Beyond Classic Search

CS 470 Introduction To Artificial Intelligence

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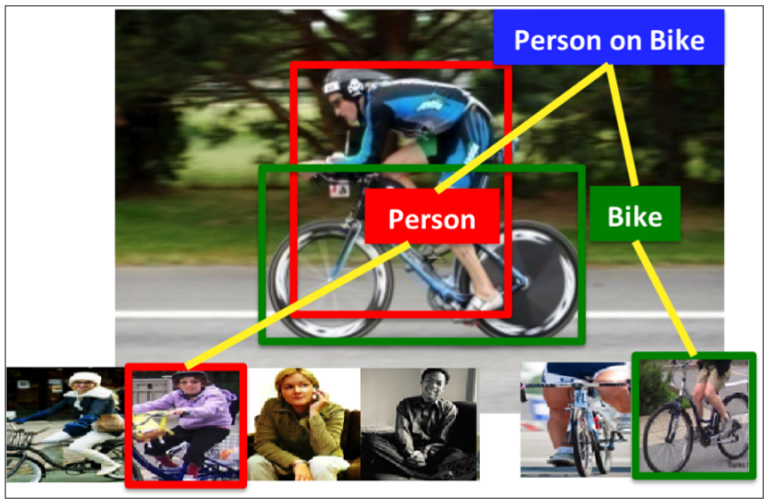
Outline

Rational agent

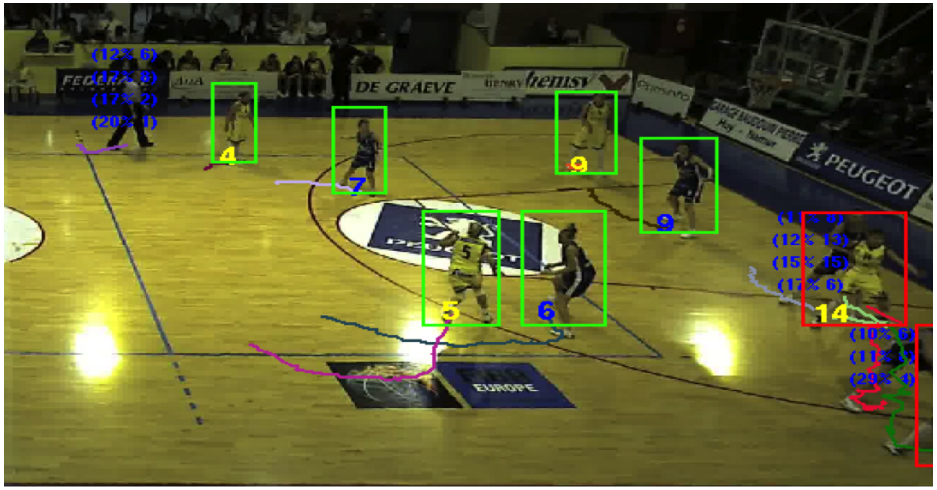
- Utility-based problem
- Optimization
  - $\arg\max_{x \in X} f(x)$
  - $\arg\min_{x \in X} f(x)$
- Find the x^* in X

Optimization in AI

Computer vision

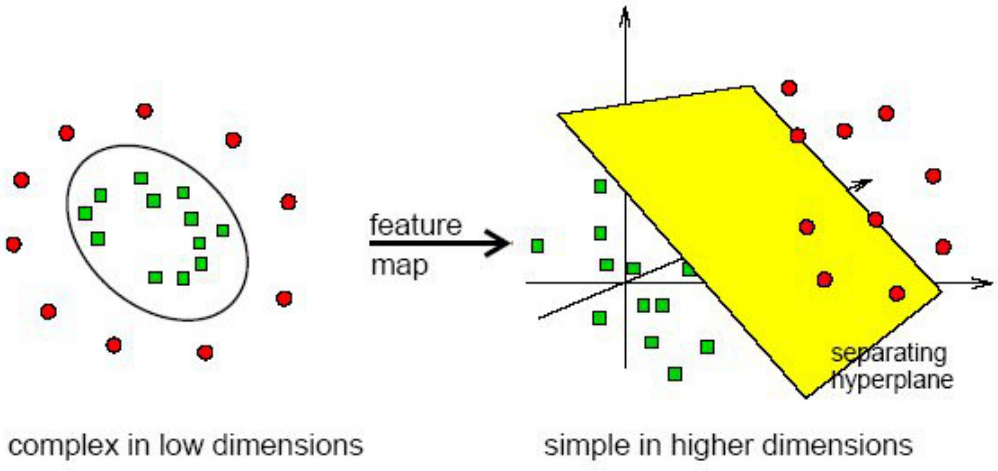


Object recognition

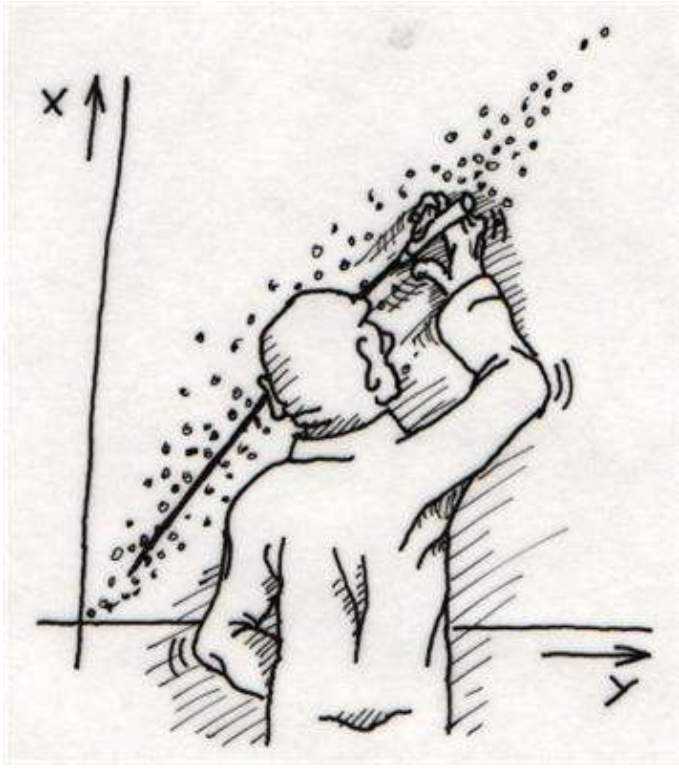


Object tracking

Machine learning



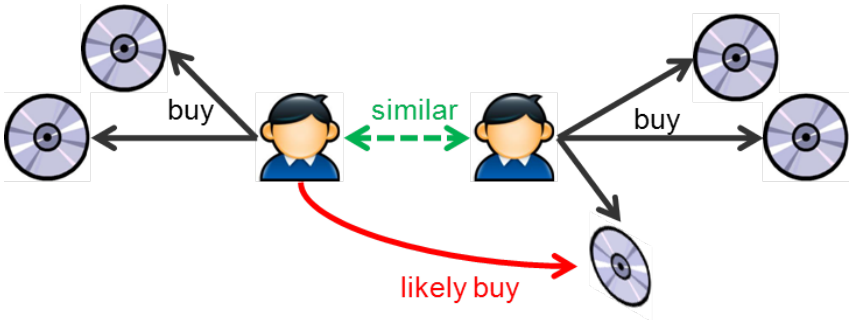
Classification



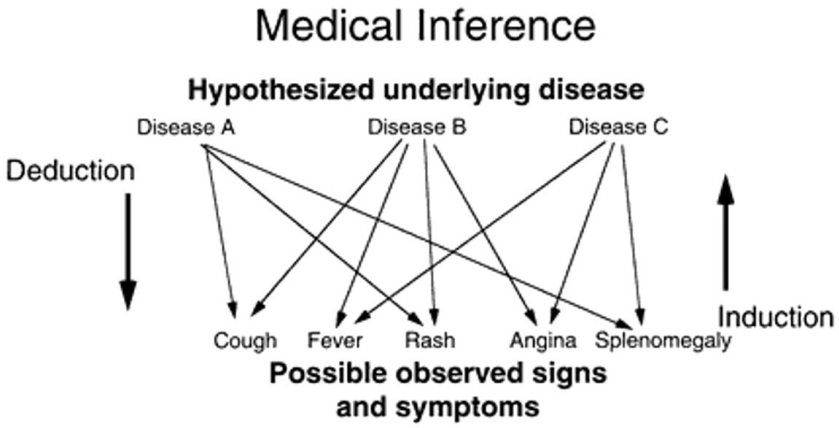
Regression

Optimization in AI

Machine inference



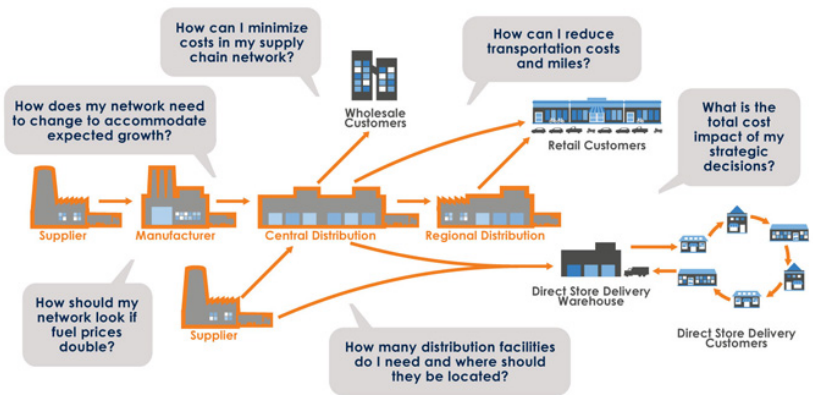
Item recommendation



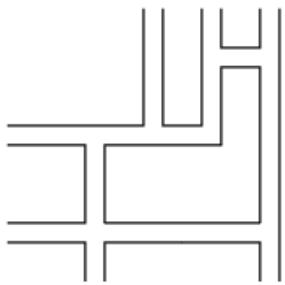
Medical inference

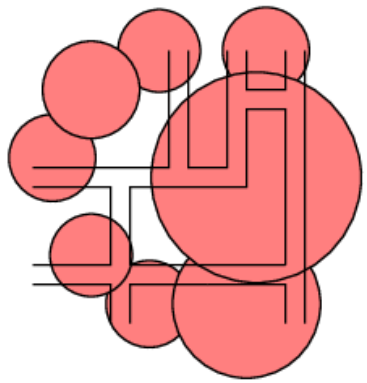
Optimization in AI

Machine planning



Supply chain optimization



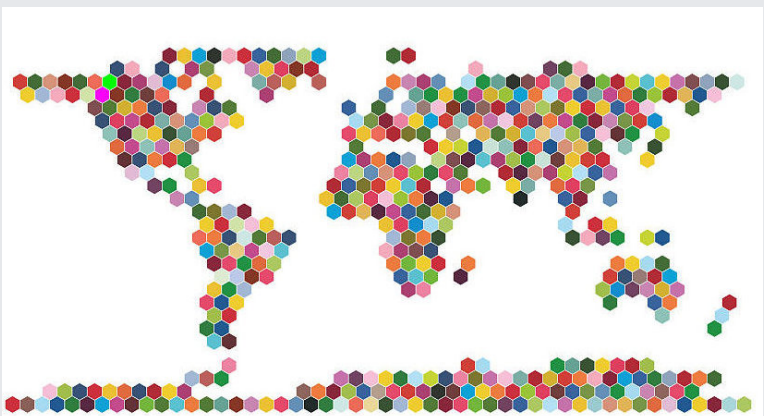


Sensor placement

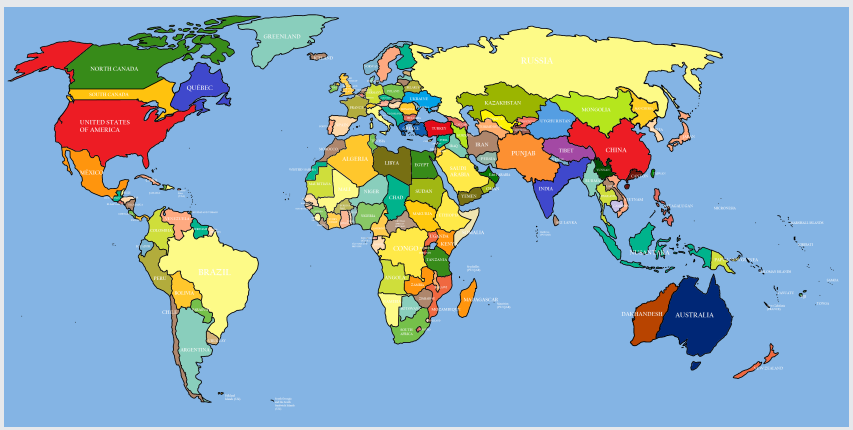
Problem space

search space

discrete space



continuous space



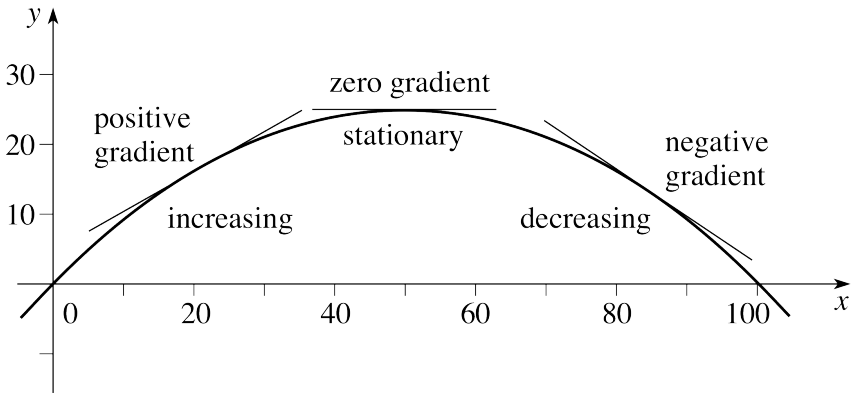
Optimization

- convex optimization
- nonconvex optimization

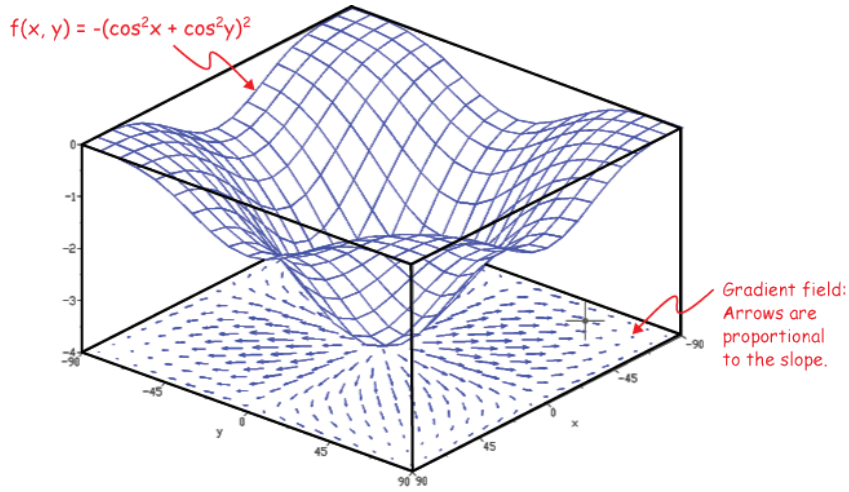
- math approach
- numerical approach
- stochastic approach

Gradient

- derivative of a function in several dimensions
- the slope of the tangent of the graph of the function



1D gradient

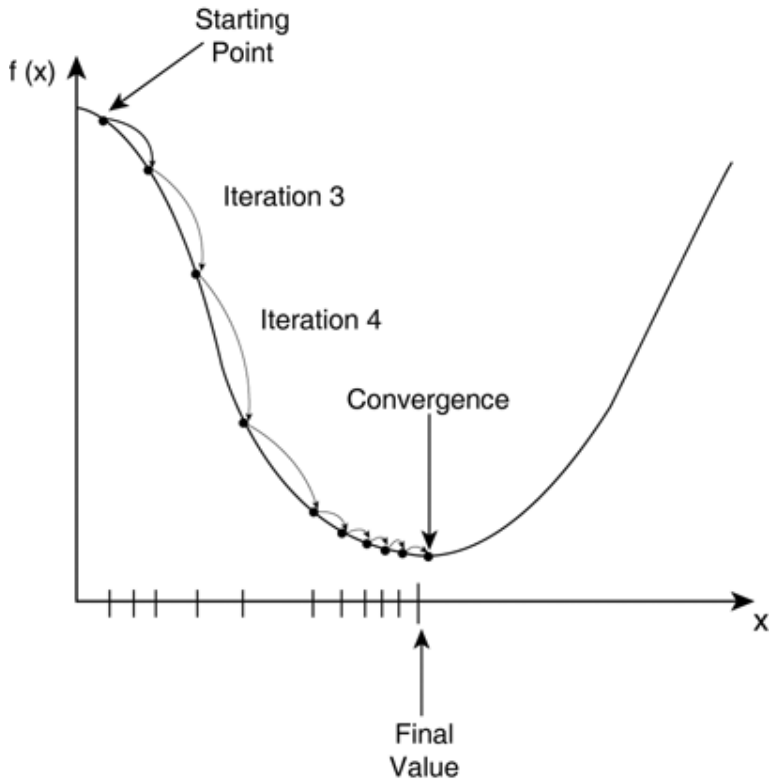


2D gradient

Hill-climbing search

steepest-ascent a loop that continually moves in the direction of increasing value

- greedy
- local optimal
- step length



Hill-climbing search

The problem of local optimal How to tweak

- random step $\rightarrow$ Stochastic hill climbing
- try till you find a better one $\rightarrow$ First-choice hill climbing
- get out of local optima $\rightarrow$ Random-restart hill climbing

Simulated annealing

Gradient descent in nonconvex optimization

adaptive step length + stochastic

- energy + temperature
- schedule

Simulated annealing

nature phenomenon

- heating a solid and then cooling it slowly
- nearly global minimum energy
- by small random displacement
- lower $\longrightarrow$ accept
- higher $\longrightarrow$ accept with Boltzmann probability

Simulated annealing

Boltzmann probability

$$P = exp\left(\frac{-\delta E}{K_b T}\right)$$

K_b - Boltzmann constant T - current temperature

- lower temperature $\longrightarrow$ high probability
- higher temperature $\longrightarrow$ low probability

Beam search

Parallel computing

- local beam search
  - k randomly generated states
  - parallel k searches
  - half when a goal is found
- stochastic beam search
  stochastic hill climbing + beam search

Metaheuristic optimization

Evolution

- Genetic algorithm
- Particle swarm optimization
- Ant colony optimization

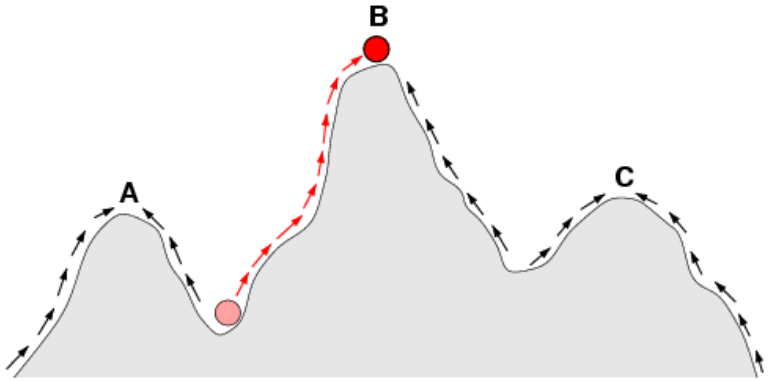
Genetic algorithm

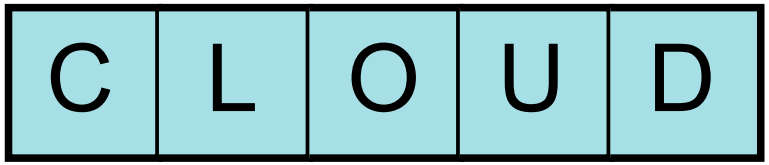
The algorithm consists of

- genetic representation
- fitness function

Evolution phases

- initialization
- crossover
- mutation

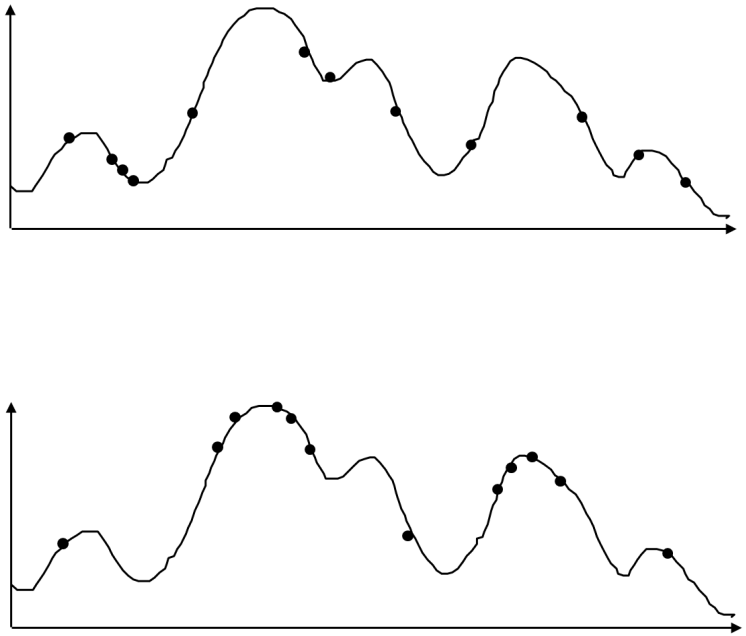




Genetic algorithm

Initialization

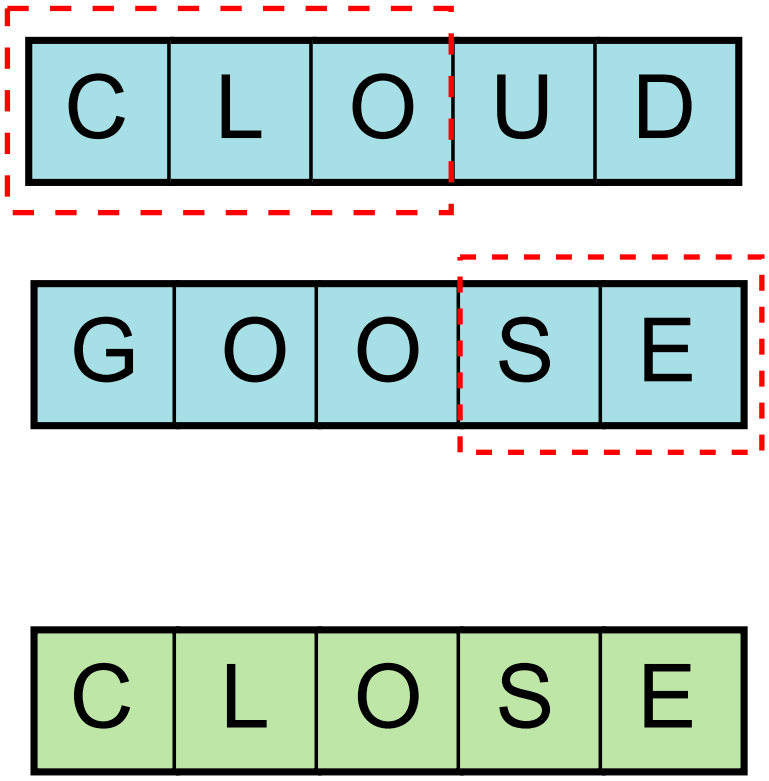
- a large population of random chromosomes
- each chromosome represents a solution
- what is the best distribution?



Genetic algorithm

Crossover

- mating between individuals
- two individuals are chosen (How?)
- generating new individual(s) from two selected individuals (How?)

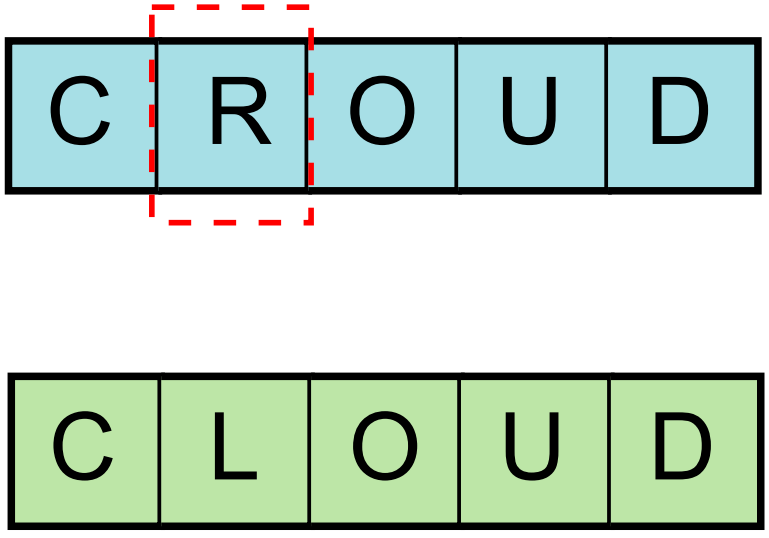


Crossover

Genetic algorithm

Mutation

- flip some bits of new individuals with some low probability (How?)
- inhibit premature convergence (a random walk through the search space)



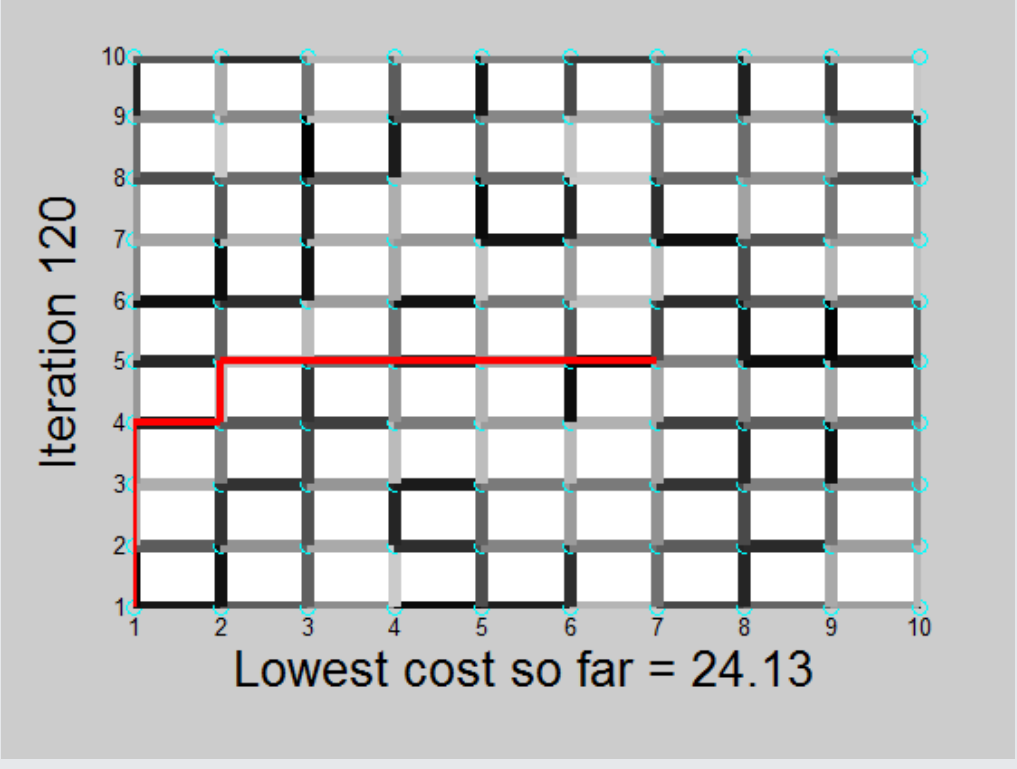
Mutation

Philosophies in genetic algorithm

- **parallel**
- **random**
- **convergence**

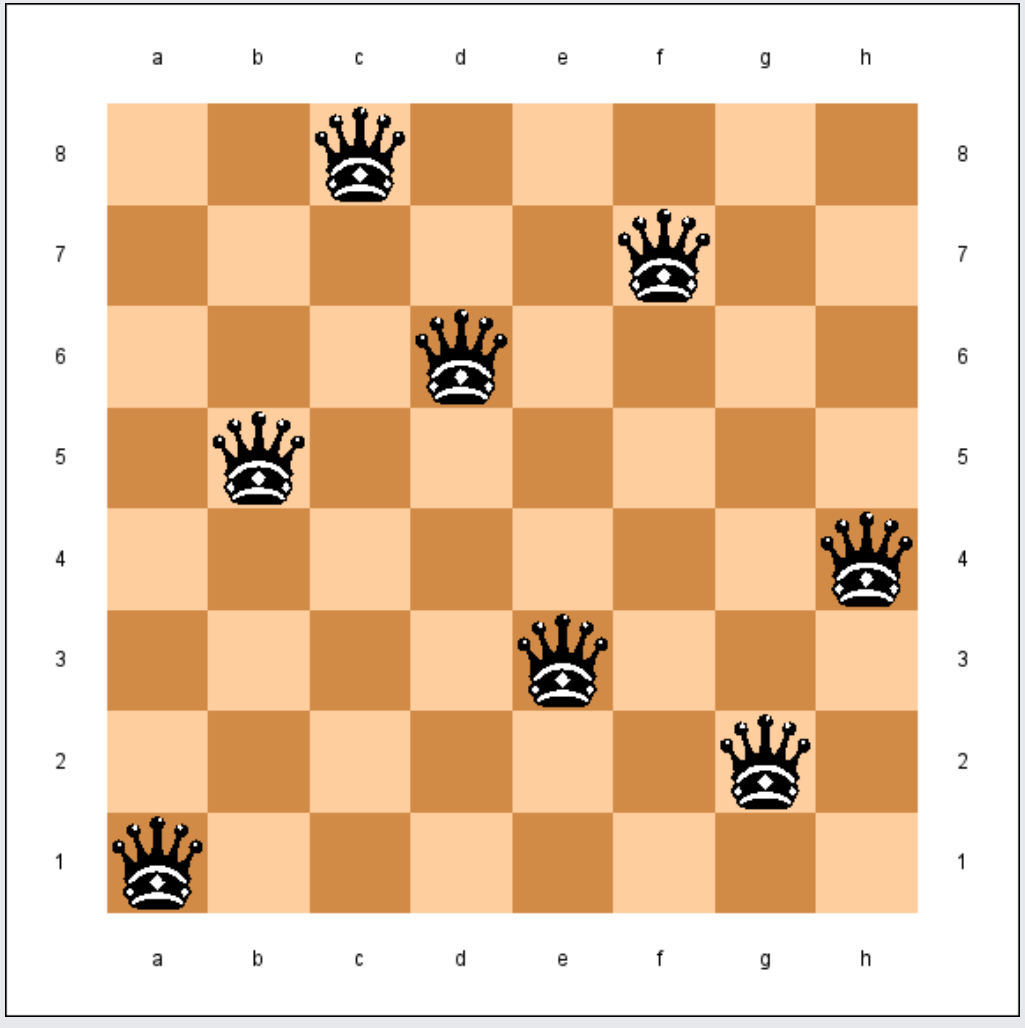
Example

Path Planning



Example

Eight queens



Example

Room Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
9:00			9:30 – 11:30 am Lorna Watt Dr. Ebert-May's lecture GTA		
10:00	10 am – 12 noon Colin Phillippo OR Ralph Tingley				
11:00			11 am – 12 noon Heidi Ziegenmeyer Drs. Bray-Speth & Momsen's lecture GTA		
Noon	12 noon – 2 pm Jeff Pierce OR Orlando Alvarez-Fuentes	12 noon – 2 pm Alana Bowers OR Jorge Celi	12 noon – 2 pm Sonya Lawrence OR Allison Rober	12 noon – 2:30 pm Kevin Wyatt 1:30 – 3:30 pm Sara Wyse Dr. Long's lecture GTA	12 noon – 2 pm Lou Keeley OR Sheridan Kelley
1:00					
2:00					
3:00	3:00 – 4:00 pm Heidi Ziegenmeyer Drs. Bray-Speth & Momsen's lecture GTA				
4:00		4:00 – 5:00 pm Rachel Cohen Dr. Peters' lecture GTA		4:00 – 5:00 pm Rachel Cohen Dr. Peters' lecture GTA	
5:00					

Genetic algorithm

Continuous space

- initialization ?
- crossover ?
- mutation ?

Swarm intelligence