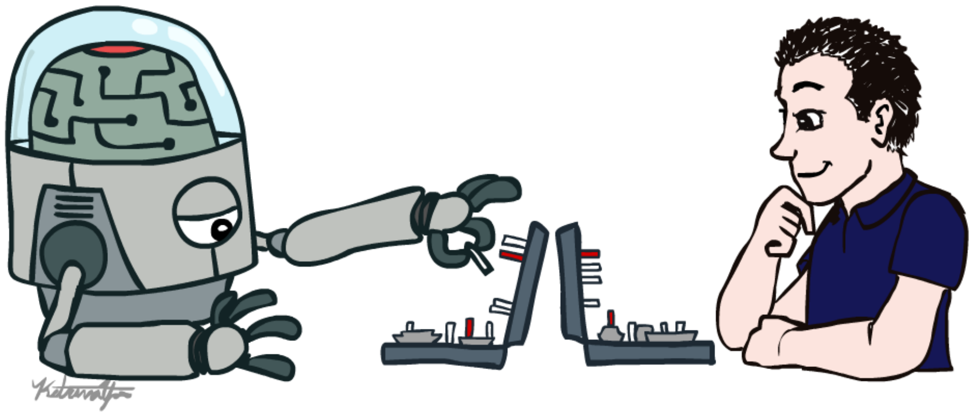
Lecture 04



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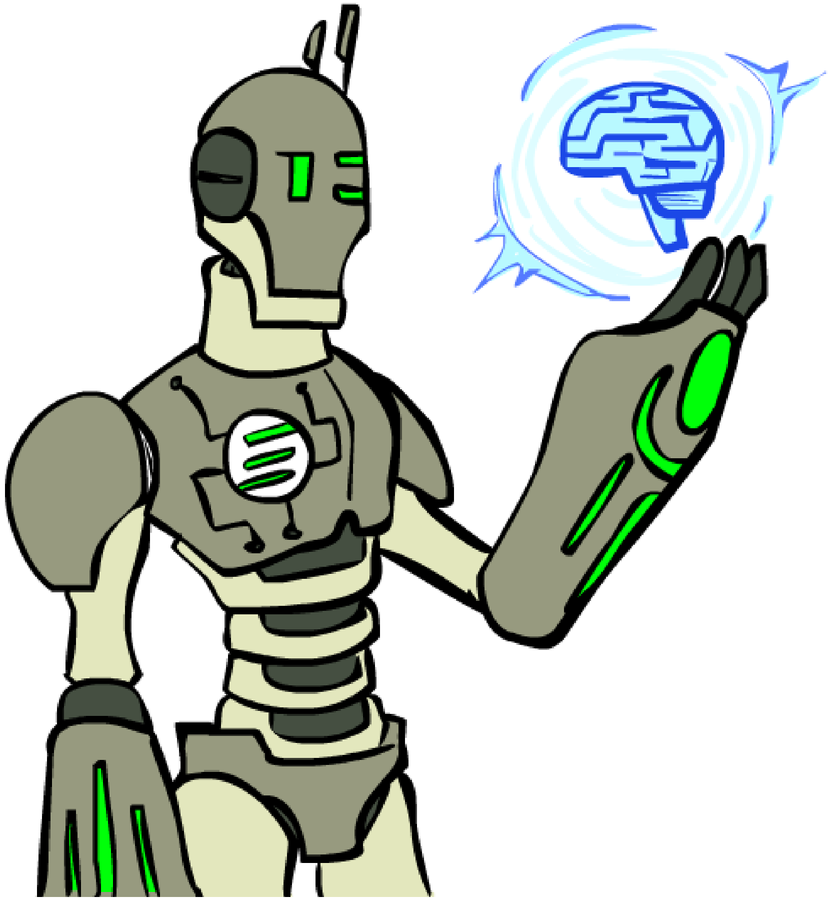
Today



- Local search
- Hill climbing problem
- 8 Queen problem
- Variation of hill climbing problem

Another Approach: Local Search

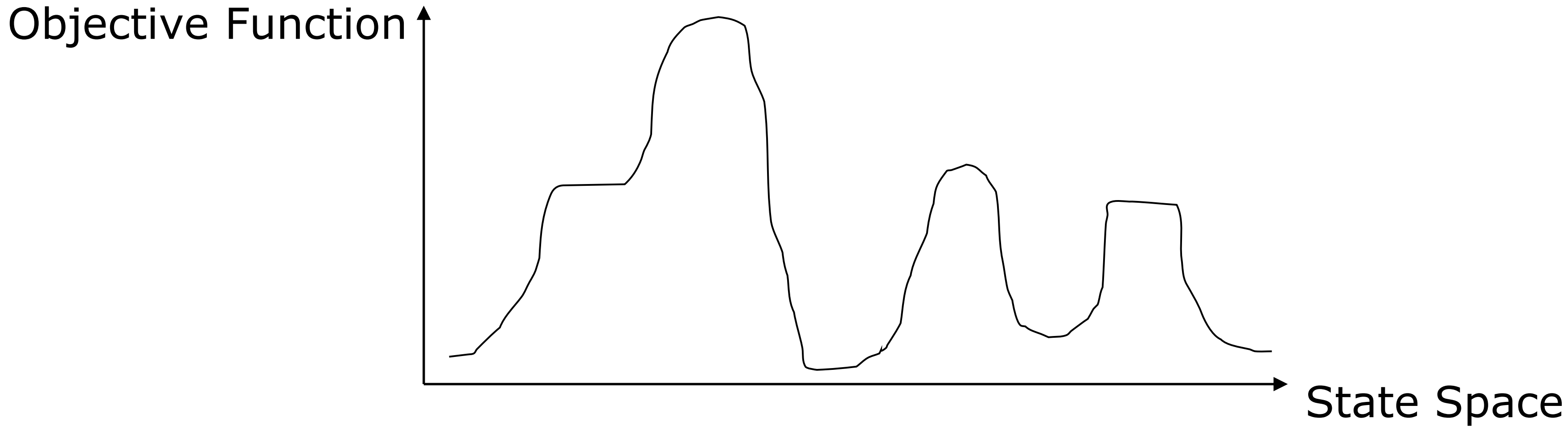
- Now we'll look at search where the *path* is irrelevant; the *goal state itself is the solution*
  - State space : set of "complete" configurations
  - Goal: some configuration satisfying.
  - Example: 8 queen problem, integrated circuit design.

Another Approach: Local Search

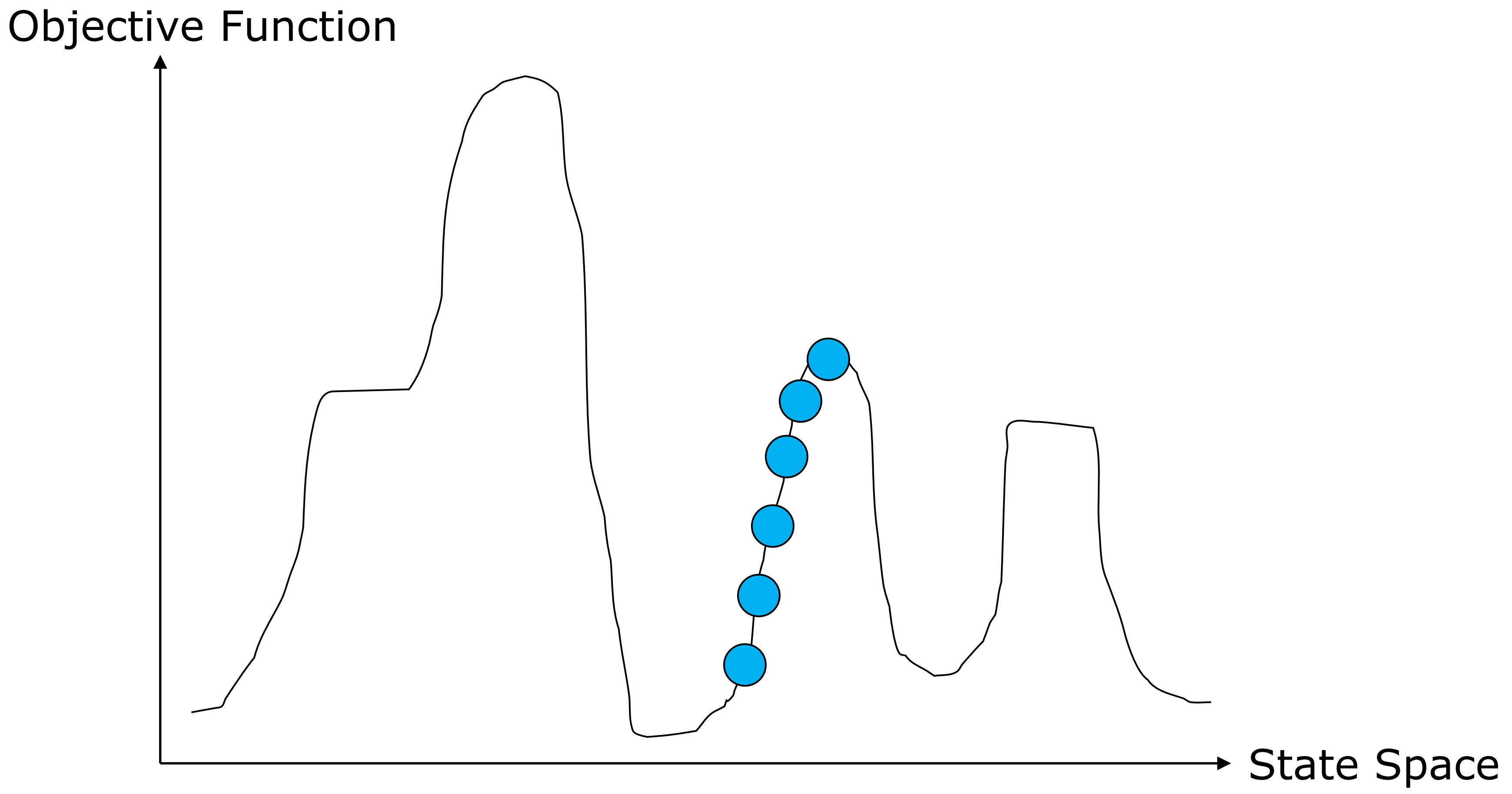
- **Local search algorithm**
  - Searching from a start state to neighboring states, without keeping track of the paths.
  - Keep a single "current" state, try to improve it in next state.
  - Might never explore a portion of the search space where a solution actually resides.

Local Search Example

- Problem: Hill climbing search
- Each point (state) in the landscape has an "elevation" defined by the objective function.
- The aim is to find the highest peak.



Hill Climbing Problems



If elevation corresponding to cost, then the aim is to find the lowest valley – a global minimum. We call it gradient descent.

Exploring the Landscape

- **Local Maxima**: peaks that aren't the highest point in the space
- **Plateaus:** the space has a broad flat region that gives the search algorithm **no direction** (random walk).
- **Ridges:** flat like a plateau, but with drop-offs to the sides; steps to the North, East, South and West may go down. Ridges result in **a sequence of local maxima.**

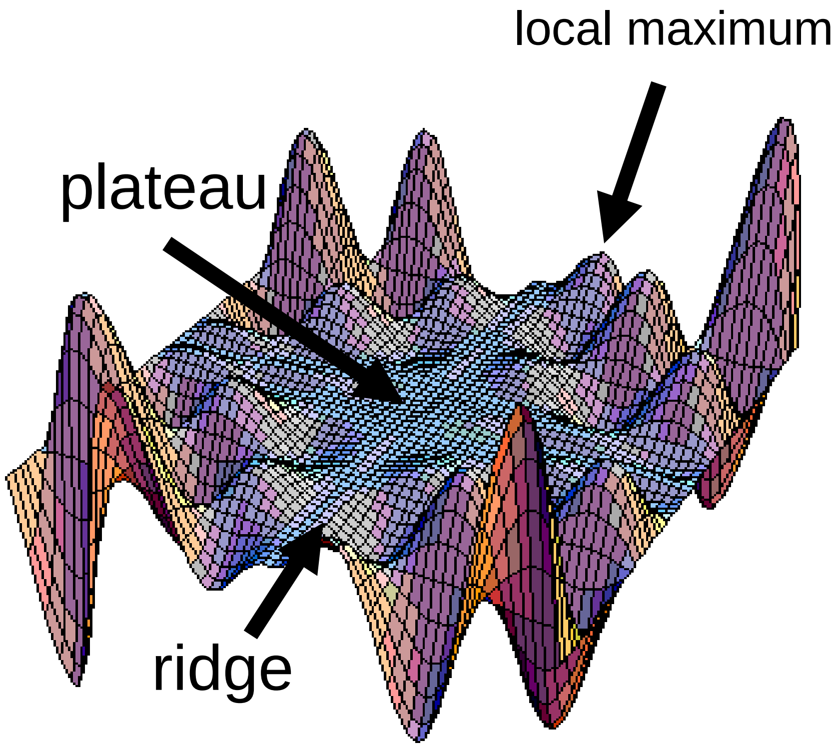
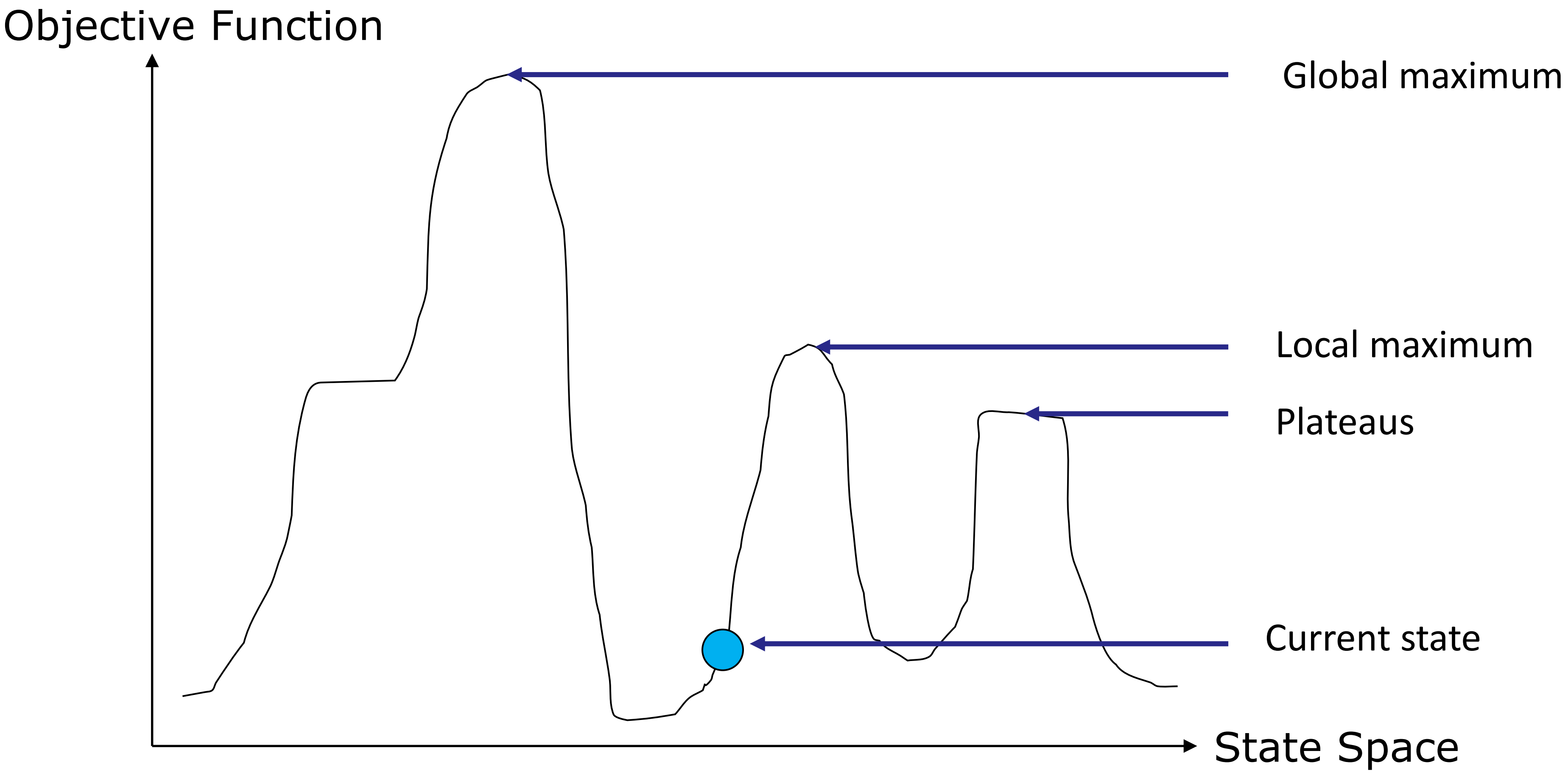
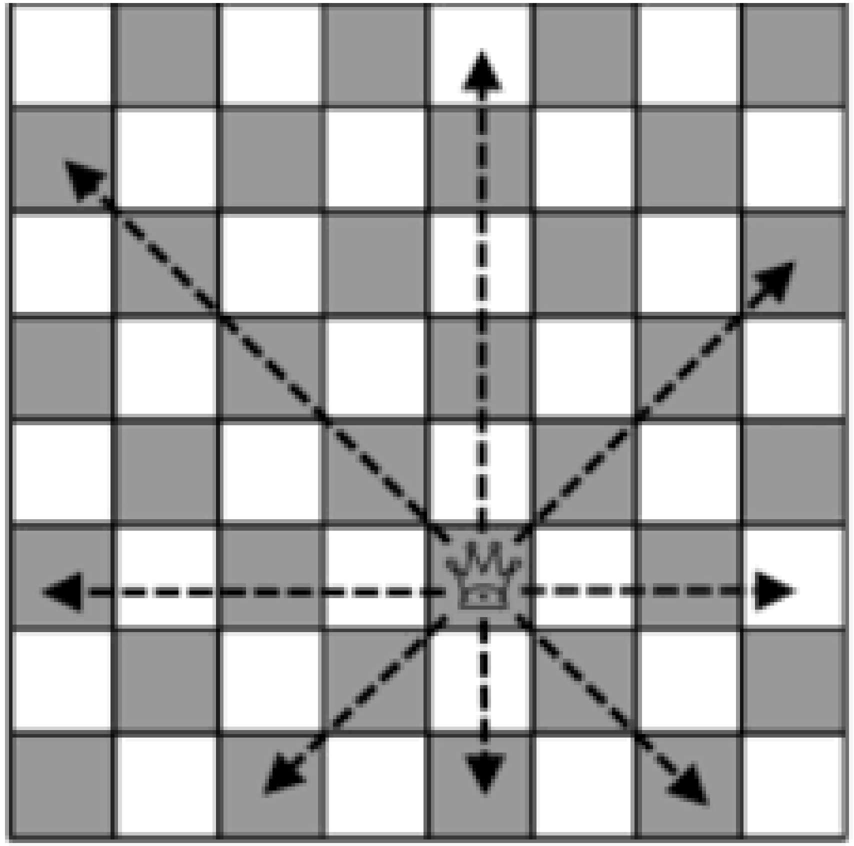


Image from:
http://classes.yale.edu/fractals/CA/GA/Fitness/Fitness.html

Hill Climbing Problems



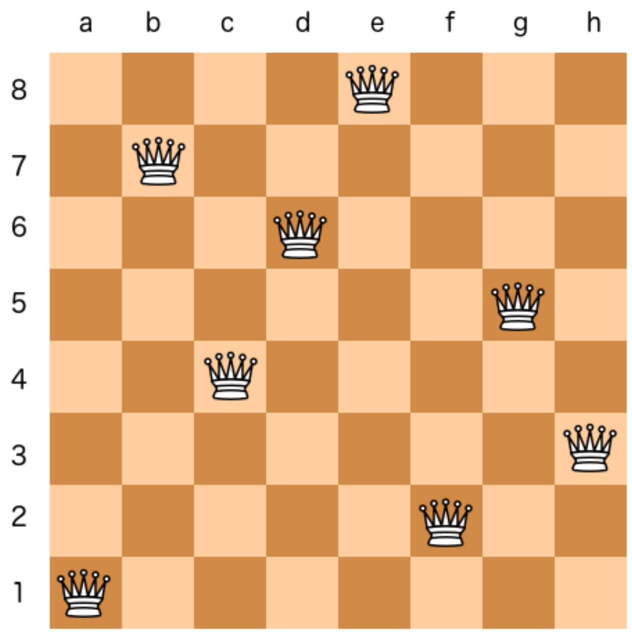
8 Queen problem



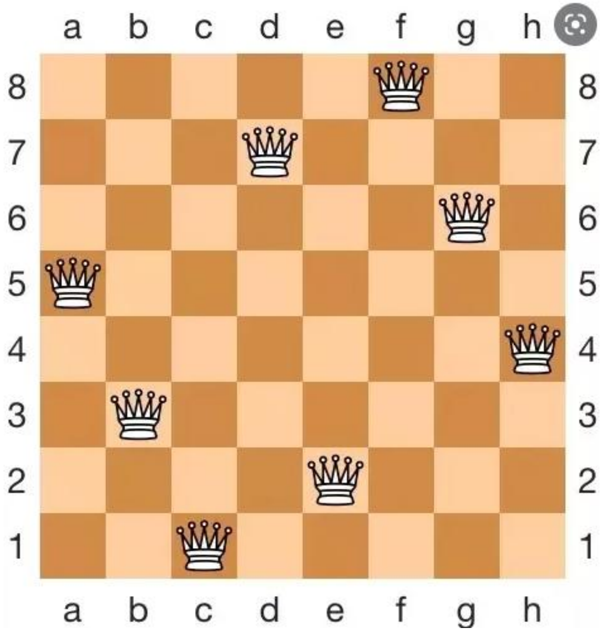
- 8 Queen problem
- A queen attacks any piece in the same row, column, or diagonal.

8 Queen problem

- Problem: put 8 queens on an 8×8 board with no two queens on the same row, column, or diagonal.
- path is irrelevant, just need to reach goal.



Solution 1



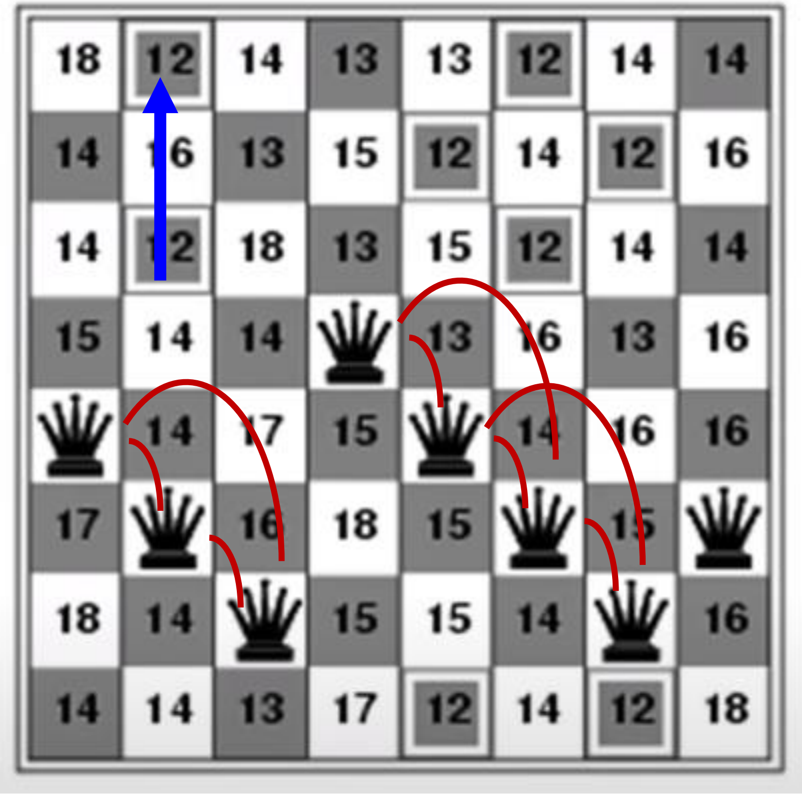
Solution 2

8 Queen problem

- The heuristic cost function h is the number of pairs of queens that are attacking each other.
- This will be zero only for solutions.

8 Queen problem

- Here, heuristic cost estimate h = 17
- There are 17 ways of queen attacks for the current board.
- The board shows the value of h for each possible successor obtained by moving a queen within its column.



Hill-climbing variations

- Random-restart hill-climbing
  - If at first you don't succeed, try, try again…
  - Tries to avoid getting stuck in local maxima.
  - It conducts a series of hill-climbing searches from randomly generated initial states, until a goal is found.
- Stochastic hill-climbing
  - Chooses at random from among the uphill moves
  - The probability of selection can vary with the steepness of the uphill move.
  - This usually converges more slowly.
- Simulated annealing
  - Generate a random move.

Simulated Annealing

- Imagine the task of getting a ping-pong ball into the deepest crevice in a bumpy surface.
- We can bounce the ball out of the local minimum.
- But not hard enough to dislodge it from global minimum.
- The trick is:
  - Start by shaking hard (i.e., at a high temperature)
  - Then, gradually reduce the intensity of the shaking (i.e., lower temperature)

Simulated Annealing

  - Moves are selected at random
  - If a move is an improvement, accept
  - Otherwise, accept with probability less than 1.
- Probability gets smaller as time passes and by the amount of “badness” of the move.

Simulated Annealing

- A "bad" move from A to B is accepted with a probability

$$e^{(f(B)-f(A)/T)}$$

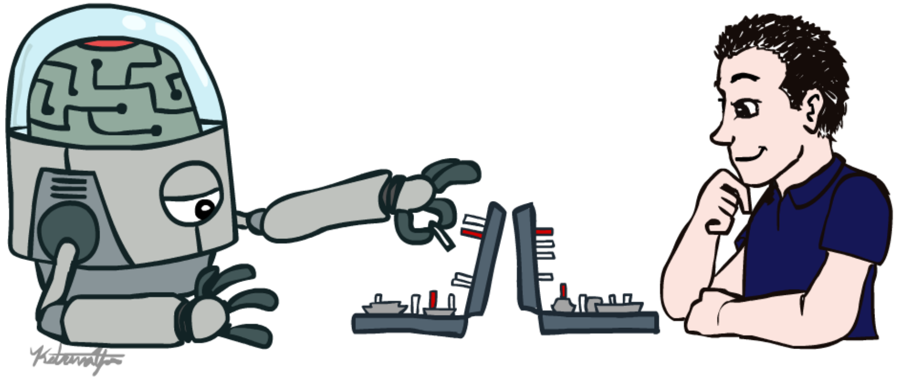
  - The higher the temperature, the more likely it is that a bad move can be made.
  - As T tends to zero, this probability tends to zero, and SA becomes more like hill climbing
  - If T is lowered slowly enough, SA is complete and admissible.

Local search and optimization

- Local search= use single current state and move to neighboring states.
- Advantages:
  - Use very little memory
  - Find often reasonable solutions in large or infinite state spaces.

Next class?

- Adversarial search
- **Game theory**



Thanks!