Artificial Intelligence

COURSE INSTRUCTOR: MUHAMMAD SAIF UL ISLAM

Outline

- Hill-Climbing Search.
- Simulated Annealing Search.
- Local Beam Search.
- Genetic Algorithms.

Classical Search vs. Local Search

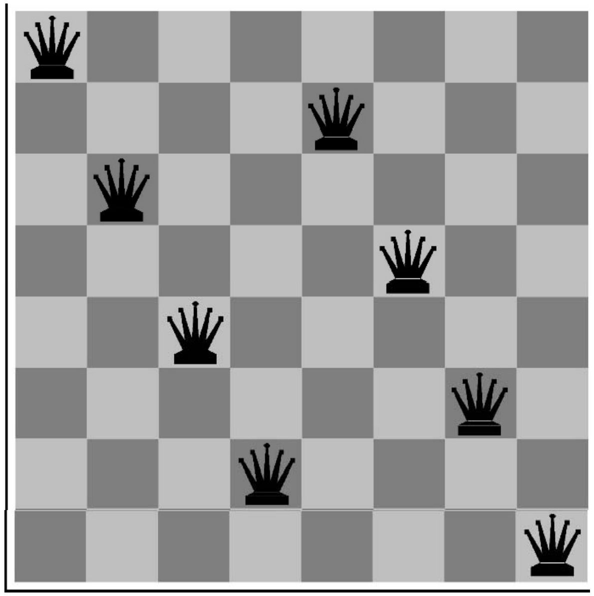
Classical search	Local Search
• systematic exploration of search space. • Keeps one or more paths in memory. • Records which alternatives have been explored at each point along the path. • The path to the goal is a solution to the problem.	• In many optimization problems, the path to the goal is irrelevant; the goal state itself is the solution. • State space = set of "complete" configurations. • Find configuration satisfying constraints, Find best state according to some objective function h(s). e.g., n-queens, h(s)= number of attacking queens. In such cases, we can use Local Search Algorithms.

Local Search Algorithms

- Local Search Algorithms keep a **single "current"** state and move to neighboring states to try to **improve** it.
- Solution path needs not to be maintained.
- Hence, the search is "local".
- Local search **suitable** for problems in which path is not important; the goal state itself is the solution.
- It is an **optimization** search

Example: n-queens

- Put n queens on an n × n board with no two queens on the same row, column, or diagonal.
- In the 8-queens problem, what matters is the final configuration of queens, not the order in which they are added.



Local Search: Key Idea

Key idea:

1. Select (random) initial state (generate an initial guess).
2. Make local modification to improve current state

   (evaluate current state and move to other states).

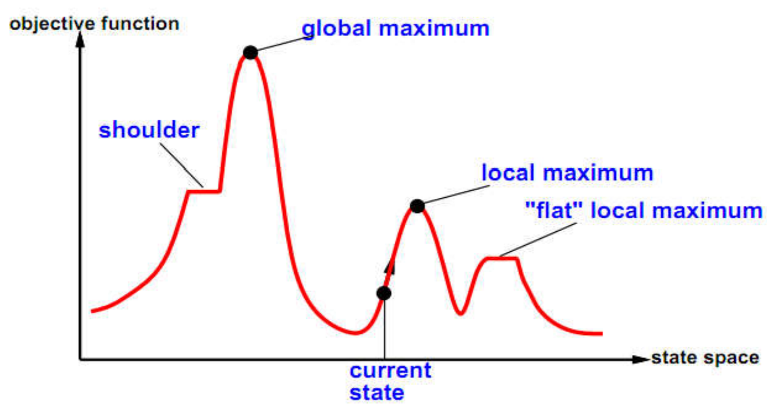
3. Repeat Step 2 until goal state found (or out of time).

Local Search: Key Idea

Advantages	Drawback:
• Use very little memory - usually a constant amount. • Can often find reasonable solutions in large or infinite state spaces (e.g., continuous). For which systematic search is unsuitable.	• Local Search can get stuck in local maxima and not find the optimal solution.

State-Space Landscape

- A state space landscape: is a graph of states associated with their costs.
- State-space landscape
  - Location (defined by state)
  - Elevation (defined by the value of the heuristic cost function or objective function)
  - If elevation = cost, aim to find the lowest valley (a global minimum)
  - If elevation = objective function, find the highest peak (a global maximum)
  - A *complete local search algorithm always find a goal* if one exists
  - An **optimal** algorithm always find a **global minimum/maximum**



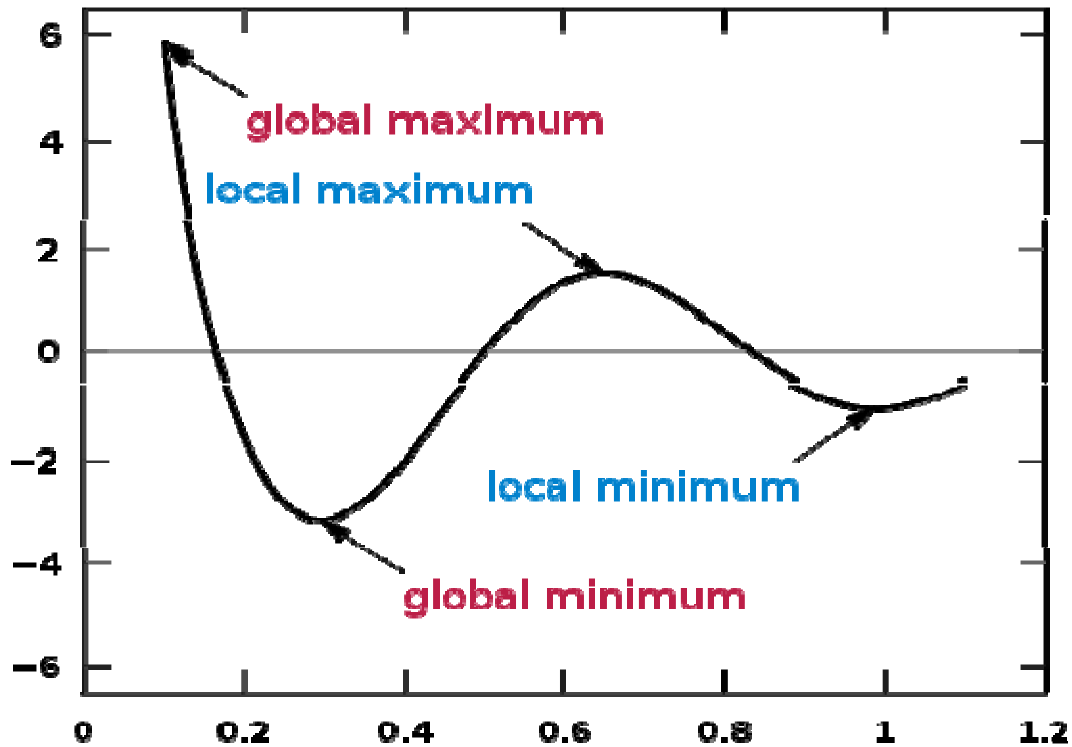
Local and Global Optima

- Global optimum
  - A solution that is better than all other solutions
  - Or no worse than any other solution
- Local optimum
  - A solution which is better than *nearby* solutions
  - A local optimum is not necessarily a global one

Global /Local(max/min)

- A local max/min is over a small area.
  - For instance, if a point is lower than the next nearest point on the left & right then it's a local min.
- There can be many local maxes and mins over an entire graph.
- A global max/min is the highest/lowest point on the entire graph.
- There can only be ONE global max and/or min on a graph and there may not be one at all.

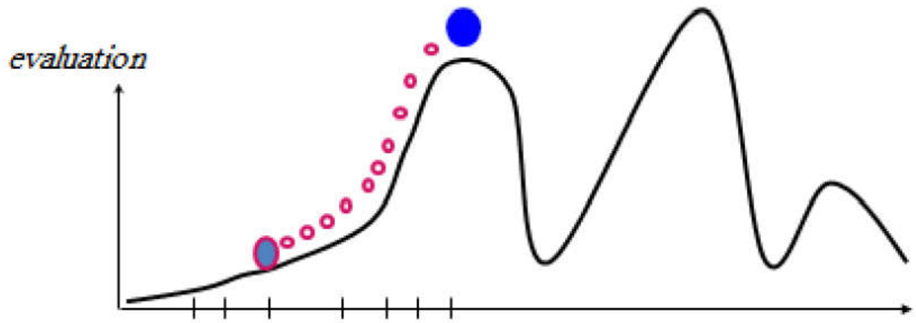
Global /Local(max/min)

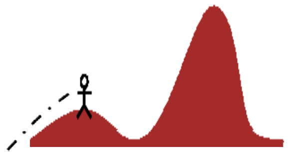


Hill-Climbing Search

Hill-Climbing Search

- **Main Idea**: Keep a single current node and move to a neighboring state to improve it.
- Uses a loop that continuously moves in the direction of increasing value (**uphill**):
  - Choose the best successor, choose randomly if there is more than one.
  - Terminate when a peak is reached where no neighbor has a higher value.
- It is also called **greedy local search**, steepest ascent/descent.





Hill-Climbing Search

- "Like climbing Everest in thick fog with amnesia"
- Only record the state and its evaluation instead of maintaining a search tree

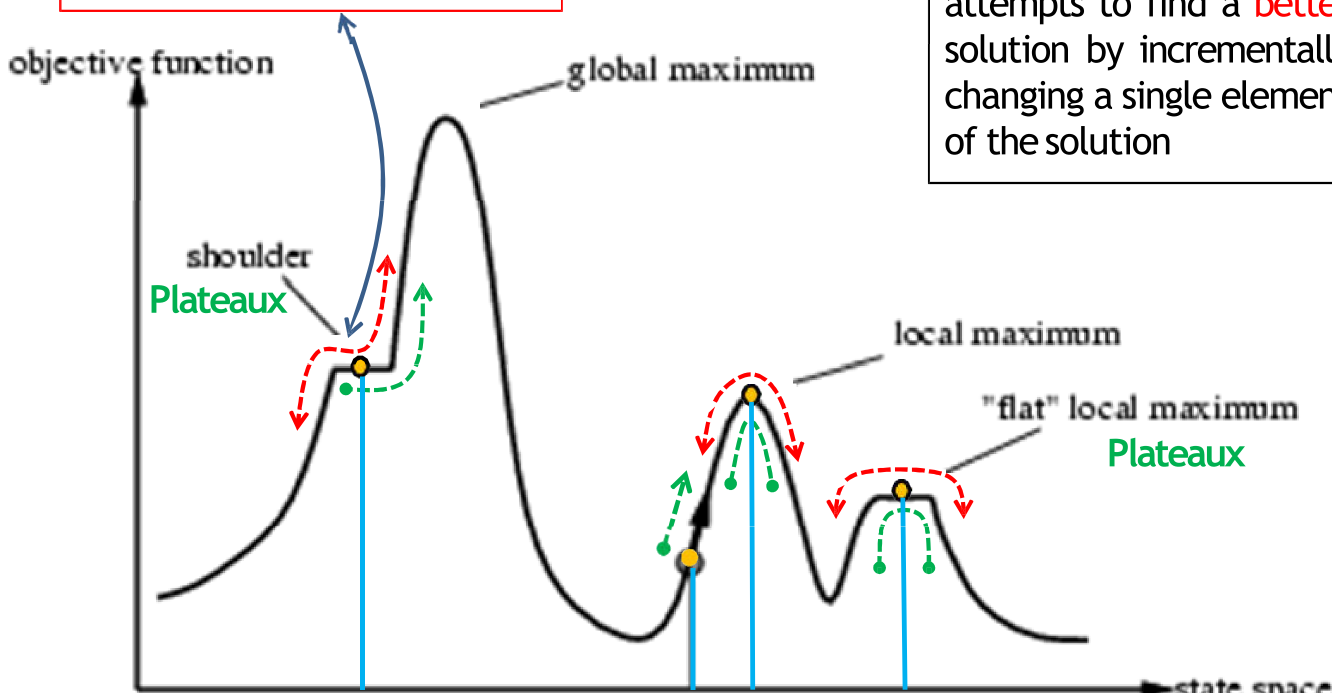
```
function HILL-CLIMBING ( problem ) returns a state that is a local maximum
  inputs: problem, a problem
  local variables:     current, a node
                       neighbor, a node

  current ← MAKE-NODE( INITIAL-STATE[ problem ])
  loop do
     neighbor ← a highest-valued successor of current
     if VALUE[ neighbor ] ≤ VALUE[ current ] then return STATE[ current ]
     current ← neighbor
```

Hill-Climbing Search

it is possible to make progress

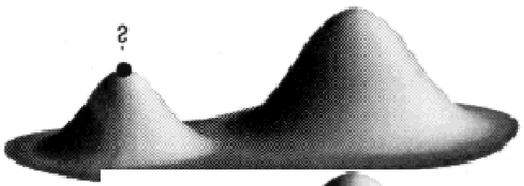
attempts to find a better solution by incrementally changing a single element of the solution



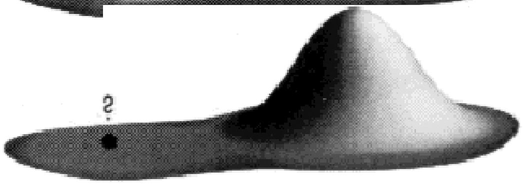
Current state

Hill-Climbing Search

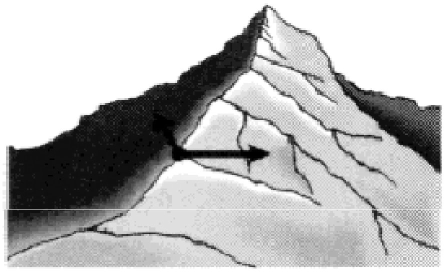
Local maxima: a local maximum is a peak that is higher than each of its neighboring states, but lower than the global maximum. Hill-climbing algorithms that reach the vicinity of a local maximum will be drawn upwards towards the peak, but will then be stuck with nowhere else to go.



Plateaux: a plateau is an area of the state space landscape where the evaluation function is flat. It can be a flat local maximum, from which no uphill exit exists, or a **shoulder,** from which it is possible to make progress.

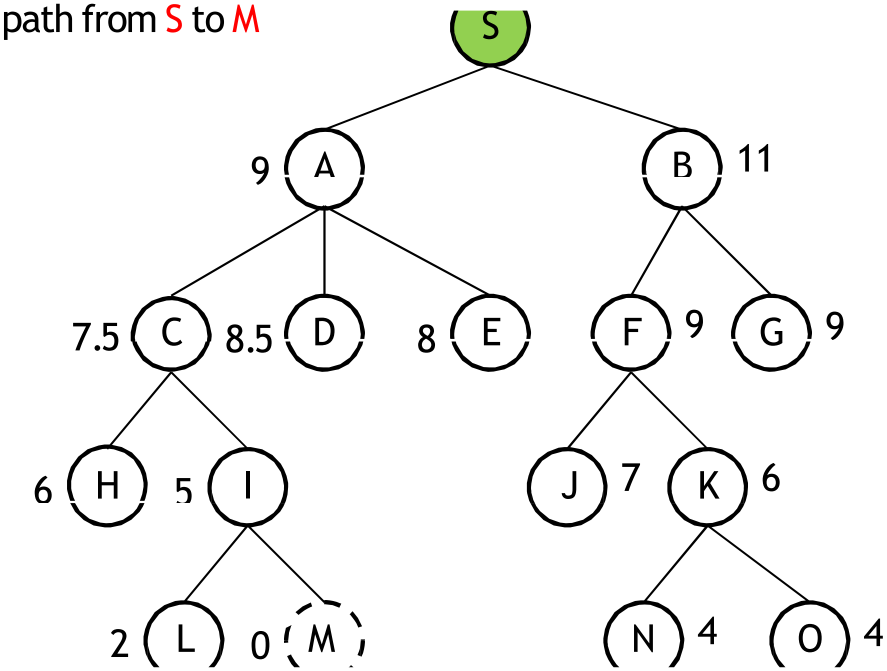


Ridges: Ridges result in a sequence of local maxima that is very difficult for greedy algorithms to navigate. (the search direction is not towards the top but theside)

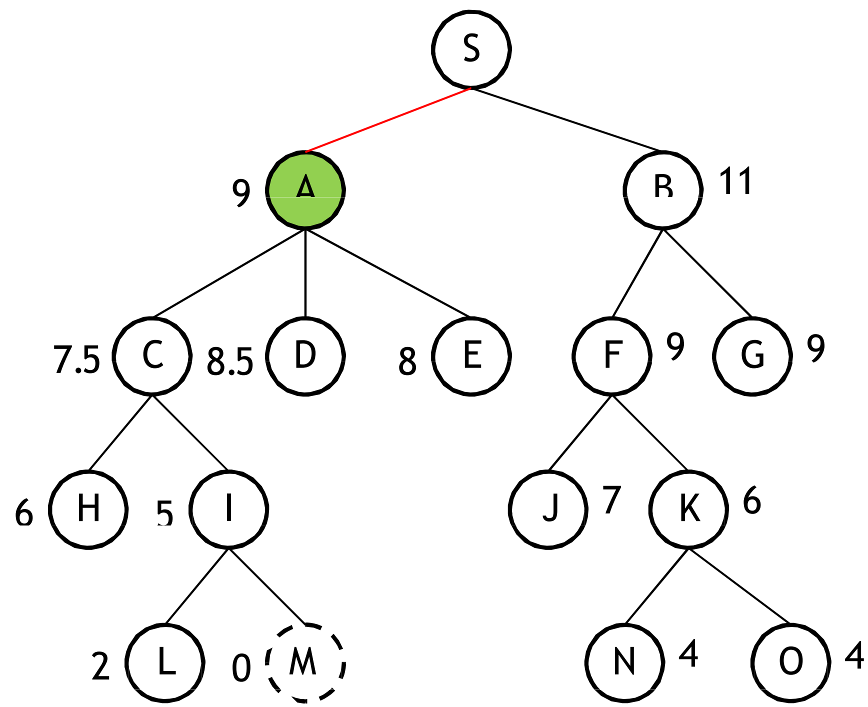


Hill-Climbing Search Example

our aim is to find a path from S to M



associate heuristics with every node, that is the straight line distance from the path terminating city to the goal city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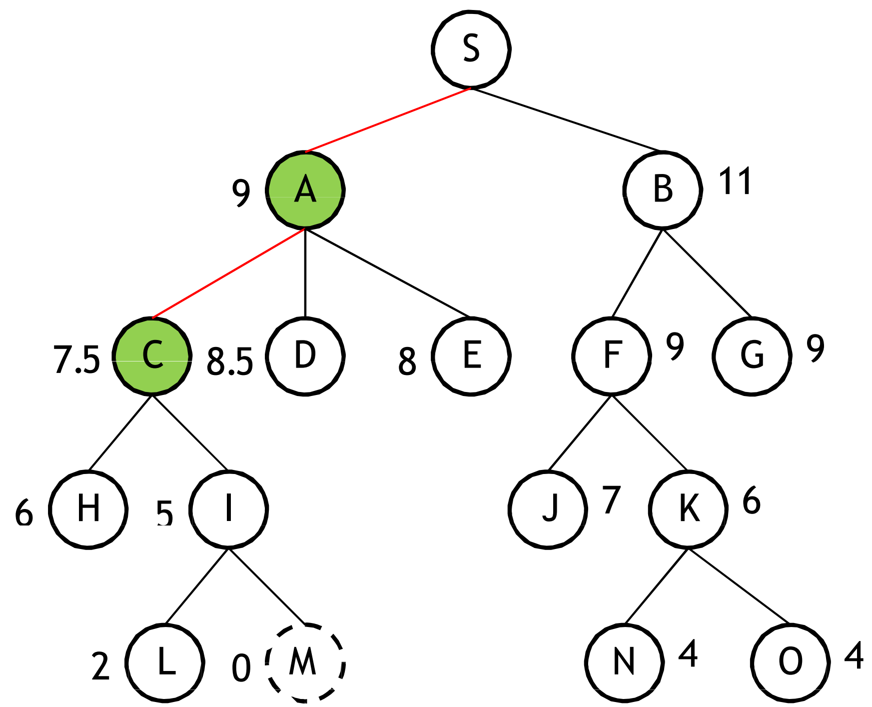
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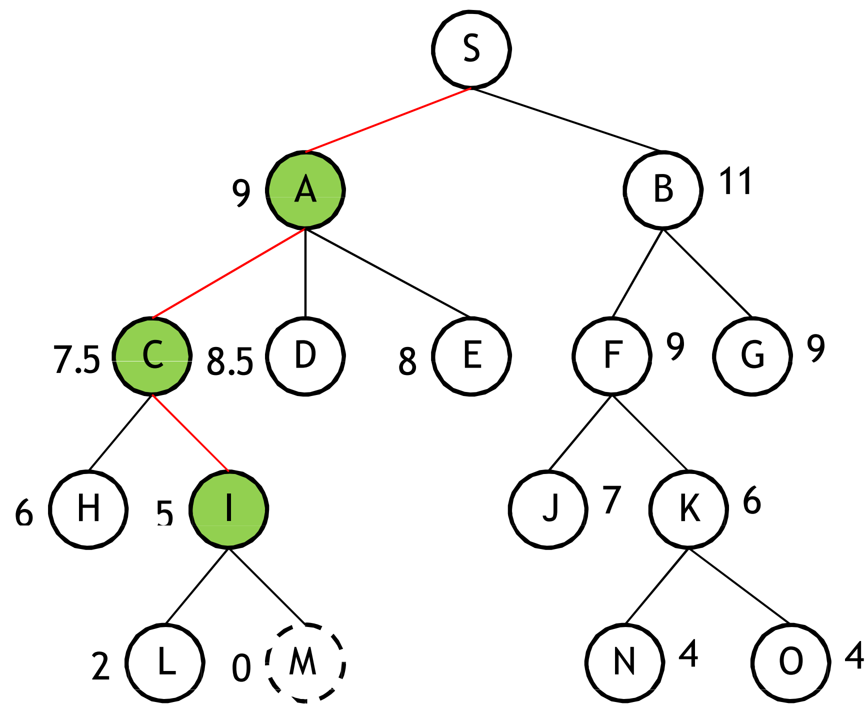
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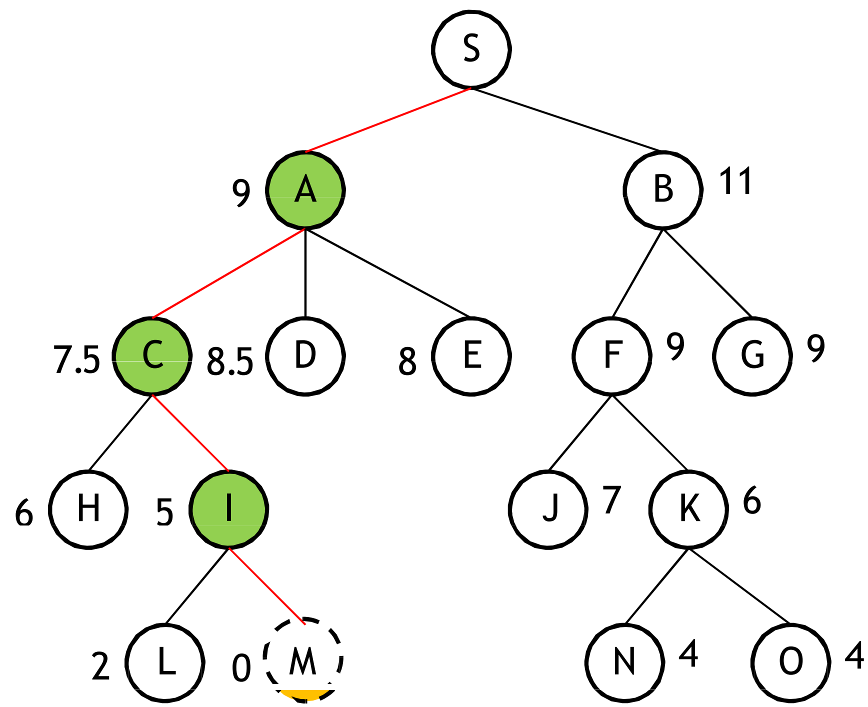
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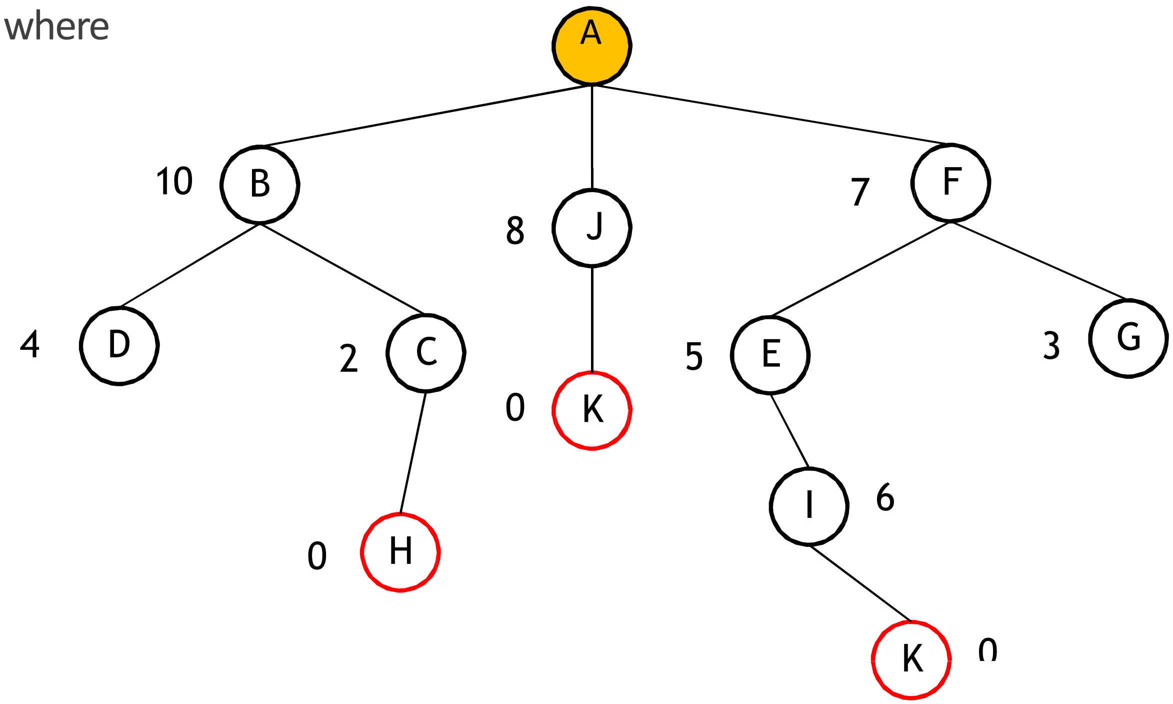
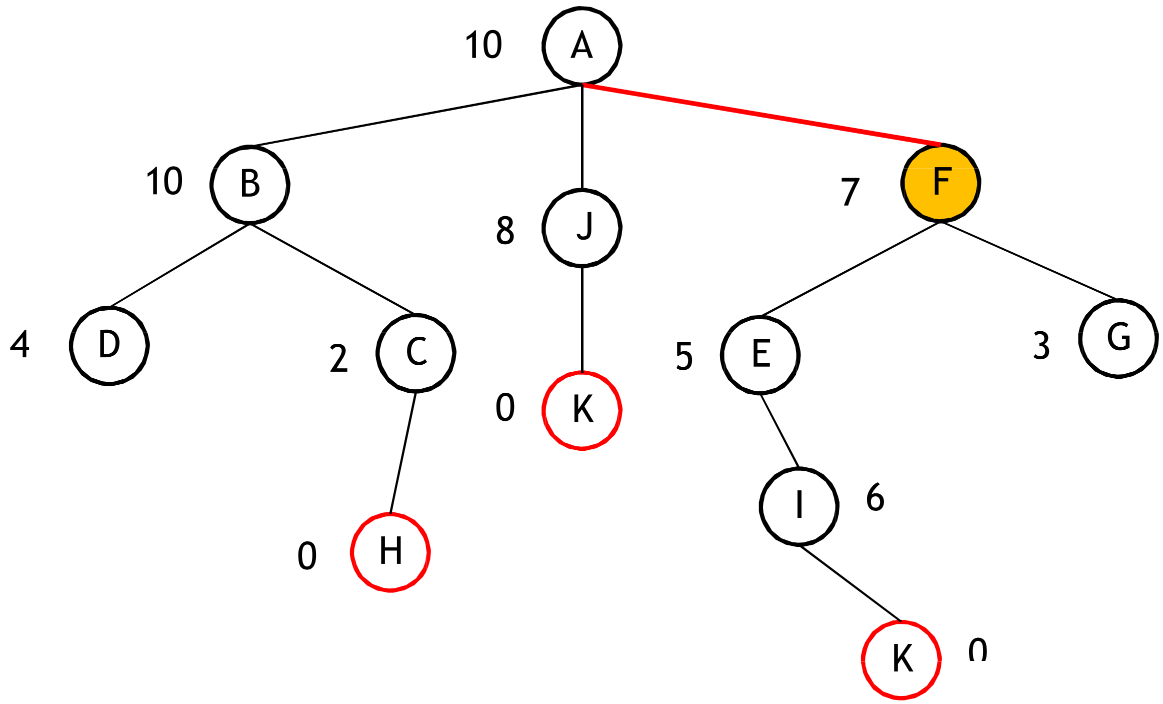
Hill-Climbing Search Example

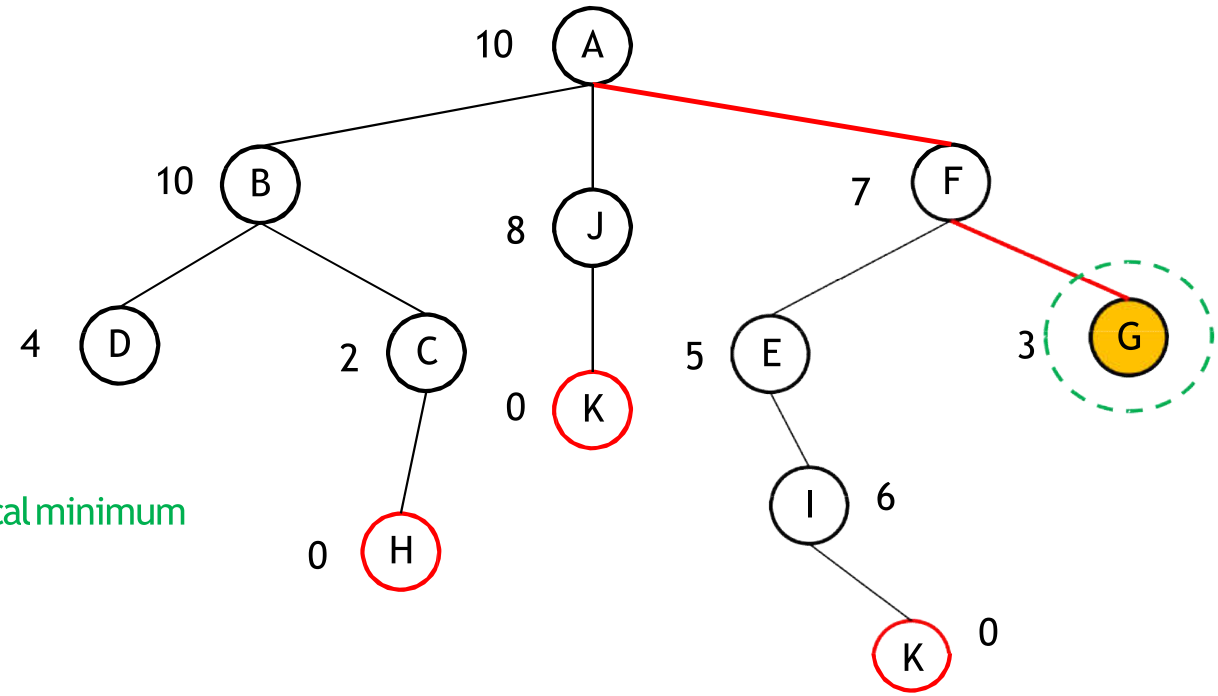
From A find a solution where
H and K are finalstates



Local Maximum



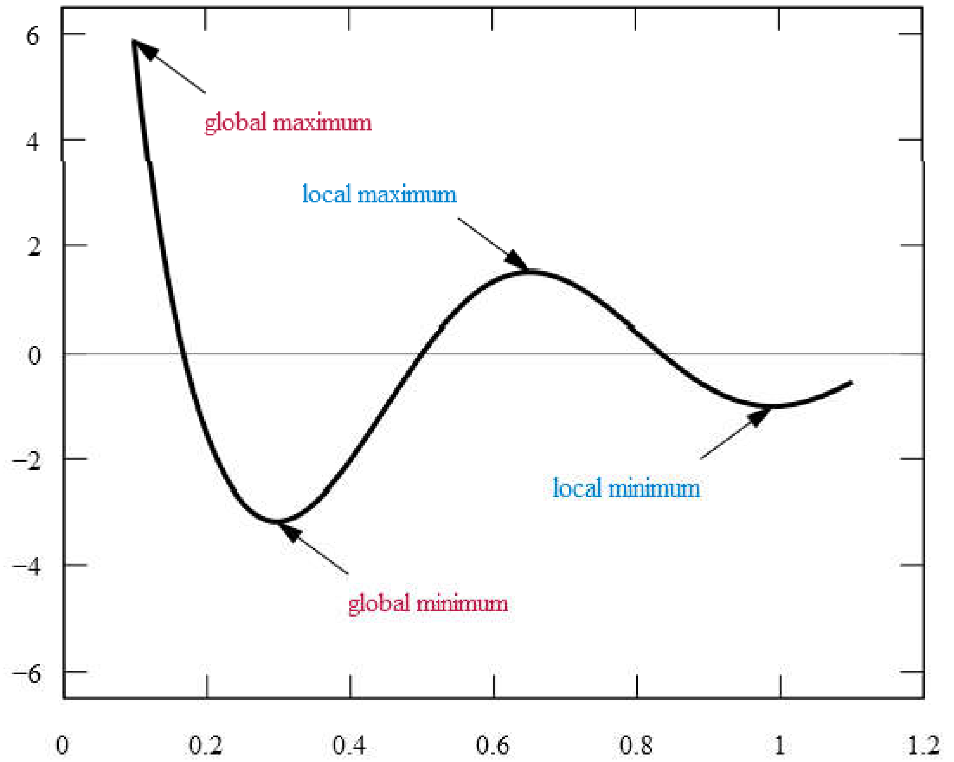
Local Minimum



G is local minimum

Hill climbing is sometimes called **greedy local search** because it grabs a good neighbor state without thinking ahead about where to go next.

Local Maximum, Local Minimum



Alternative hill climbing

- Stochastic hill climbing
  - chooses at random from among the uphill moves (neighbors); the probability of selection can vary with the steepness of the uphill move.
  - This usually converges more slowly than the steepest ascent, but in some state landscapes, it finds better solutions.
- First-choice hill climbing
  - implements stochastic hill-climbing by generating successors randomly until one is generated that is better than the current state.
  - This is a good strategy when a state has many (e.g., thousands) of successors.
- Random-restart hill climbing
  - adopts the well-known adage(proverb), "If at first, you don't succeed, try, try again." It conducts a series of hill-climbing searches from the randomly generated initial state, stopping when a goal is found. t is complete with probability approaching **1**, for the trivial reason that it will eventually generate a goal state as the initial state. (It iteratively does hill-climbing, each time with a random initial condition)