Informed search

Classes of Search

Blind (uninformed)	**Depth-First** **Breadth-First** **Iterative-Deepening**	Systematic exploration of whole tree until the goal is found.
Heuristic (informed)	**Hill-Climbing** **Best-First** **Beam**	Uses heuristic measure of goodness of a node,e.g. estimated distance to goal.
Optimal (informed)	**Branch&Bound** **A***	Uses path "length" measure. Finds "shortest" path. A* also uses heuristic

INFORMED SEARCH STRATEGIES

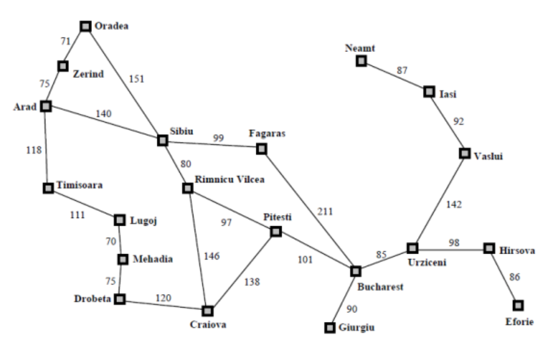
- One that uses problem specific knowledge beyond the definition of the problem itself.
- Find solutions more efficiently than an uninformed strategy.

Best-first search

- Uses an evaluation function *f(n)* for each node
  - f(n) provides an estimate for the total cost.
  - → Expand the node n with smallest f(n).
- Implementation:
  Order the nodes in increasing order of cost.
- Special cases:
  - Greedy best-first search
  - A^* search

- Most best-first algorithms include as a component of **f** a **heuristic function denoted by h(n)**
- **h(n)** = estimated cost of the cheapest path from the **state at node n** to a **goal state**

A simplified road map of part of Romania



Romania with straight-line distance

Arad	366	Mehadia	241
Bucharest	0	Neamt	234
Craiova	160	Oradea	380
Drobeta	242	Pitesti	100
Eforie	161	Rimnicu Vilcea	193
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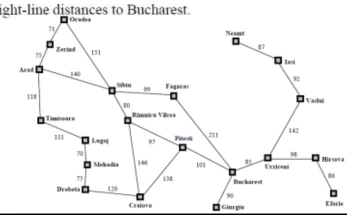
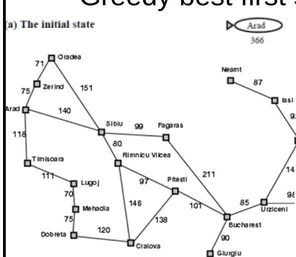
Values of h_{SLD}—straight-line distances to Bucharest.



Greedy Best first search

- f(n) = estimate of cost from n to goal
- **f(n) = straight-line distance from n to Bucharest**
- Greedy best-first search expands the node that appears **to be closest to goal.**

Greedy best first search example



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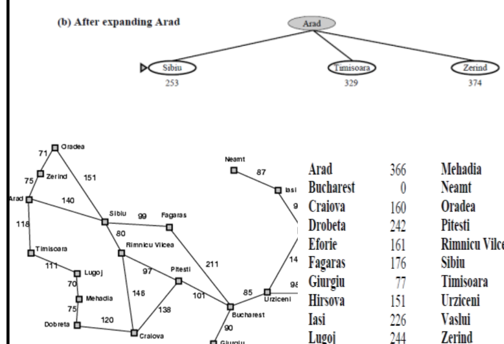

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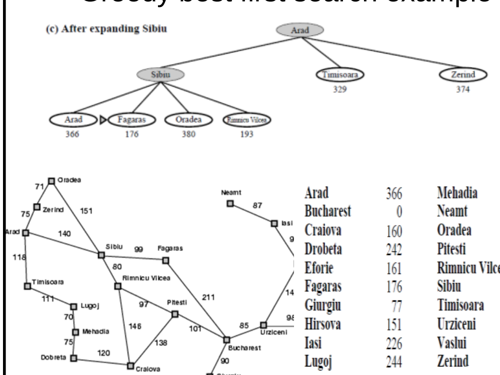

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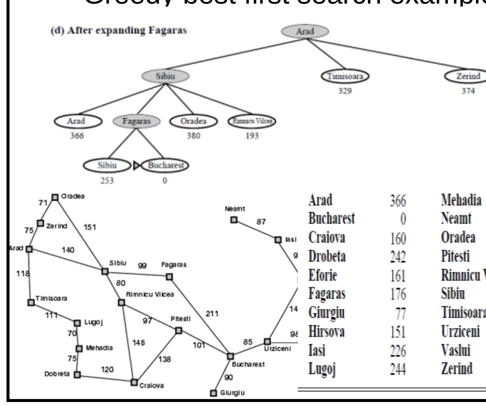

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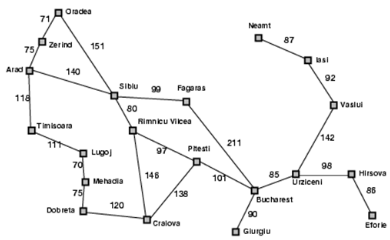
Properties of greedy best-first search

- Can stuck in loops.
- Optimal? No

e.g. Arad→Sibiu→Rimnicu Virea→Pitesti→Bucharest is shorter



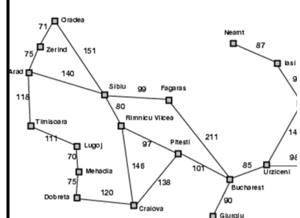
A* search

- Idea: avoid expanding paths that are already expensive
- Evaluation function f(n) = g(n) + h(n)
- g(n) = cost so far to reach n
- h(n) = estimated cost from n to goal
- f(n) = estimated total cost of path through n to goal
- Best First search has f(n)=h(n)

Admissible heuristics

- A heuristic h(n) is admissible if for every node n, $h(n) \le h^*(n)$, where $h^*(n)$ is the true cost to reach the goal state from n.
- An admissible heuristic never overestimates the cost to reach the goal, i.e., it is optimistic
- Example: $h_{SLD}(n)$ (never overestimates the actual road distance)

A* search example



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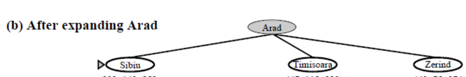

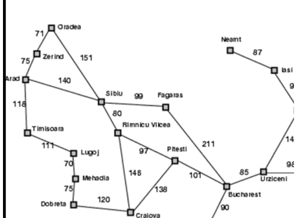

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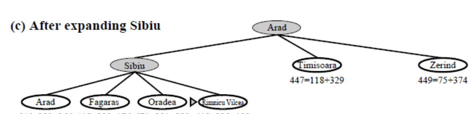

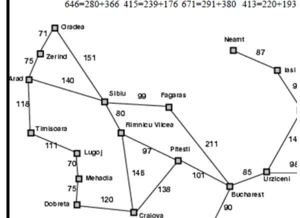

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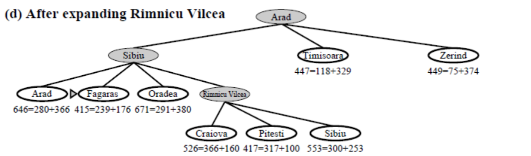
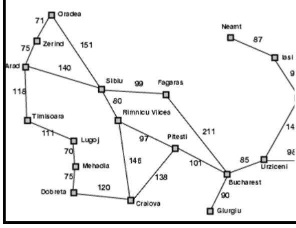
A* search example

(d) After expanding Rimnicu Vilcea





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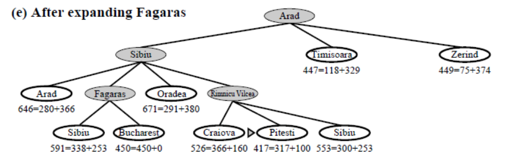
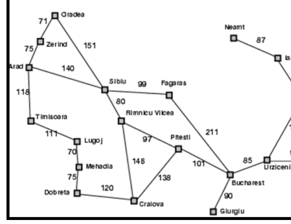
A* search example

(e) After expanding Fagaras





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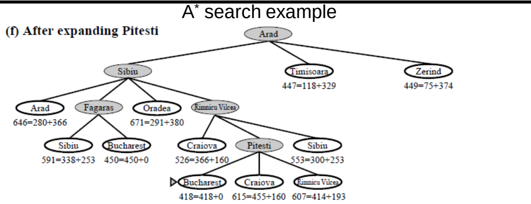
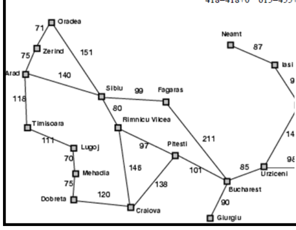
A* search example

(f) After expanding Pitesti





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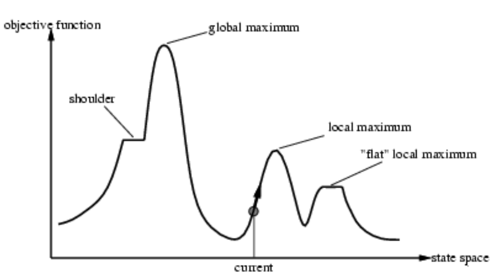
Hill-climbing search

- If there exists a **successor state s** for the **current state n** such that
  - h(s) < h(n)
  - h(s) <= h(t) for all the successors t of n,

  then move from n to s. Otherwise, halt at n.
- Looks one step ahead to determine if any successor is better than the current state; if there is, move to the best successor.
- Similar to Greedy search, it uses h but does not allow backtracking or jumping to an alternative path since it doesn't "**remember**" where it has been.
- Not complete since the search will terminate at "local minima", "plateaus", and "ridges".

Hill-climbing search

- Problem: depending on initial state, can get stuck in local maxima



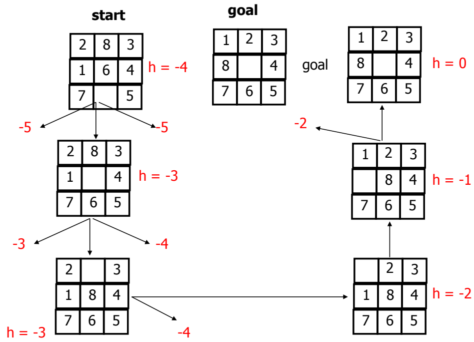
Hill-climbing search

- "Like climbing Everest in thick fog with amnesia (memory loss)

```
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 example



f(n) = -(number of tiles out of place)

Drawbacks of hill climbing

- Problems:
  - **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
  - **Ridges:** flat like a plateau, but with dropoffs to the sides; steps to the North, East, South and West may go down, but a step to the NW may go up.
- Remedy:
  - Random restart.
- Some problem spaces are great for hill climbing and others are terrible.