CS 4100/5100: Foundations of AI

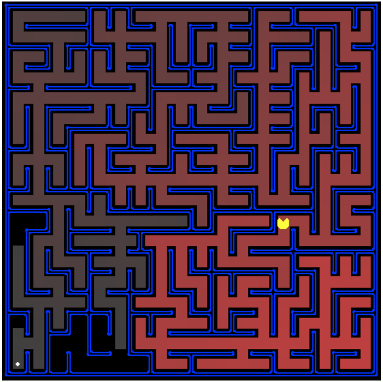
Search

Instructor: Rob Platt
rplatt@ccs.neu.edu

College of Computer and information Science
Northeastern University

Fall, 2014

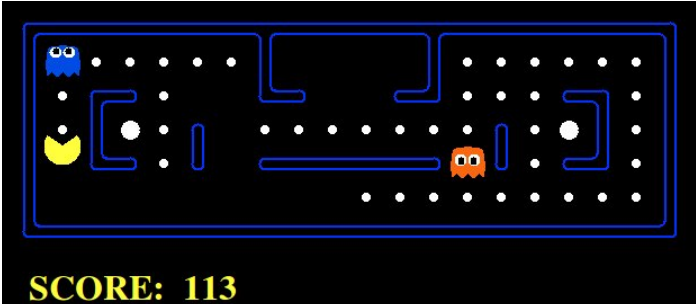
Examples of search problems



Suppose the problem is to find a path to the x.

- state space ($n = 56$)?
- action space?
- transition function?
- goal test / path cost?

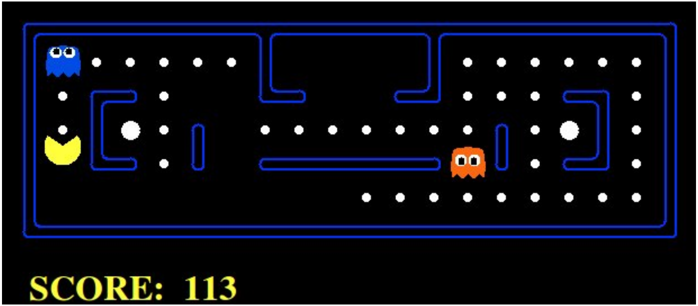
Examples of search problems



Suppose the problem is to reach the x while avoiding ghosts.

- state space ($56^3 = 175k$)?
- action space?
- transition function?
- goal test / path cost?

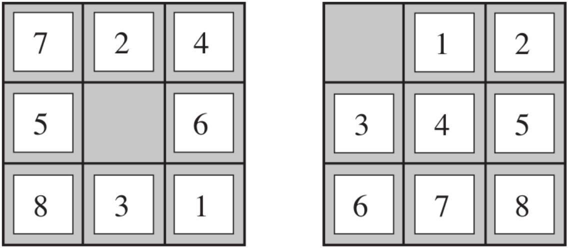
Examples of search problems



Suppose the problem is to eat all the dots and avoid the ghosts?

- state space $56^3 + 2^56 > 7.2^{16}$?
- action space?
- transition function?
- goal test / path cost?

Examples of search problems



7	2	4
5		6
8	3	1

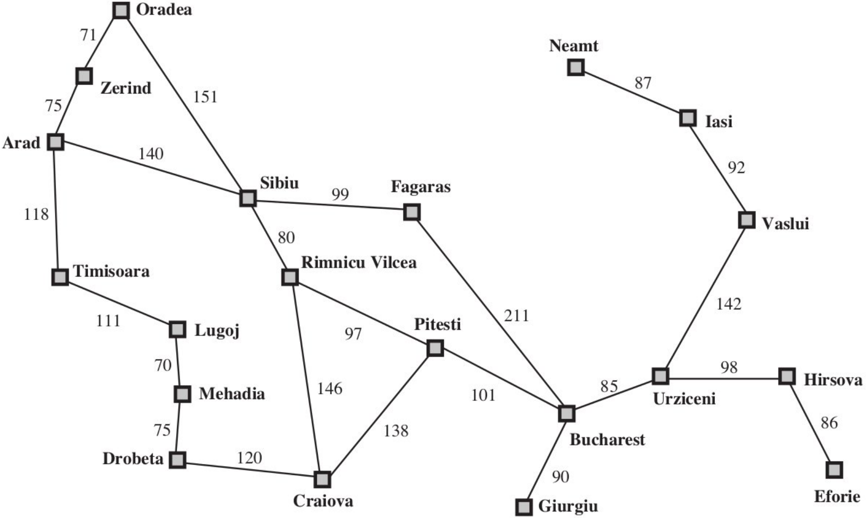
Start State

	1	2
3	4	5
6	7	8

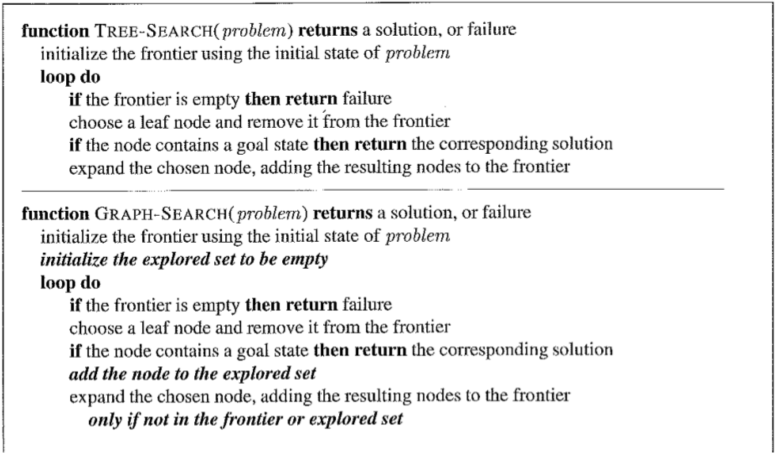
Goal State

- state space (no greater than $9! = 362$k states)?
- action space?
- transition function?
- goal test / path cost?

Examples of search problems



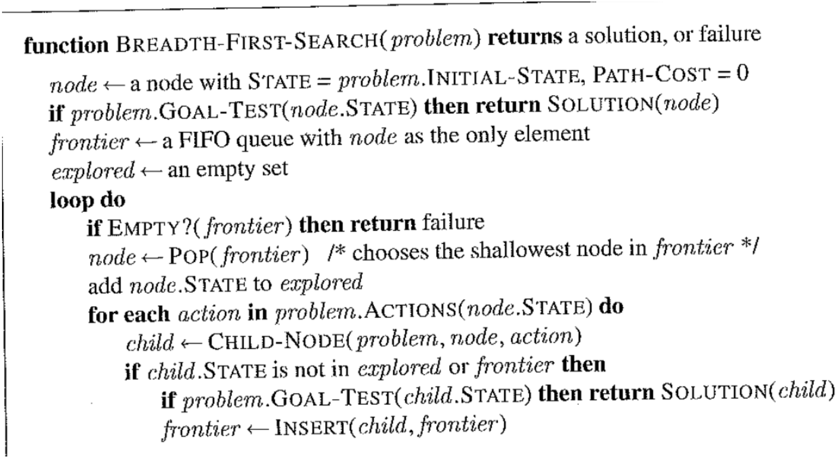
Generalized search algorithm



```
function TREE-SEARCH(problem) returns a solution, or failure
  initialize the frontier using the initial state of problem
  loop do
      if the frontier is empty then return failure
      choose a leaf node and remove it from the frontier
      if the node contains a goal state then return the corresponding solution
      expand the chosen node, adding the resulting nodes to the frontier
```

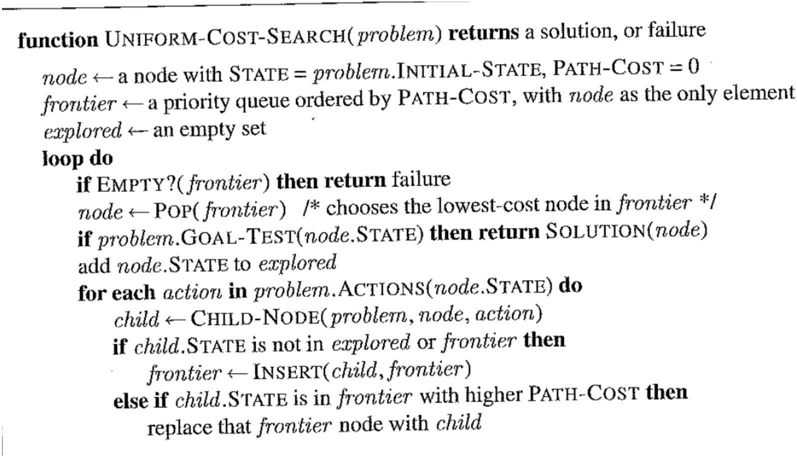
```
function GRAPH-SEARCH(problem) returns a solution, or failure
  initialize the frontier using the initial state of problem
  initialize the explored set to be empty
  loop do
      if the frontier is empty then return failure
      choose a leaf node and remove it from the frontier
      if the node contains a goal state then return the corresponding solution
      add the node to the explored set
      expand the chosen node, adding the resulting nodes to the frontier
        only if not in the frontier or explored set
```

Breadth First Search (BFS)



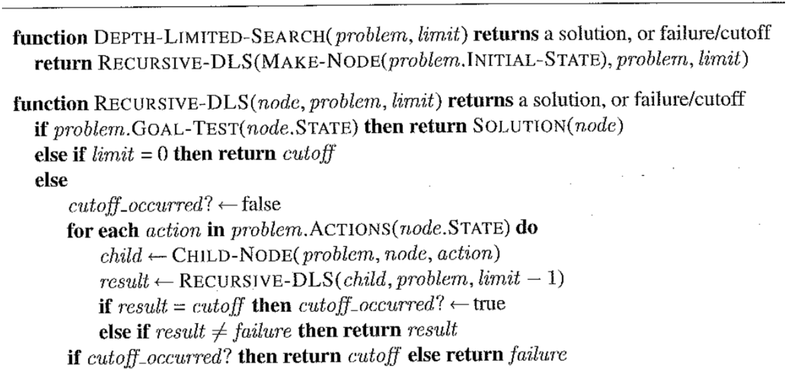
```
function BREADTH-FIRST-SEARCH(problem) returns a solution, or failure
    node ← a node with STATE = problem.INITIAL-STATE, PATH-COST = 0
    if problem.GOAL-TEST(node.STATE) then return SOLUTION(node)
    frontier ← a FIFO queue with node as the only element
    explored ← an empty set
    loop do
        if EMPTY?(frontier) then return failure
        node ← POP(frontier)   /* chooses the shallowest node in frontier */
        add node.STATE to explored
        for each action in problem.ACTIONS(node.STATE) do
            child ← CHILD-NODE(problem, node, action)
            if child.STATE is not in explored or frontier then
                if problem.GOAL-TEST(child.STATE) then return SOLUTION(child)
                frontier ← INSERT(child, frontier)
```

Uniform Cost Search (UCS)



```
function UNIFORM-COST-SEARCH(problem) returns a solution, or failure
  node ← a node with STATE = problem.INITIAL-STATE, PATH-COST = 0
  frontier ← a priority queue ordered by PATH-COST, with node as the only element
  explored ← an empty set
  loop do
      if EMPTY?(frontier) then return failure
      node ← POP(frontier)  /* chooses the lowest-cost node in frontier */
      if problem.GOAL-TEST(node.STATE) then return SOLUTION(node)
      add node.STATE to explored
      for each action in problem.ACTIONS(node.STATE) do
          child ← CHILD-NODE(problem, node, action)
          if child.STATE is not in explored or frontier then
              frontier ← INSERT(child, frontier)
          else if child.STATE is in frontier with higher PATH-COST then
              replace that frontier node with child
```

Depth Limited Depth First Search (DLDFS)



```
function DEPTH-LIMITED-SEARCH(problem, limit) returns a solution, or failure/cutoff
  return RECURSIVE-DLS(MAKE-NODE(problem.INITIAL-STATE), problem, limit)

function RECURSIVE-DLS(node, problem, limit) returns a solution, or failure/cutoff
  if problem.GOAL-TEST(node.STATE) then return SOLUTION(node)
  else if $limit = 0$ then return cutoff
  else
      cutoff_occurred? ← false
      for each action in problem.ACTIONS(node.STATE) do
          child ← CHILD-NODE(problem, node, action)
          result ← RECURSIVE-DLS(child, problem, $limit - 1$)
          if $result = cutoff$ then cutoff_occurred? ← true
          else if $result \neq failure$ then return result
      if cutoff_occurred? then return cutoff else return failure
```

Bidirectional search