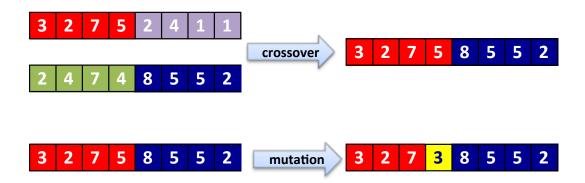
Artificial Intelligence Search Agents Local search



- Search algorithms seen so far are designed to explore search spaces systematically.
- Problems: observable, deterministic, known environments where the solution is a sequence of actions.
- Real-World problems are more complex.
- When a goal is found, the path to that goal constitutes a solution to the problem. But, depending on the applications, the path may or may not matter.
- If the path does not matter/systematic search is not possible, then consider another class of algorithms.

- In such cases, we can use iterative improvement algorithms, **Local search**.
- Also useful in pure **optimization problems** where the goal is to find the best state according to an **optimization function**.

• Examples:

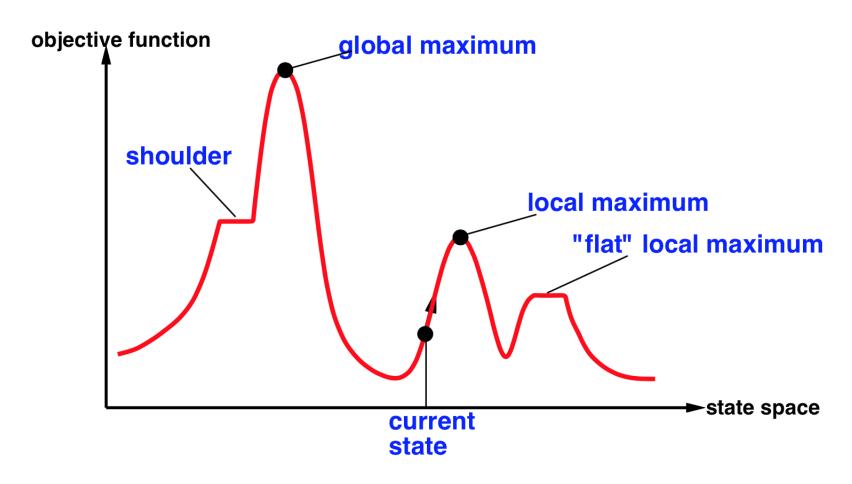
- Integrated circuit design, telecommunications network optimization, etc.
- N-puzzle or 8-queen: what matters is the final configuration of the puzzle, not the intermediary steps to reach it.

- Idea: keep a single "current" state, and try to improve it.
- Move only to neighbors of that node.

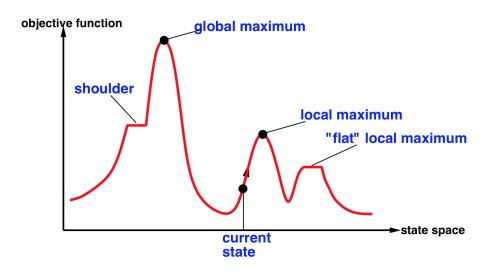
Advantages:

- 1. No need to maintain a search tree.
- 2. Use very little memory.
- 3. Can often find good enough solutions in continuous or large state spaces.

- Local Search Algorithms:
 - Hill climbing (steepest ascent/descent).
 - Simulated Annealing: inspired by statistical physics.
 - Local beam search.
 - Genetic algorithms: inspired by evolutionary biology.



State space landscape



- Also called greedy local search.
- Looks only to immediate good neighbors and not beyond.
- Search moves uphill: moves in the direction of increasing elevation/value to find the top of the mountain.
- Terminates when it reaches a pick.
- Can terminate with a local maximum, global maximum or can get stuck and no progress is possible.
- A node is a state and a value.

function Hill-Climbing(initialState)

returns State that is a local maximum

initialize current with initialState

loop do

neighbor = a highest-valued successor of current

if neighbor.value ≤ current.value: return current.state

current = neighbor

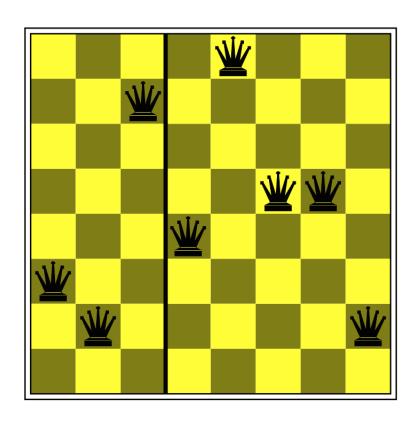
Other variants of hill climbing include

- **Sideways moves** escape from plateaux where best successor has same value as the current state.
- Random-restart hill climbing overcomes local maxima: keep trying! (either find a goal or get several possible solution and pick the max).
- **Stochastic** hill climbing chooses at random among the uphill moves.

- **Hill climbing** effective in general but depends on shape of the landscape.
- Successful in many real-problems after a reasonable number of restarts.
- Local beam search maintains k states instead of one state.
- ullet Select the k best successor, and useful information is passed among the states.
- Stochastic beam search choose k successors are random.
- Helps alleviate the problem of the the states agglomerating around the same part of the state space.

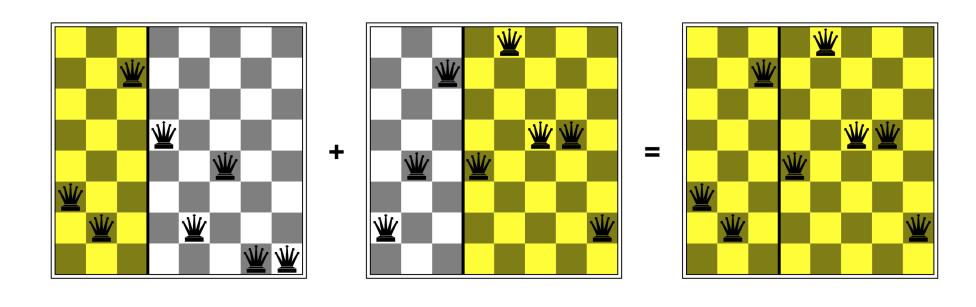
- **Genetic algorithms (GA)** is a variant of stochastic beam search.
- Successor states are generated by combining two parents rather by modifying a single state.
- The process is inspired by **natural selection**.
- Starts with k randomly generated states, called population. Each state is an individual.
- An individual is usually represented by a **string** of 0's and 1's, or digits, a finite set.
- The objective function is called **fitness function**: better states have high values of fitness function.

• In the 8-queen problem, an individual can be represented by a **string** digits 1 to 8, that represents the position of the 8 queens in the 8 columns.

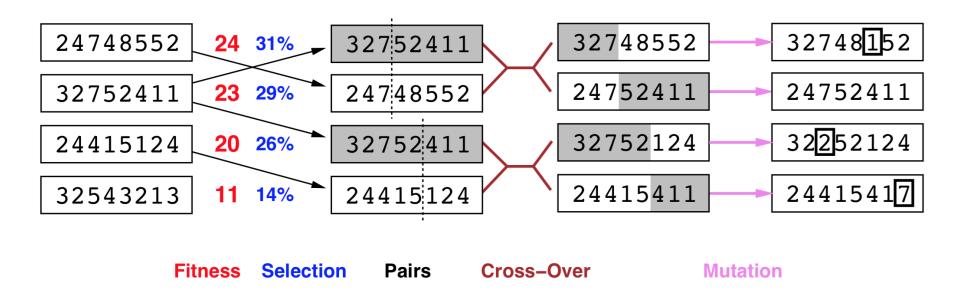


- The objective function is called **fitness function**: better states have high values of fitness function.
- Possible fitness function is the number of non-attacking pairs of queens.
- Fitness function of the solution: 28.

- Pairs of individuals are selected at random for reproduction w.r.t. some probabilities.
- A crossover point is chosen randomly in the string.
- **Offspring** are created by crossing the parents at the crossover point.
- Each element in the string is also subject to some mutation with a small probability.



Generate successors from pairs of states.



```
function Genetic-Algorithm (population, fitness-function)
    returns an individual
    repeat
         initialize new-population with \emptyset
         for i=1 to size(population) do
             x = random-select(population, fitness-function)
             x = random-select(population, fitness-function)
             child = cross-over(x,y)
             mutate (child) with a small random probability
             add child to new-population
         population = new-population
    until some individual is fit enough or enough time has elapsed
    return the best individual in population w.r.t. fitness-function
```

Credit

• Artificial Intelligence, A Modern Approach. Stuart Russell and Peter Norvig. Third Edition. Pearson Education.

http://aima.cs.berkeley.edu/