Searching

Artificial Intelligence @ Allegheny College

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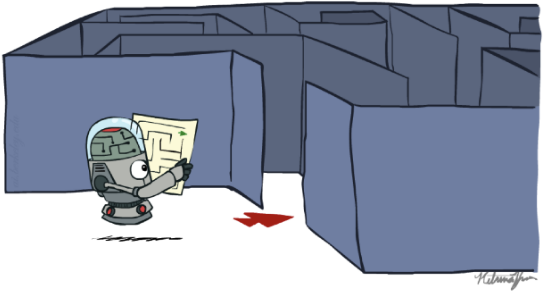
September 6–10, 2021

Ref: "Artificial Intelligence: A Modern Approach" textbook

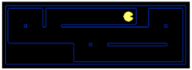
Agents that Plan Ahead

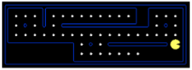


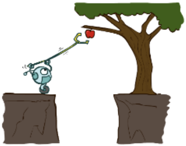
Problem Solving via Search: building goal-based agents that can plan ahead to solve problems.

- Model world with state space.
- Setting up state spaces.

Planning Agents







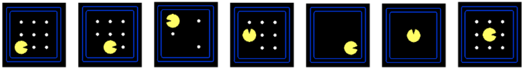
Planning agents:

Ask “what if?”
Decisions based on (hypothesized) consequences of actions.
Must have a model of how the world evolves in response to actions.
Must formulate a goal (test).
Consider how the world WOULD BE.

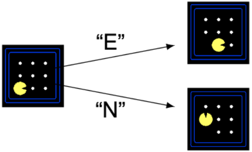
Search Problems

A search problem consists of:

A state space



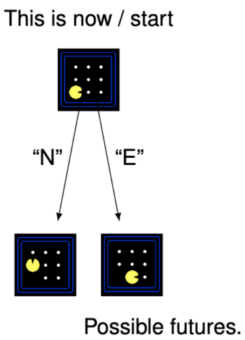
A successor function
(with actions, costs)



A start state and a goal test

A solution is a sequence of actions (a plan) which transforms the start state to a goal state

Search Trees



A search tree:

A "what if" tree of plans and their outcomes

The start state is the root node

Children correspond to successors

Nodes show states, but correspond to PLANS that achieve those states

For most problems, we can never actually build the whole tree

General-purpose Search Methods

Uninformed Search Algorithms

Search algorithms which explore the search space without having any information about the problem other than its definition.

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Uninformed Search Algorithms

Search algorithms which explore the search space without having any information about the problem other than its definition.

Informed Search Algorithms

Search algorithms which leverage any information (heuristics, path cost) on the problem to search through the search space to find the solution efficiently.

Uninformed Search Methods

- Breadth-First Search
- Depth-First Search
- Depth Limited Search
- Iterative Deepening Search

Uninformed Search Methods

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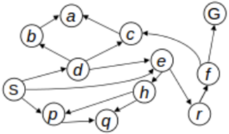
Fringe: data structure used to store all the possible states (nodes) that you can go from the current states.

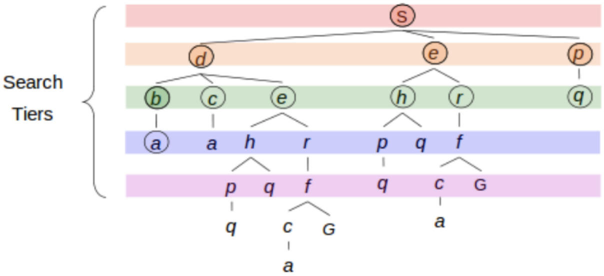
Breadth-First Search

Explores all of the neighbor nodes at the current depth prior to moving on to the nodes at the next depth level.

Strategy: expand a shallowest node first

Implementation: Fringe is a FIFO queue



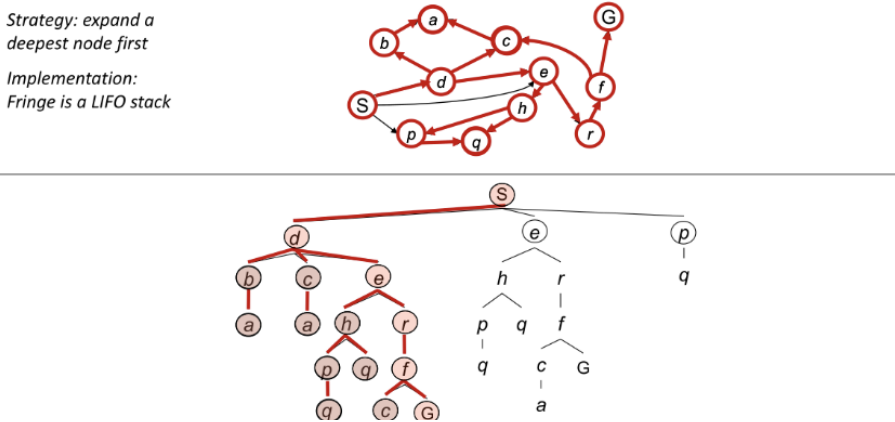


Breadth-First Search

```
function BREADTH-FIRST-SEARCH(problem) returns a solution node or failure
  node ← NODE(problem.INITIAL)
  if problem.IS-GOAL(node.STATE) then return node
  frontier ← a FIFO queue, with node as an element
  reached ← {problem.INITIAL}
  while not IS-EMPTY(frontier) do
    node ← POP(frontier)
    for each child in EXPAND(problem, node) do
      s ← child.STATE
      if problem.IS-GOAL(s) then return child
      if s is not in reached then
        add s to reached
        add child to frontier
  return failure
```

Depth-First Search

Starts at the root node and explores as far as possible along each branch before backtracking.



Depth-Limited Search

Idea: DFS with pre-determined limit to avoid the problem of infinite path of DFS.

- If the depth limit is reached, assume there are no successor nodes.
- It is memory efficient.
- It can be incomplete.

Iterative Deepening Search

Idea: get DFS's space advantage with BFS's time

- Run a DFS with depth limit 1. If no solution . . .
- Run a DFS with depth limit 2. If no solution . . .
- Run a DFS with depth limit 3 ...

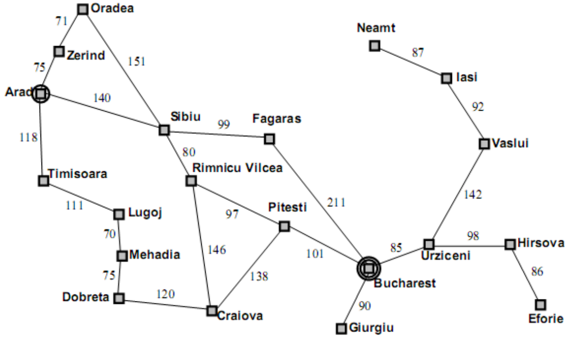
Informed Search Methods

- Best First Search
- A* (“A star”)
- Recursive Best First Search

Example: Romania

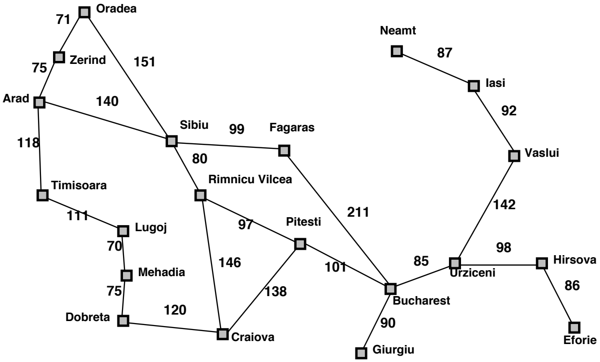
On holiday in Romania; currently in Arad.
Flight leaves tomorrow from Bucharest
Formulate goal: be in Bucharest
Formulate problem:
states: various cities
actions: drive between cities
Find solution: sequence of cities, e.g., Arad, Sibiu, Fagaras, Bucharest

Example: Romania



Can use Tree Search Algorithms (BFS, DFS)
Special cases: greedy search, A^* search

Romania with step costs in km



Straight−line distance
to Bucharest

Arad	366
Bucharest	0
Craiova	160
Dobreta	242
Eforie	161
Fagaras	178
Giurgiu	77
Hirsova	151
Iasi	226
Lugoj	244
Mehadia	241
Neamt	234
Oradea	380
Pitesti	98
Rimnicu Vilcea	193
Sibiu	253
Timisoara	329
Urziceni	80
Vaslui	199
Zerind	374

A* search

Idea:

avoid expanding paths that are already expensive

A* search

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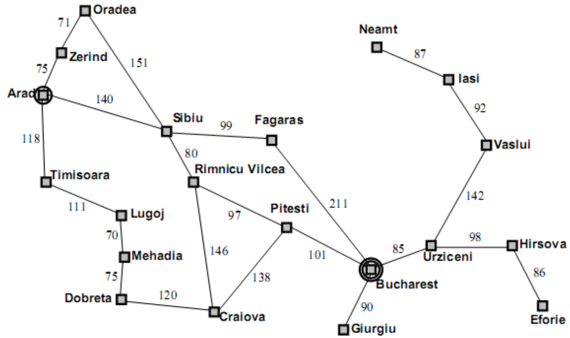
avoid expanding paths that are already expensive

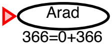
- Evaluation function $f(n) = g(n) + h(n)$
- $g(n)$ = cost so far to reach n
- $h(n)$ = estimated cost to goal from n
- $f(n)$ = estimated total cost of path through n to goal

Romania with step costs

Example: Romania



A* Search



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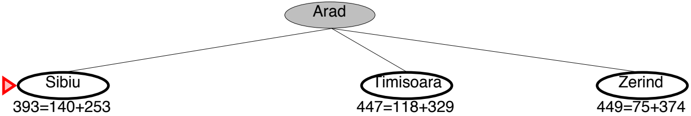
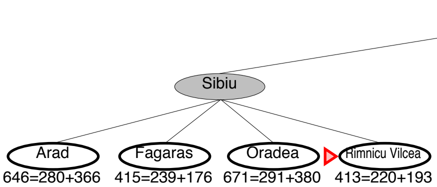

Arad
Sibiu
393=140+253
Timisoara
447=118+329
Zerind
449=75+374

A* Search



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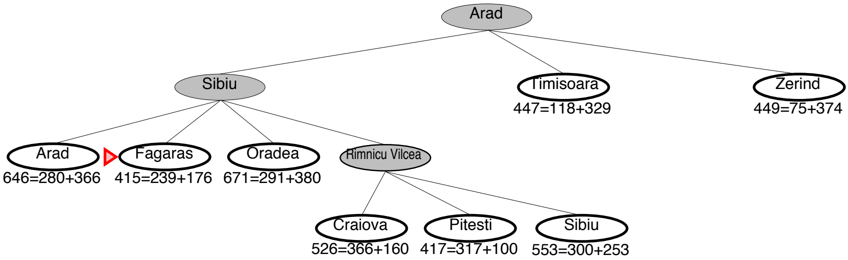

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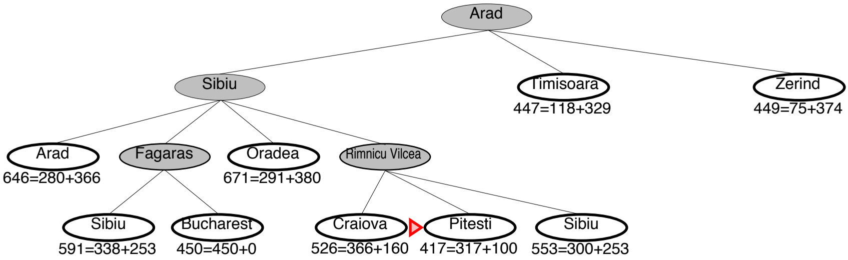
Sibiu
553=300+253

A* Search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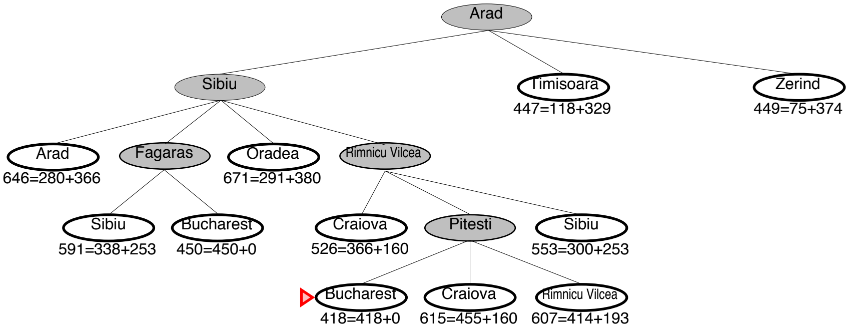
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