

# **Evolutionary Algorithms:**

## **Bird's-Eye View**

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**Prof. Chang Wook Ahn**



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**S**ungkyunkwan **E**volutionary **A**lgorithms **L**ab.  
**S**chool of Info. & Comm. Eng.  
**S**ungkyunkwan University

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# Principle of Evolutionary Algorithms

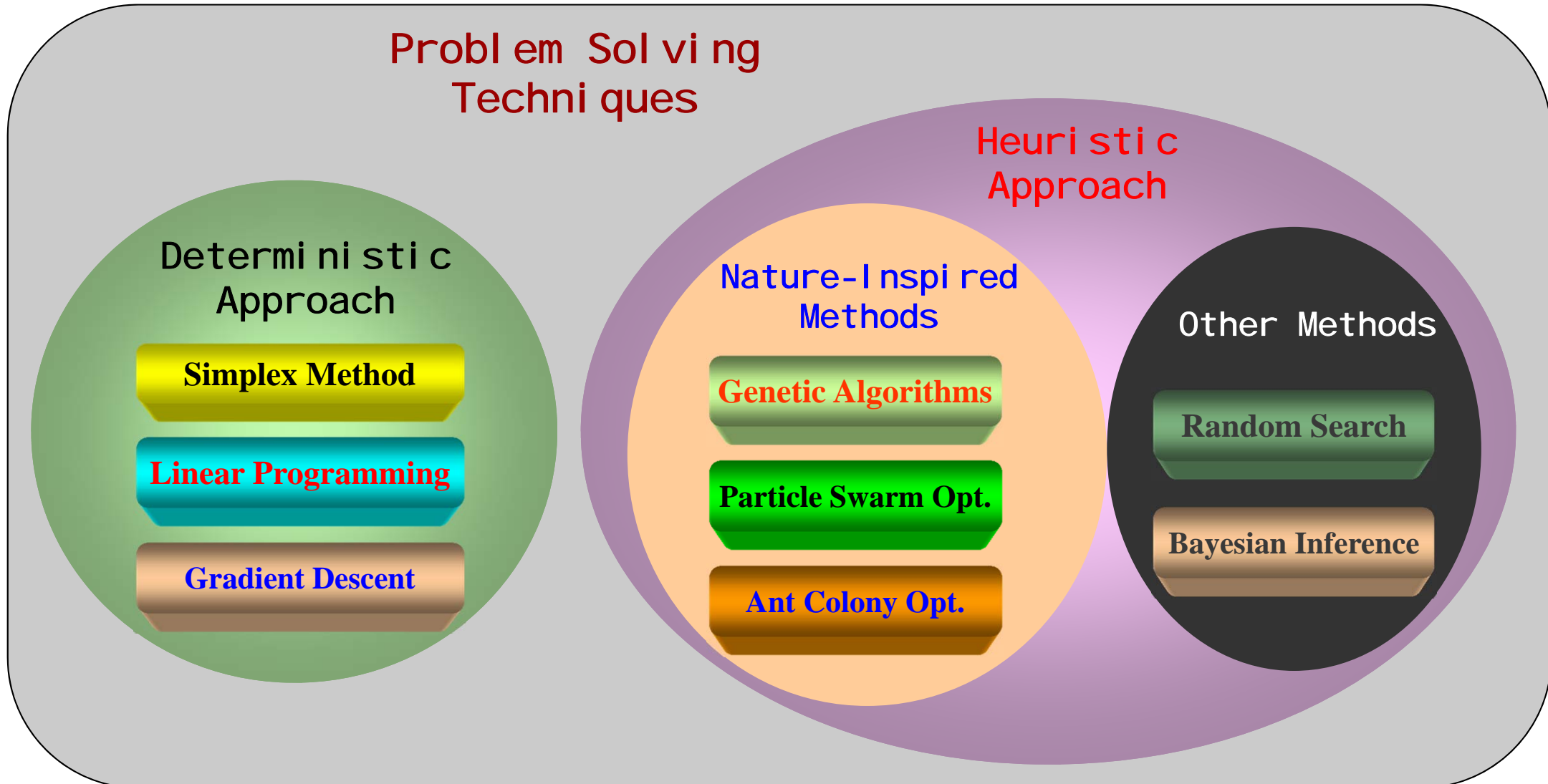




# Prologue (1)



## ● Where are Evolutionary Algorithms placed?

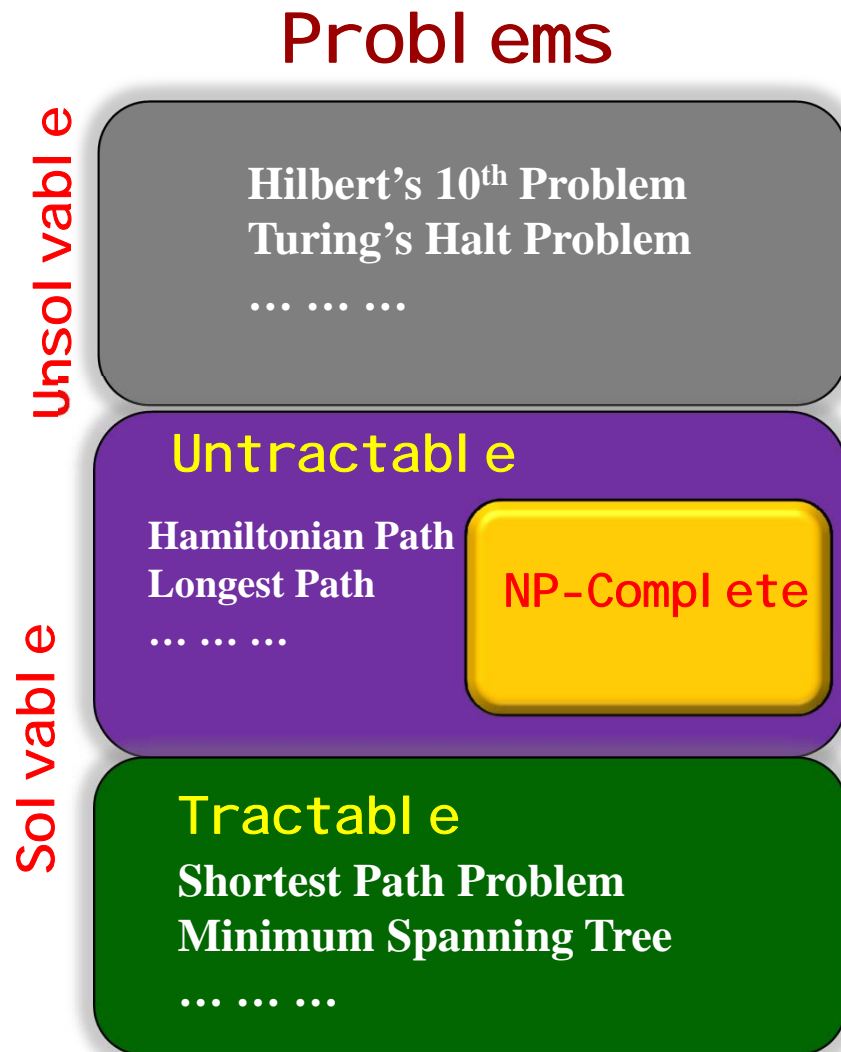




# Prologue (2)



## ● Where to be Applied?

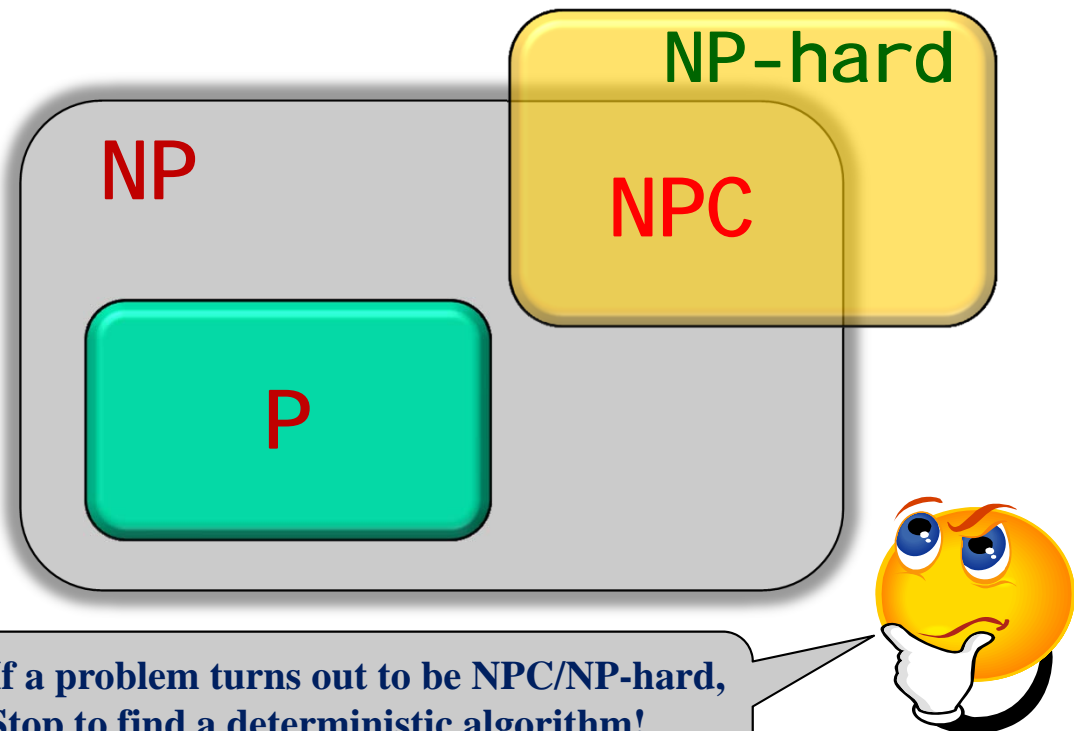


### Tractable:

- Solve the problems in a polynomial time;  
 $O(n^k)$ , not  $O(n!)$  or  $O(2^n)$

**P: Polynomial**

**NP: Nondeterministic Polynomial**



If a problem turns out to be NPC/NP-hard,  
Stop to find a deterministic algorithm!  
In this case, **EAs** become a good tool!

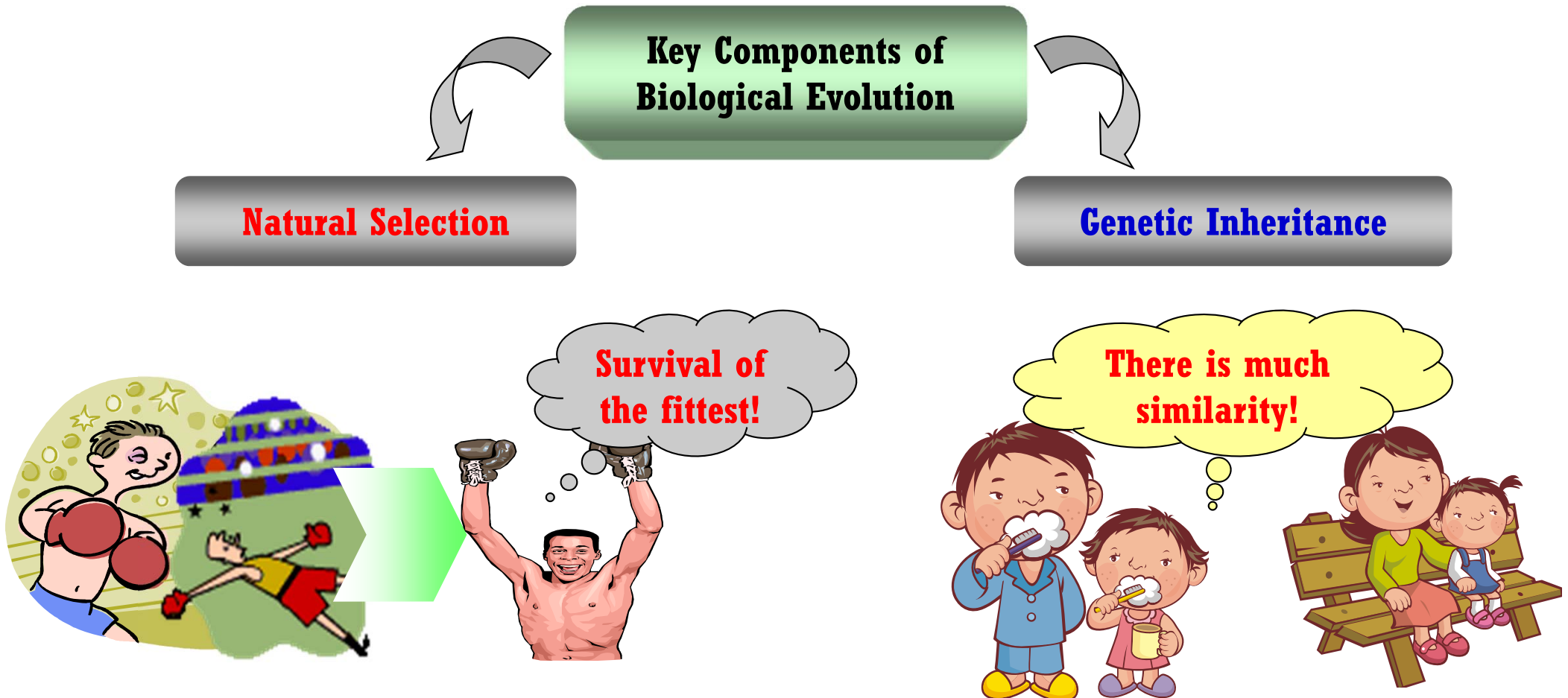


# Principle (1)



## ● What are Evolutionary Algorithms (EAs) ?

- **An algorithmic abstraction** inspired from the theory of **biological evolution**, usually implemented on computers, which is employed for resolving problems





# Principle (2)

## ● Lessons from Biological Evolution

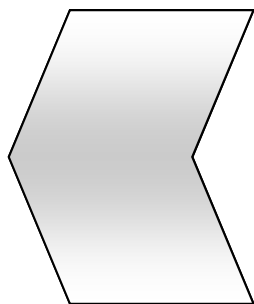
Implications for applying  
to computing techs.

Multiple

Surviving

Mixing

Generation



POPULATION

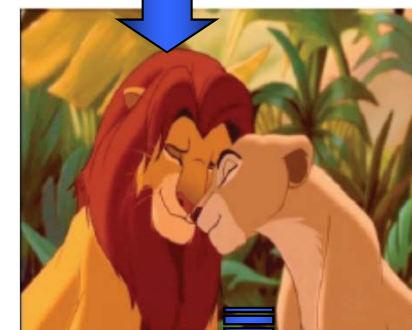
MATING POOL

MATES SELECTED

MATING

OFFSPRING

NEW POPULATION

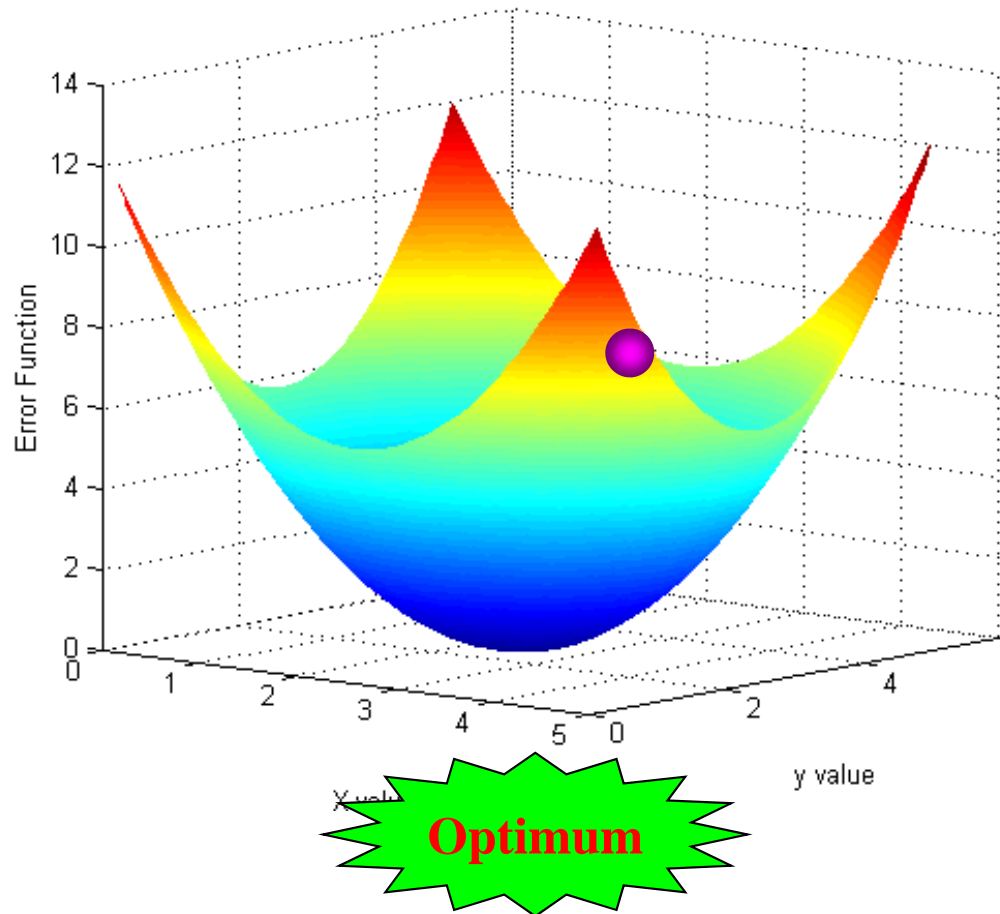




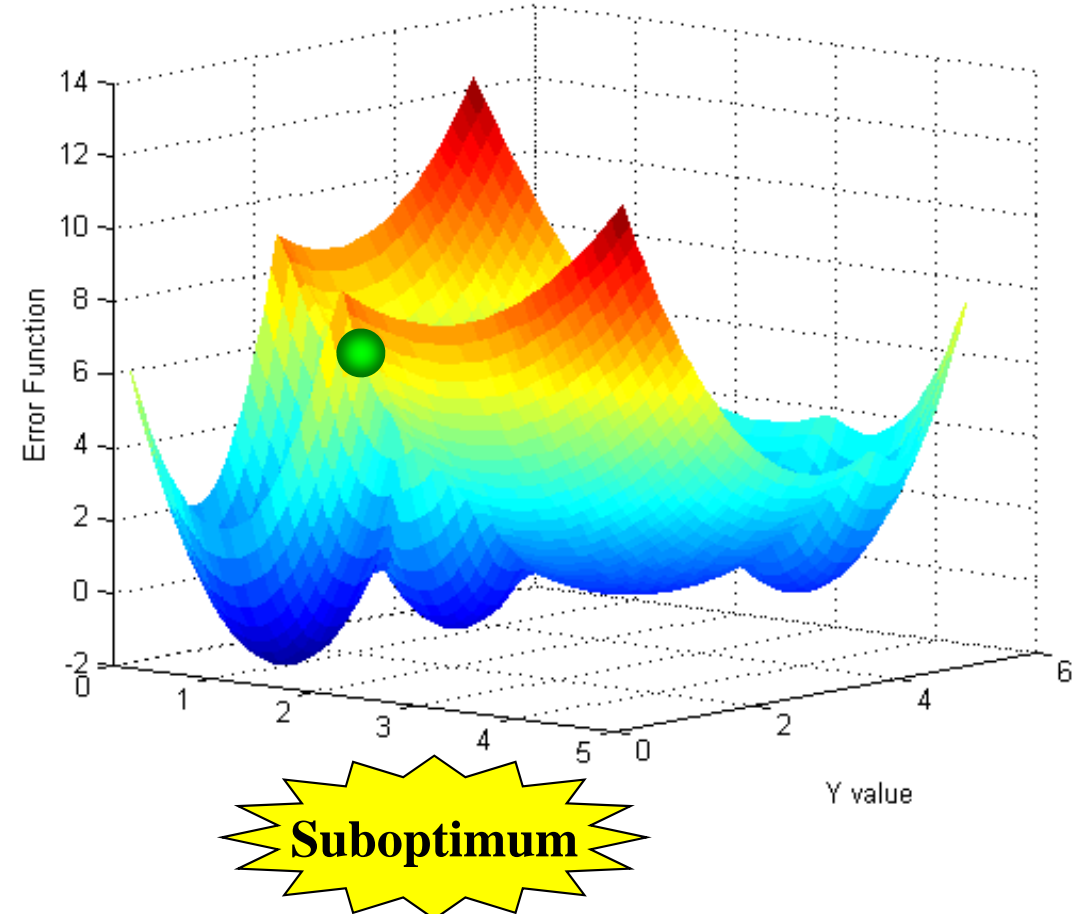
# Conventional Approach

## ● What's the Problem of Conventional (Search) Approaches?

Single nodal case



Multiple nodal case



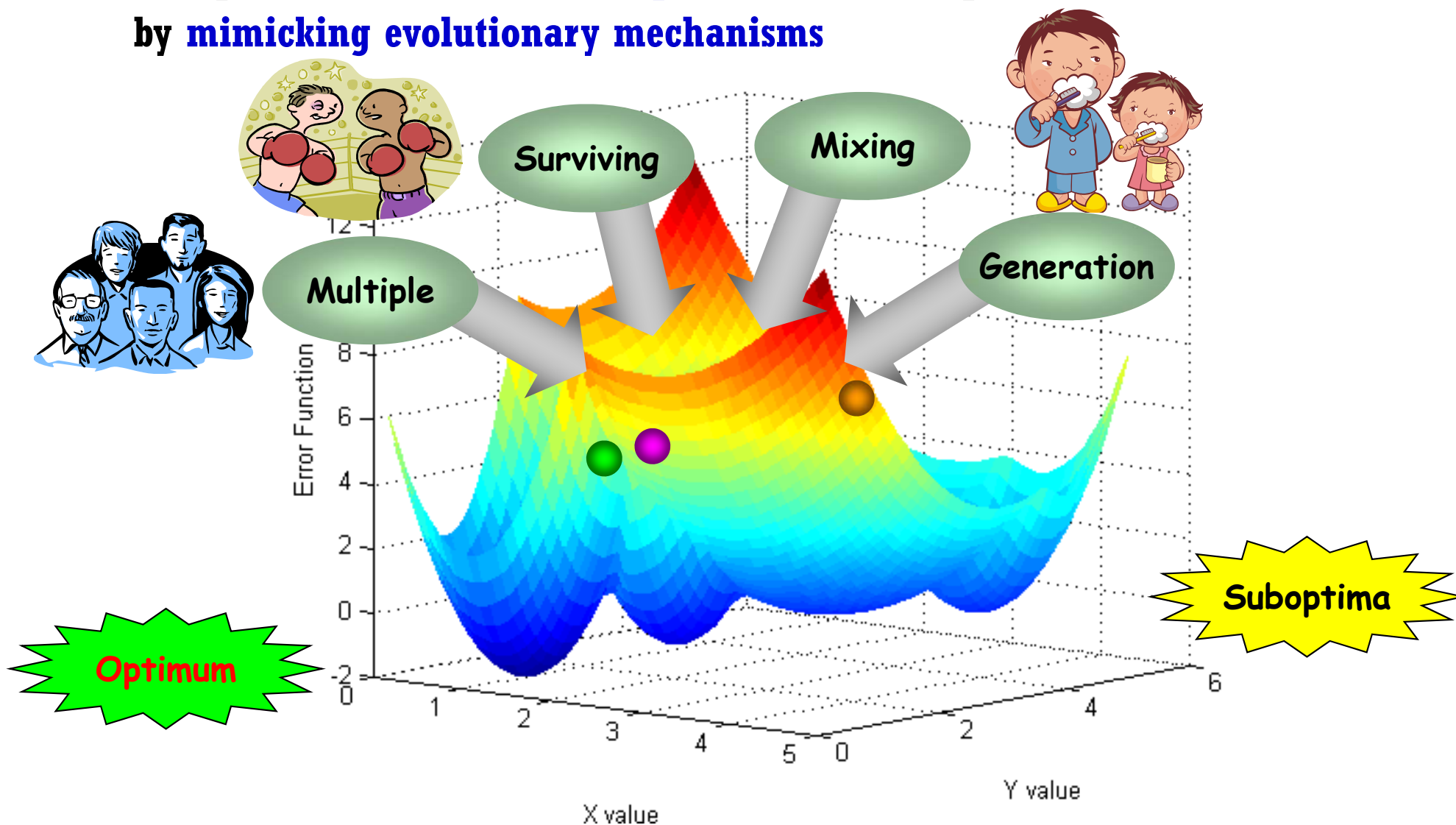




# Operational Concept

## ● Main Principle of Evolutionary Algorithms

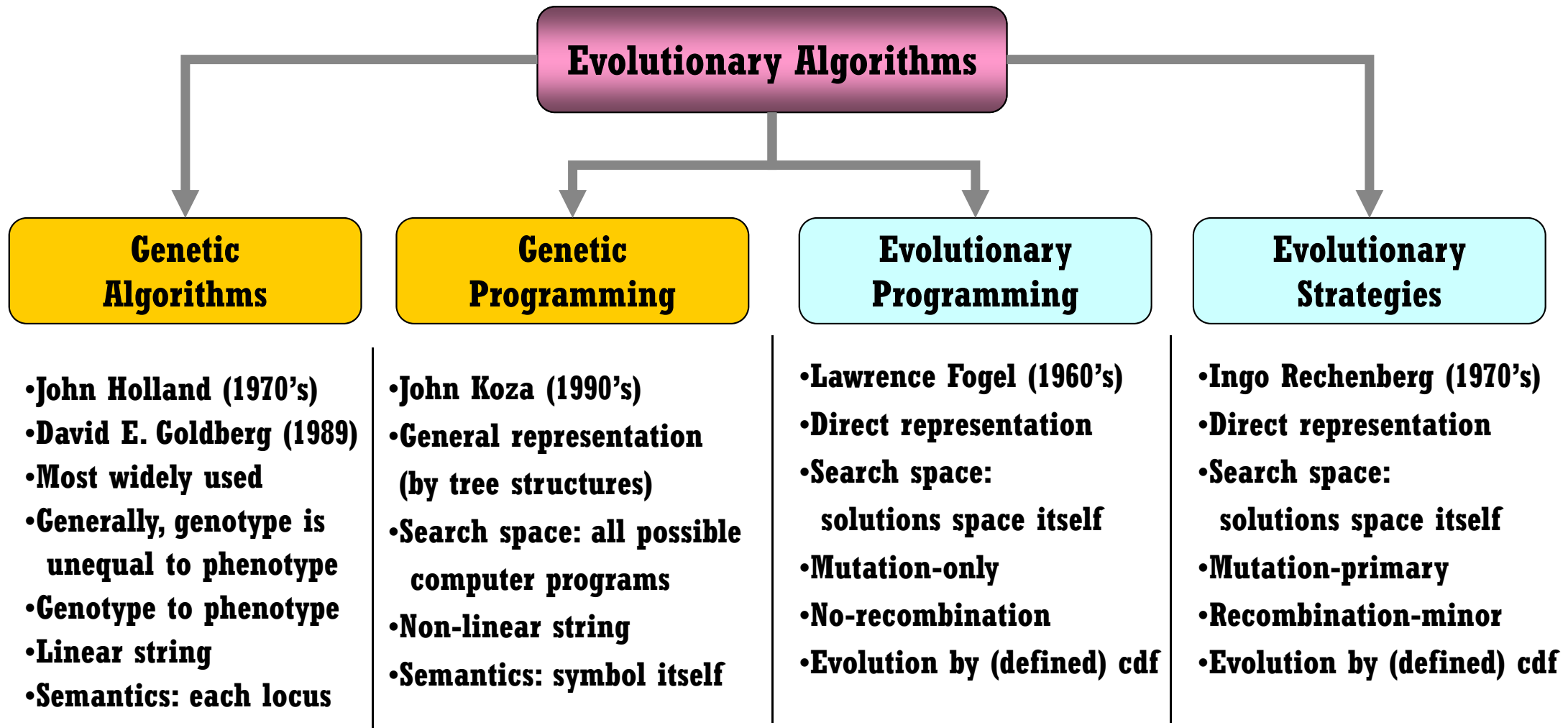
- Multiple individuals try to **cooperatively** resolve problems by **mimicking evolutionary mechanisms**



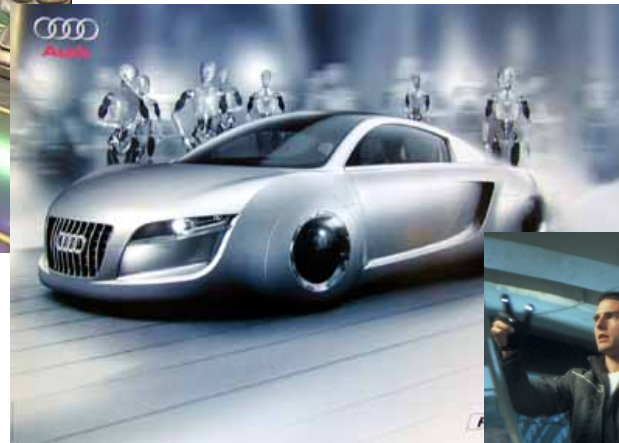


## ● Taxonomy of Evolutionary Algorithms

➤ There are four main categories; GA, GP, ES, EP



# Real-World Applications





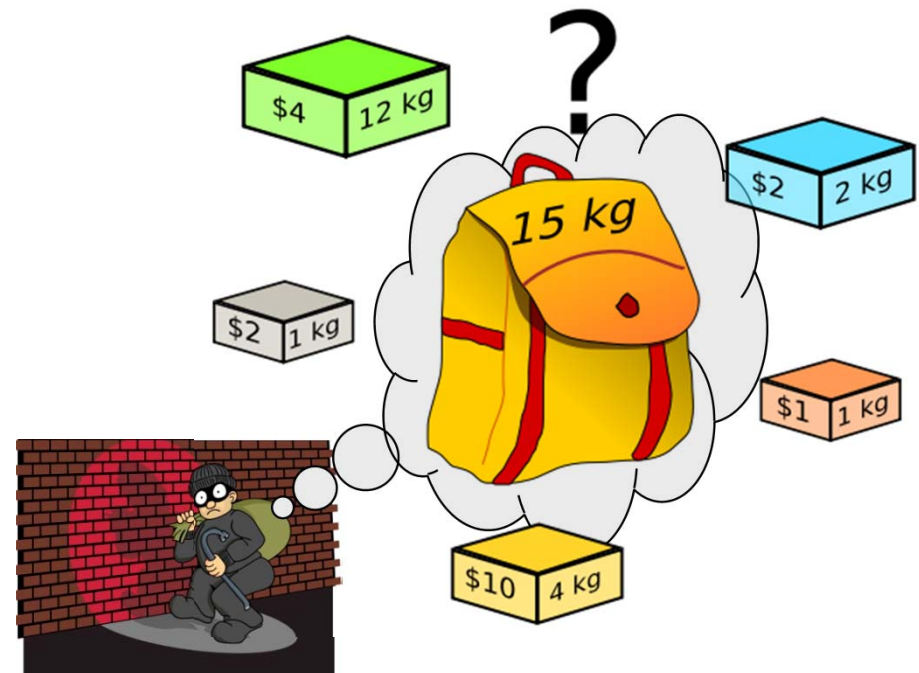
# Classical Combinatorial Problems



## Traveling Salesman Problem



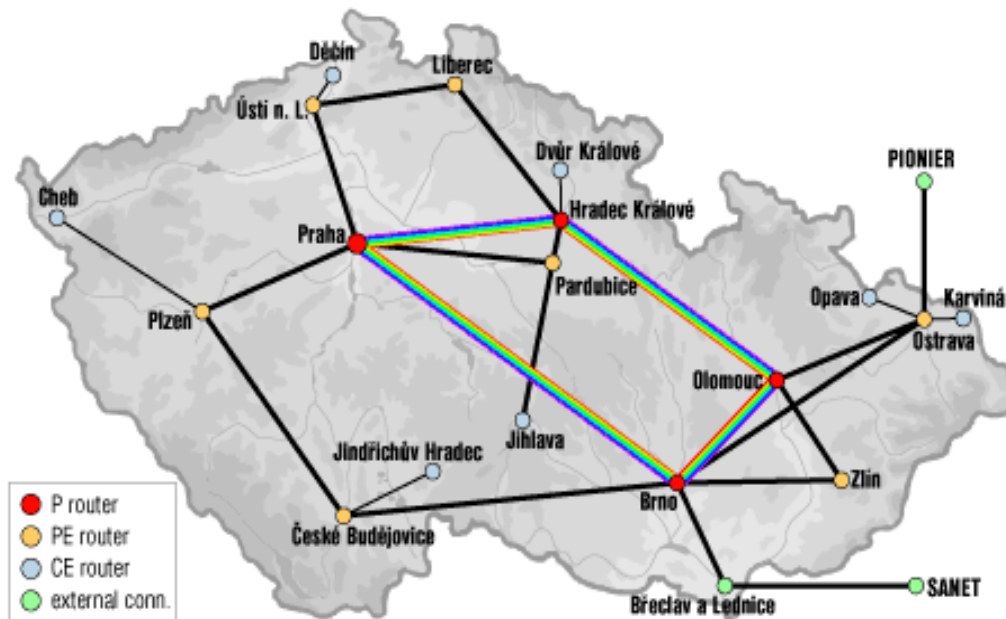
## Knapsack Problem



- Maximize the amount of profits (e.g., money) while still keeping the overall weight under or equal to a given limit!

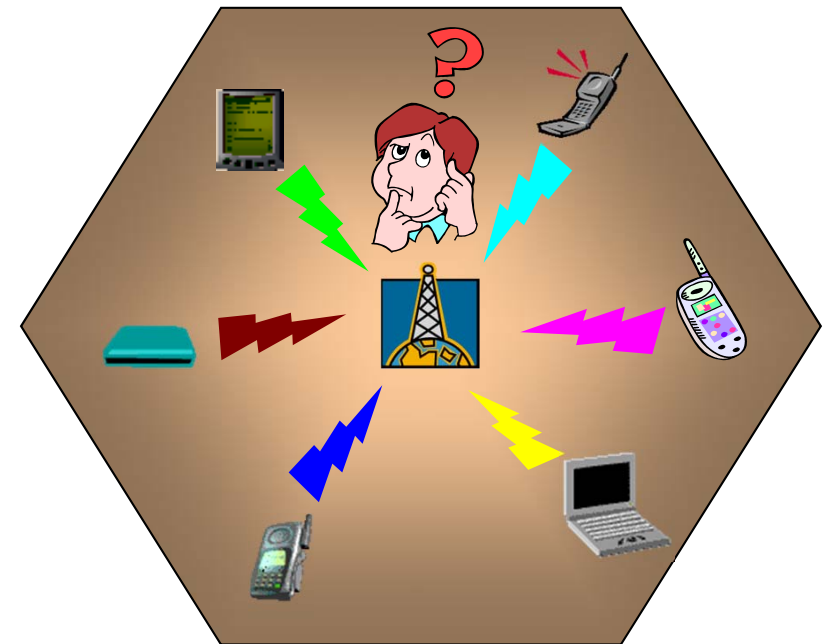


## Multicast Routing



- Minimize the cost of multicast tree while satisfying delay and bandwidth constraints

## Resource Allocation



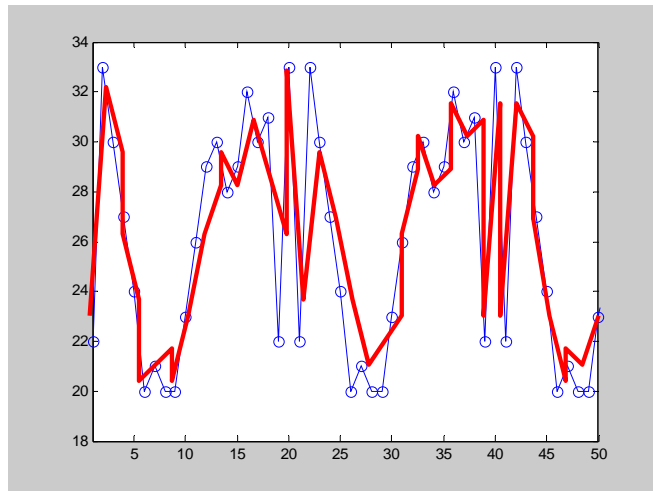
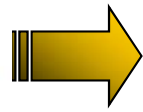
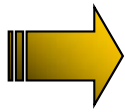
- Maximize resource utilization by fairly distributing wireless resources among the connections





## Time-Series Forecasting

CRC40	6.380	10H01	➡ +1,85%
SBF120	4.315	10H01	➡ +1,69%
SBF250	4.042	10H01	➡ +1,55%
FMDCRC	2.667	10H01	➡ +0,10%
INDICE RM	4.450	10H01	➡ -0,66%



- Predicting some future outcomes from a set of historical events
- Stock prediction, Weather forecasting, etc.

## Decision in Dilemma



- Choosing a decision in conflict objectives
- Prisoner's dilemma, Game theory, etc.



# Game



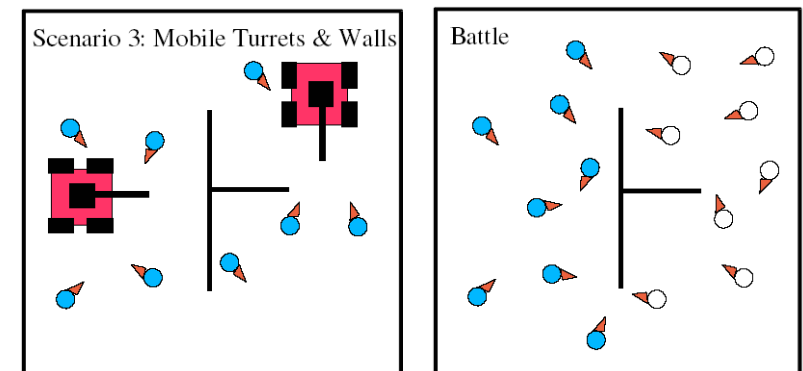
## ● Evolutionary Checker

- 8X8 board, 12 checkers for each player
  - Diagonal moves, Jumps are forced, etc.
- **Neural Networks + Evolutionary Prog.**
  - Checkerboards are evaluated by NNs
  - NNs and King value are evolved with EP
- Almost **the expert level without knowledge**



## ● Video Game: NERO

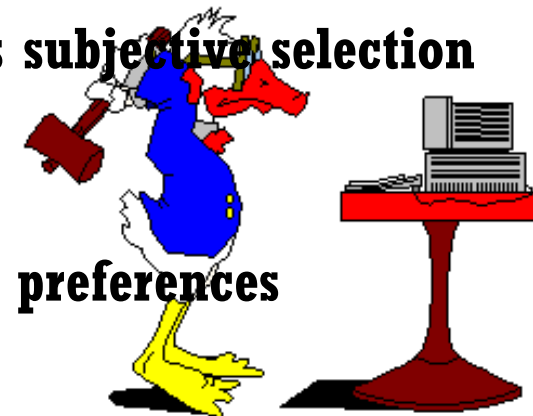
- Univ. of Texas at Austin
- Player's role
  - Train agents for competition
- **No prepackaged or scripted agents**
- **Evolve in real-time**



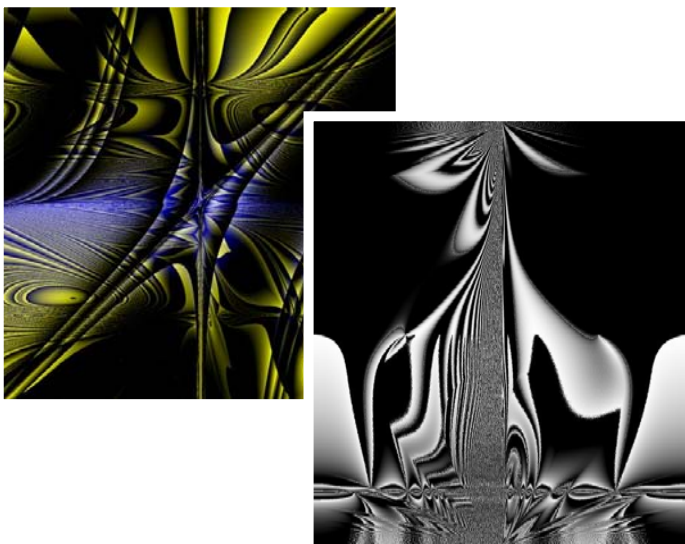


## ● What's Evolutionary Art?

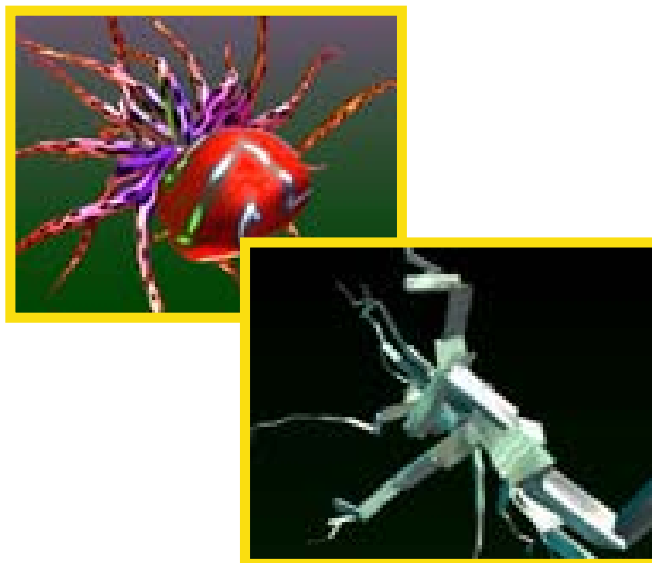
- **Technically, it is creating pieces of art through human-computer interaction**
- **Computer runs evolutionary algorithms and human applies subjective selection**
  - Role of computers: offer choices and create diversity
  - Role of human: make (subjective) choices and reduce diversity
- **Selection (aesthetic/subjective) steers towards implicit user preferences**



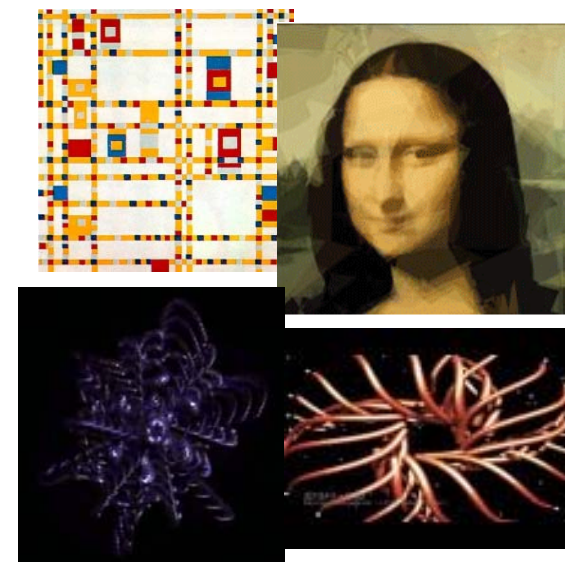
Evol. Art by Kleiweg



Galapagos by Karl Sims



Other Examples







# Music

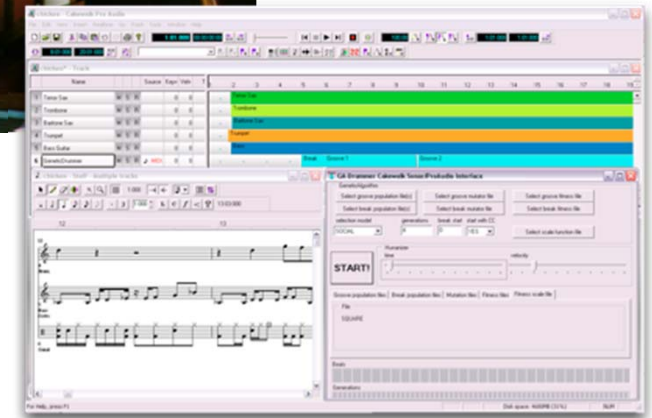


## ● GenJam (Genetic Jammer)

- Developed in 1993~94 by Prof. John Al Biles
- Interactive GA that learns to play jazz solos
- GenJam's repertoire: Over 250 jazz-style tunes
- Evolving by special fitness operators;  
e.g., rhythm conformity
- What can it be done?
  - ✓ Playing full-chorus improvised solos
  - ✓ Listening to trumpet and responds  
interactively when we trade fours
  - ✓ Engaging in collective improvisation;  
we both solo simultaneously and GenJam  
performs a smart echo of improvisation
  - ✓ Listening to me and play the head of a tune  
and breeds my measures



Source:  
<http://www.it.rit.edu/~jab/GenJam.html>



Source: <http://phoenix.inf.upol.cz/~dostal/evm.html>



Virtual  
quintet

MusiGenesis



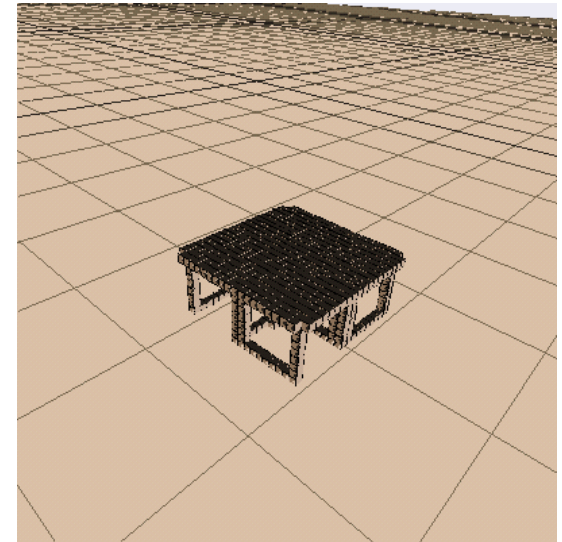


# Design



## ● Structure Design

- Bridge structure optimization
- Building structure design



## ● Aviation System Design

- Airfoil, wing, and antenna designs
- Space platform structure optimization
- Jet aircraft model optimization



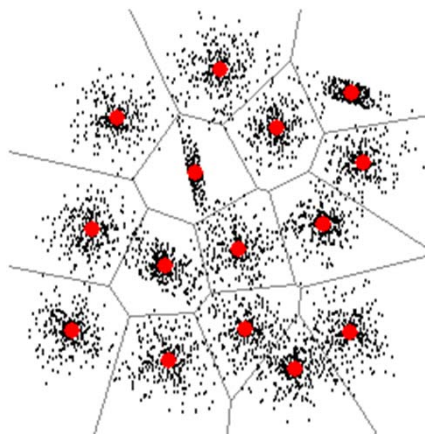


# Information Mining



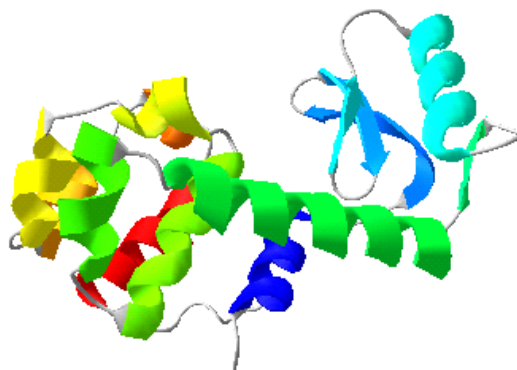
## ● Clustering

- Data clustering
- Text mining
- Web search



## ● Bioinformatics

- Drug discovery
- Protein folding
- Cancer diagnosis





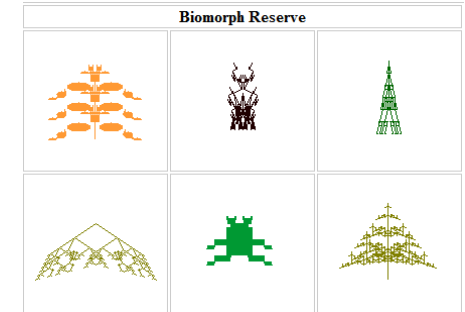
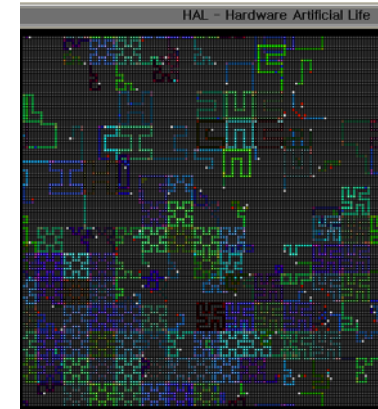
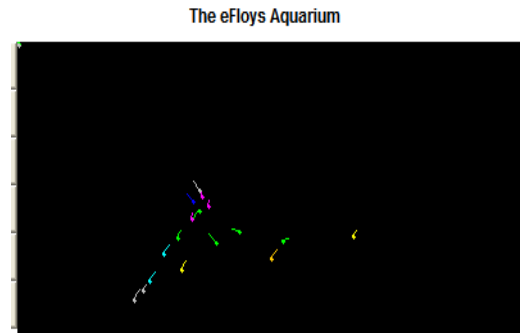


# Artificial Creatures & Robotics



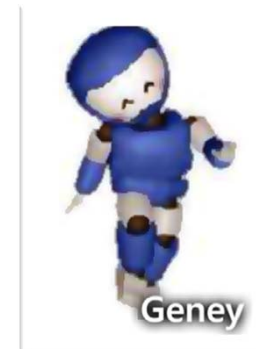
## ● Artificial Creatures

- eFly, Biomorph, HAL,
- Self-replicating Worms
- Gozilla, Solitaire



## ● Robotics

- Humanoid Robots; e.g., e.g., ASIMO
- Genetic Robots; e.g., Gene
- Others; e.g., Six-Legged Robot  
Robot Snake





# THANK YOU!

<http://www.evolution.re.kr>  
[cwan@skku.edu](mailto:cwan@skku.edu)

Please take a close look around.  
'Evolution' is happening everywhere, at all the time!