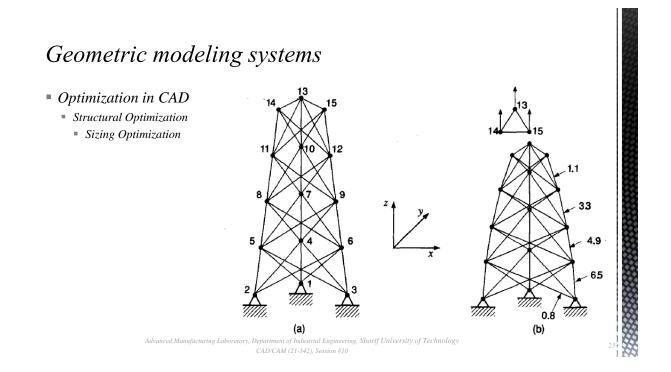
- By analogy with this physical process, each step of the SA algorithm attempts to replace the current solution by a random solution (chosen according to a candidate distribution, often constructed to sample from solutions near the current solution).
- The new solution may then be accepted with a probability 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

Optimization in CAD				
<ul> <li>Search techniques for findin classes:</li> </ul>	ng the minimum/max	imum of objective function	is can be grouped	in three broad
Calculus based		N-D Search I	Methods	
<ul> <li>Guided random search te</li> </ul>	echnique 🕓			
Enumerative technique	Calculus Based	Guided Random	Random	Enumerative
	Cubic, Gradient Based, Newton-Raphson	Genetic Algorithm Simulated Annealing	Monte Carlo	
	:			

#### Optimization in CAD

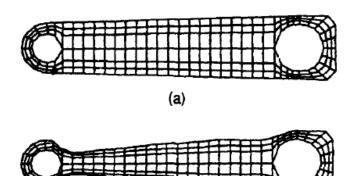
- Search techniques for finding the minimum/maximum of objective functions can be grouped in three broad classes:
  - Calculus based
  - Guided random search technique
  - *Enumerative technique*





## Geometric modeling systems

- Optimization in CAD
  - Structural Optimization
    - Shape Optimization



(b)