Local Search

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Local Search

• What if finding the optimal is impractical? A **good** solution might be acceptable. For example,

  - Do we have to find the absolute best driving route, or will one that is within 5% of the optimal be fine?
Local search terms

- Objective function: what we want to optimize
- State-space landscape
- Global minimum/maximum
- Local minimum/maximum
- Complete – always finds goal if there is one
- Optimal – always finds global min/max
Hill Climbing Search

• Generate successor states, and choose one that is better than the current state.
• Repeat until no successors are better

function HILL-CLIMBING(problem) returns a state that is a local maximum

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

Figure 4.2 The hill-climbing search algorithm, which is the most basic local search technique. At each step the current node is replaced by the best neighbor; in this version, that means the neighbor with the highest VALUE, but if a heuristic cost estimate $h$ is used, we would find the neighbor with the lowest $h$. 
N-Queens Hill Climbing

• (We have already seen N-queens using depth-first search.)

• **Hill Climbing version of N-Queens**
  
  • Use complete state formulation (N queens always on board)
  
  • Initialize by placing 1 queen in each column randomly
  
  • “Successors” states are generated by moving 1 queen to a different row
  
  • Heuristic cost $h$ is the number of queen pairs attacking each-other.
N-Queens Hill Climbing
N-Queens Hill Climbing

• Hill climbing from a random initial state will solve 8-queens 14% of the time.

• If we allow (up to 100 consecutive) sideways moves, where the objective function stays the same, the chance of success raises to 94%.

• If we are willing to restart a few times, then the chance of success becomes very high.
Hill Climbing Problems

• (Q) What are some issues with hill climbing you can think of?
Hill Climbing Problems

- Objective function
- Global maximum
- Shoulder
- Local maximum
- "Flat" local maximum
- Current state
- State space
Hill Climbing Variants

• **Steepest Ascent (Gradient descent)**
  • If the objective function can be differentiated, move in the gradient direction

• **Stochastic hill climbing**
  • Don't always choose the best direction, just one of the directions that improves things

• **First-choice hill climbing**
  • Choose the first move that improves the objective function. (Good if there are many successors)

• **Random restart hill climbing**
  • Restart the search at a few random locations