Announcements

Project 0: Python Tutorial.
Due on Monday 1/27. 11:59 pm.

Homework 0: Math Diagnostic.
Due on Wednesday 1/29. 11:59 pm.

Project 1: Search.
Out: longer than average. Get started.
Due Friday. 2/7. 11:59 pm.

Sections.
Start next week!

Office Hours: still working on rooms.
Department/university issues still being dealt with.

Check: signed up for Piazza and Gradescope?

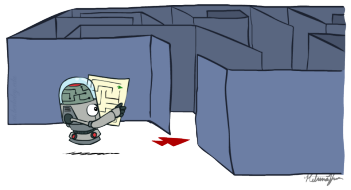
Pinned Post: AI in the news!

Lecture Attendance Link

Lecture Attendence Link: http://bit.ly/2GEMokS

CS 188: Artificial Intelligence

Search.



Today.

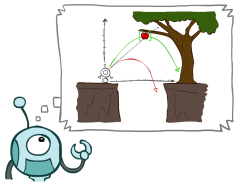
Agents that Plan Ahead

Search Problems.
Model world with state space.
Setting up state spaces.

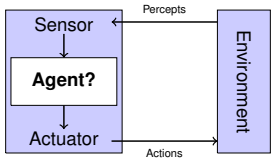
Maybe today.

Uninformed Search Methods:

- Depth-First Search
- Breadth-First Search
- Uniform-Cost Search



Frame of AI



An agent percieves its environment with sensors and acts on environment using actuators.

Car:
Sensors: camera, lidar, speed gauge, ..
Actuators: gas petal, , steering wheel, brake petal, ...

Website, Program, ...

Input/Output: Outputs affect environment, which affects input , which outputs, . . .

Rationality

A rational agent chooses actions that maximize expected utility.

Today: agents that have a goal, and a cost.
E.g., reach goal with lowest cost.

Later: agents have numerical utilities, rewards, etc.
E.g., takes action that maximizes total reward over time.
(Reward: largest total profit. or expected total profit.)

Agent Design

The environment largely determines the agent design.

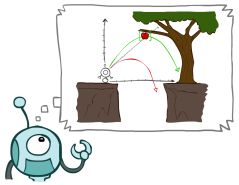
Fully/partialy observable → agent request memory (internal state)

Discrete/ continuous → agent can/can't enumerate all states

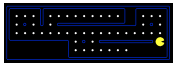
Stochastic/deterministic → agent deals with contingencies

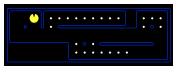
Single-agent/multi-agent → agent may need to behave randomly.

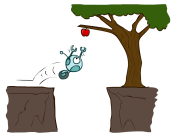
Agents that Plan



Reflex Agents







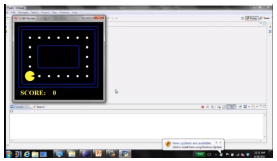
Reflex agents:

- Choose action based on current percept (and maybe memory)
- May have memory or a model of the world's current state
- Do not consider the future consequences of their actions.
- Consider how the world IS.

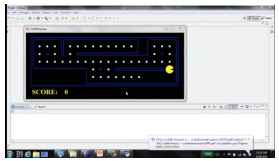
Can a reflex agent be rational?
Examples:
Stove: hot, ouch!
Car: deer, brake!
Go to Tahoe: skid in snow, ???

[Demo: reflex (L2D1 and L2D2)]

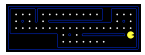
Video of Demo Reflex Optimal



Video of Demo Reflex Odd



Planning Agents



Planning agents:

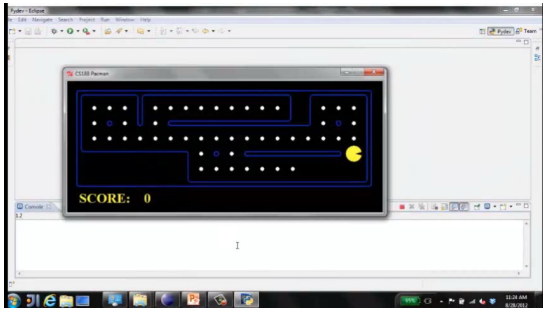
Ask "what if?"
Decisions based on (hypothesized) consequences of actions.
Must have a model of how the world evolves in response to actions.
Must formulate a goal (test).
Consider how the world WOULD BE.

Optimal or not optimal.
Complete or not.
Planning vs. replanning

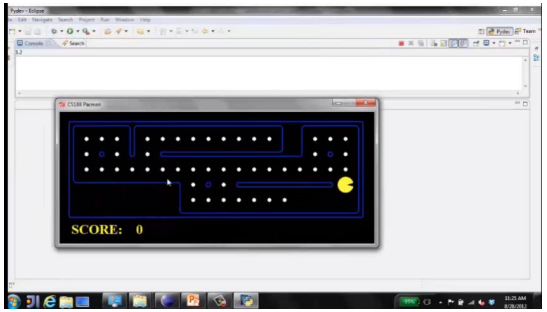
[Demo: nearest dot re-planning (L2D3), mastermind (L2D4)]

Video of Demo

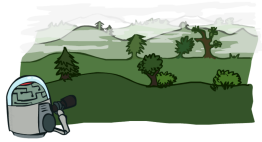
Replanning



Video of Demo Mastermind



Search Problems

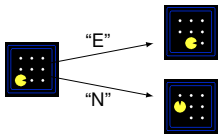


Search Problems

A search problem consists of:

A state space

A successor function
(with actions, costs)

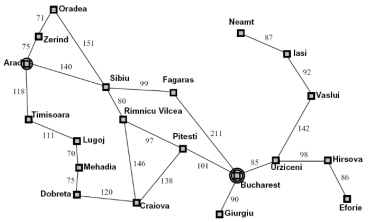


A start state and a goal test

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

Search Problems Are Models

Example: Traveling in Romania



State space:
Cities

Successor function:
Roads: Neighboring city with cost = distance

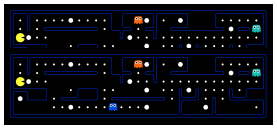
Start state:
Arad

Goal test:
Is state == Bucharest?

Solution?

What's in a State Space?

The world state includes every last detail of the environment.



Search state keeps only details needed for planning (abstraction).

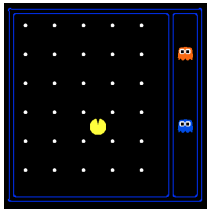
Problem: Pathing

States: (x, y) location
Actions: NSEW
Successor: update location only
Goal test: is $(x, y) =$END?

Problem: Eat-All-Dots

States: $\{(x, y)$, dot booleans$\}$
Actions: NSEW
Successor: update location and possibly a dot boolean
Goal test: dots all false

State Space Sizes?



World state:

Agent positions: 120

Food count: 30

Ghost positions: 12

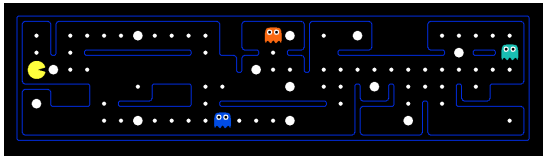
Agent facing: NSEW

How many World states?
$120 \times (2^{30}) \times (12^2) \times 4$

States for pathing?
120

States for eat-all-dots?
$120 \times (2^{30})$

Problem: Safe Passage



Problem: eat all dots while keeping the ghosts perma-scared?

What does the state space have to specify?

agent position
dot booleans
power pellet booleans
remaining scared time

Agent Design

The environment largely determines the agent design.

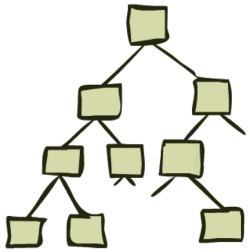
Fully/partialy observable $\rightarrow$ agent request memory (internal state)

Discrete/ continuous $\rightarrow$ agent can/can't enumerate all states

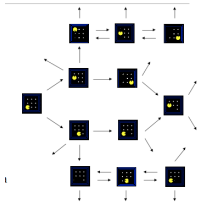
Stochastic/deterministic $\rightarrow$ agent deals with contingencies

Single-agent/multi-agent $\rightarrow$ agent may need to behave randomly.

State Space Graphs and Search Trees



State Space Graphs



State space graph: A mathematical representation of a search problem

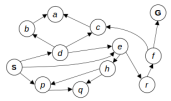
- Nodes are (abstracted) world configurations.
- Arcs represent successors (action results).
- The goal test is a set of goal nodes (maybe only one).

In a state space graph, each state occurs only once!

We can rarely build this full graph in memory (it's too big), but it's a useful idea.

E.g., replanning.

State Space Graphs



Tiny search graph for a tiny search problem

State space graph: A mathematical representation of a search problem

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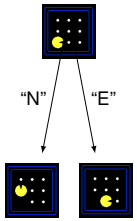
Search Trees

This is now / start



Possible futures.

A search tree:

A "what if" tree of plans and their outcomes

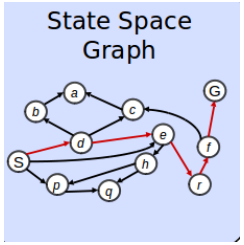
The start state is the root node

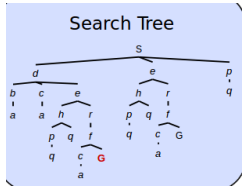
Children correspond to successors

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

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

State Space Graphs vs. Search Trees



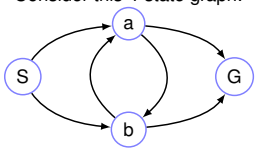


Each NODE in search tree is an entire PATH in state space graph.

We construct both on demand – and we construct as little as possible.

Quiz:State Space Graphs vs. Search Trees

Consider this 4-state graph:

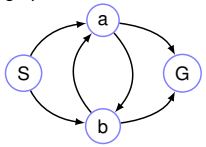


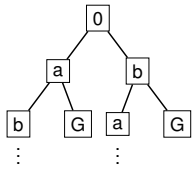
How large could search tree be?

∞

Quiz:State Space Graphs vs. Search Trees

Consider this 4-state graph:

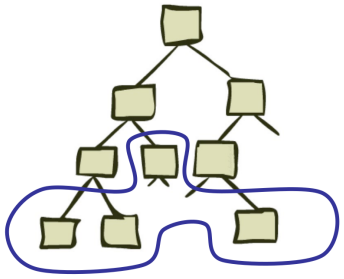




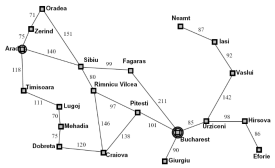
How large could search tree be?

∞

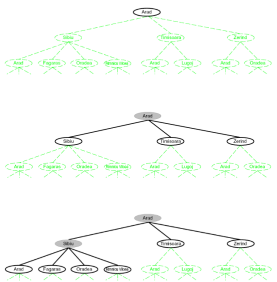
Tree Search



Search Example: Romania



Searching with a Search Tree



Search:
(1) Expand out potential plans (tree nodes)
(2) Maintain a fringe of partial plans under consideration.
(3) Try to expand as few tree nodes as possible

General Tree Search

Important ideas:

- Fringe
- Expansion
- Exploration strategy

Main question: which fringe nodes to explore?

```
function TREE-SEARCH( problem, strategy) returns a solution, or failure
    initialize the search tree using the initial state of problem
    loop do
        if there are no candidates for expansion then return failure
        choose a leaf node for expansion according to strategy
        if the node contains a goal state then return the corresponding solution
        else expand the node and add the resulting nodes to the search tree
    end
```