Artificial Intelligence
CSE 5/7320

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Problem Solving

Last Lecture

- Definitions of AI
  - Think like humans
  - Act like humans
  - Think rationally
  - **Act rationally**
- What is an agent?
- Percept, percept sequence
- Rational agent
- Task Environment
  - Performance measure
  - Environment (and their properties)
  - Sensors
  - Actuators
- Types of agents

Today (and next week)

- Solving problems by search
  - Problem formulation /definition
  - Search space

- Search algorithms
  - Uninformed search
  - Informed search
  - Adversarial search

Defining Problems

- Formally, five components (plus defining a *state*)
  - Initial state
    - The state the agent starts in
  - Actions
    - What actions can the agent perform in each state?
    - Given a state, list all actions available
  - Transition model
    - What does an action do?
    - From state *s,* applying action *a* we move to state *s*'
  - Goal test
    - Check if a state is a *goal state*
    - Goal test (property) vs. goal state
    - Path: sequence of states connected by actions
  - Path Cost
    - Functions that assign a numeric cost to a path

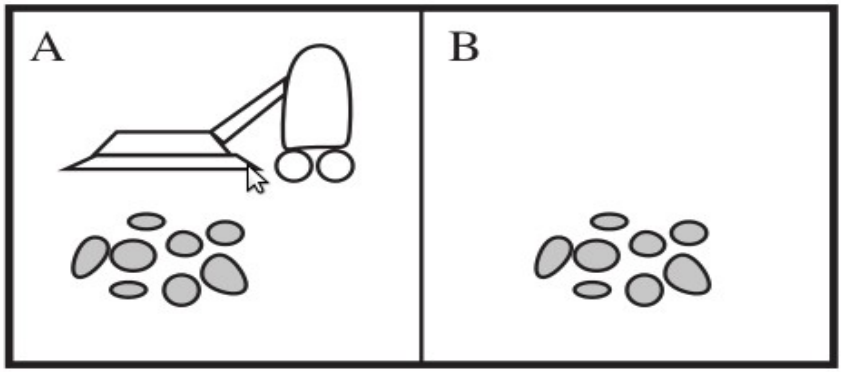
Defining Problems

- Initial state, Actions, Transition model, Goal test, Path Cost

- Initial state, actions and transition model form a directed graph
  - Nodes are states
  - Links between nodes are actions

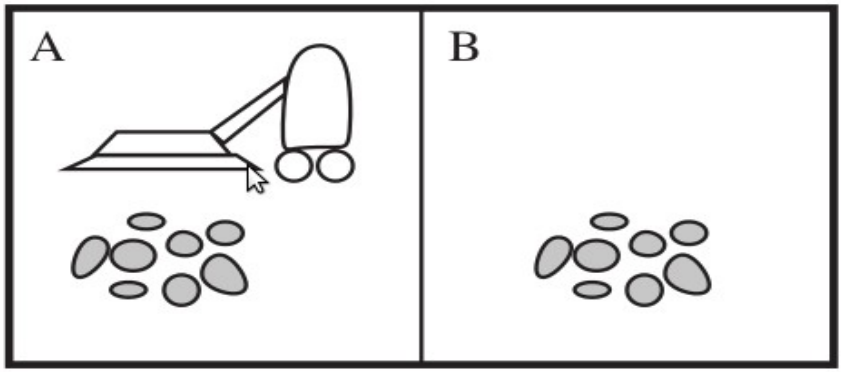
- Abstraction level
  - We want an *abstract model* of the problem
    - Abstract states and actions
    - Skip unnecessary details

Vacuum World



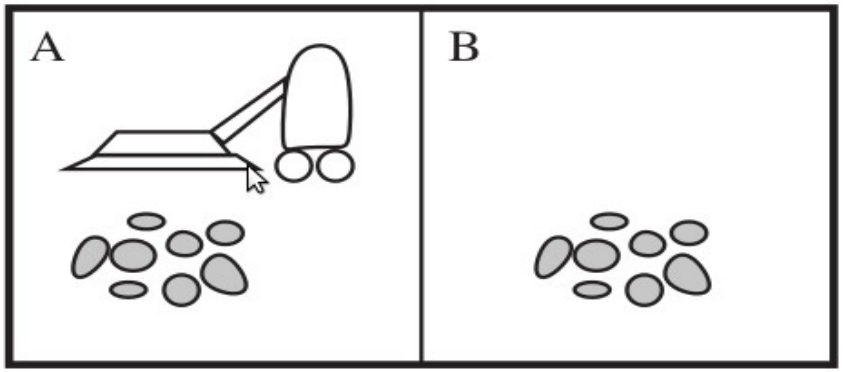
- What is a state?
- Initial state
- Actions
- Transition model
- Goal Test
- Path Cost

Vacuum World



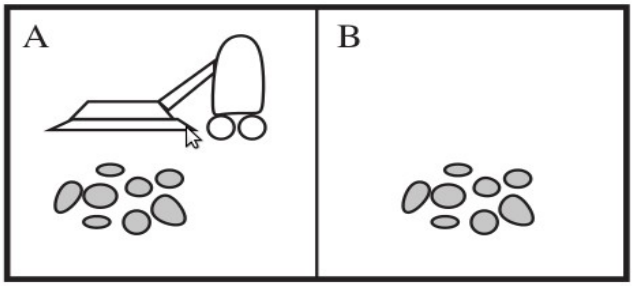
- What is a state?
  - Agent is in *A* or *B*
  - *A* may or may not have dirt
  - *B* may or may not have dirt
  - How many possible states?
    - If only two locations:
    - In general, for *n locations:*

Vacuum World



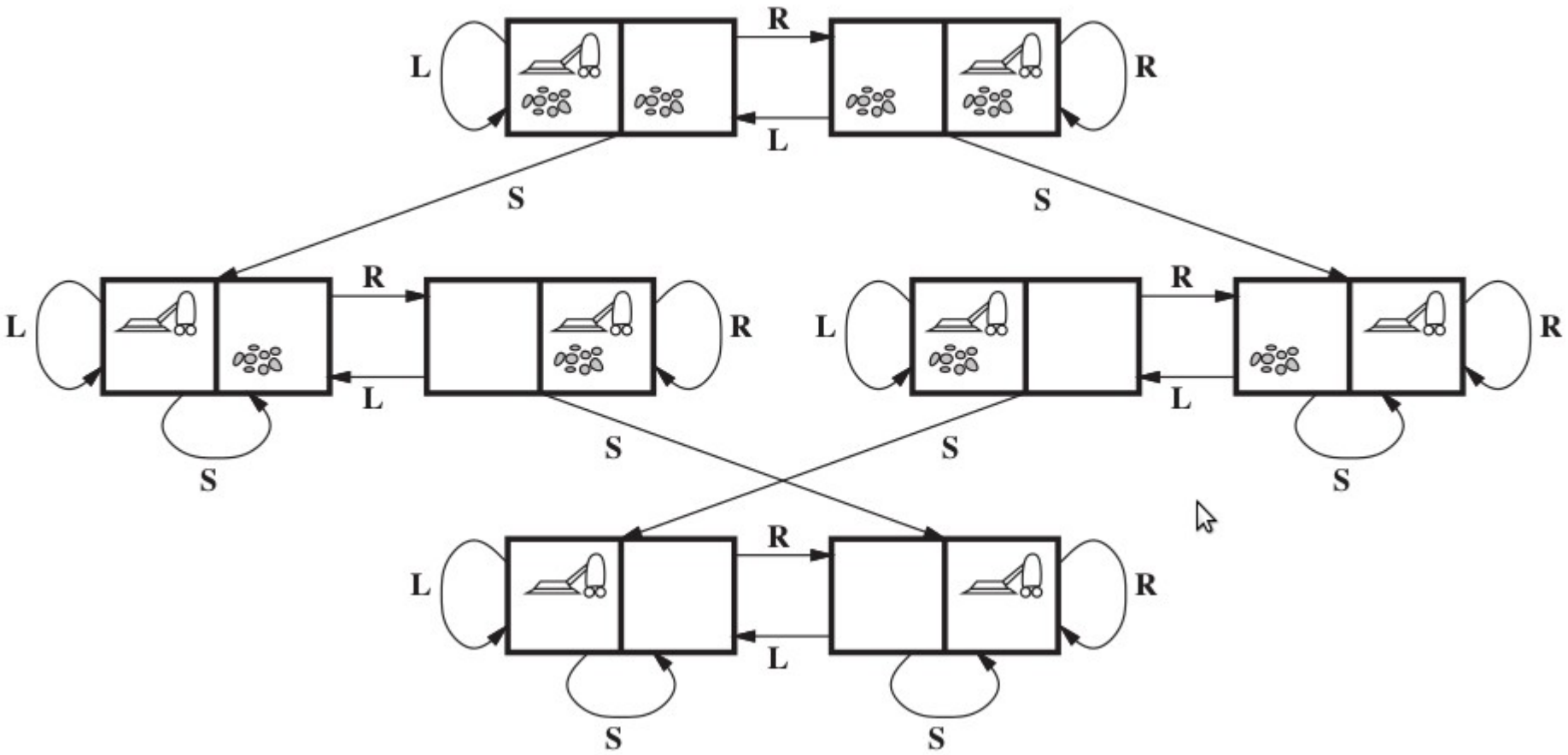
- Initial state
  - Any state is a plausible initial state
- Actions
  - Move to the left
  - Move to the right
  - Suck
  - If more than two location (a grid), move up / down

Vacuum World

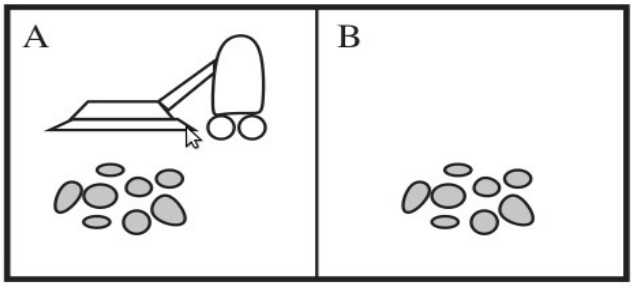


- Transition Model
  - Moving left from state *A*?
  - Moving right from state *B*?

Vacuum World



Vacuum World

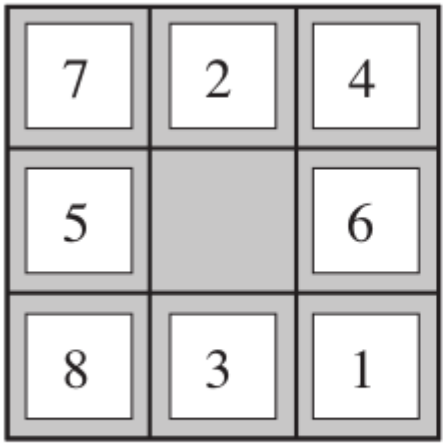


- Goal Test
  - Check if squares are clean
  - How many states satisfy the goal test?

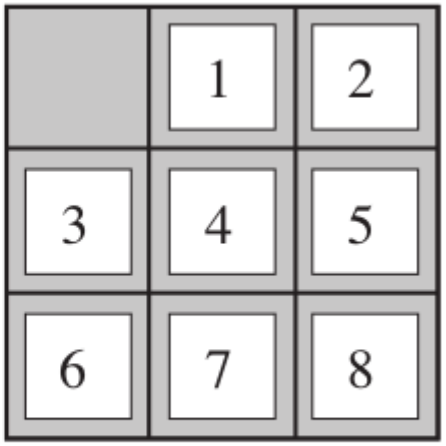
- Path Cost
  - Each action has uniform cost

The 8-puzzle

- 3x3 board
  - 8 numbered tiles
  - 1 blank space
- A tile adjacent to the blank space can slide into the space
- Goal: reach a specified state

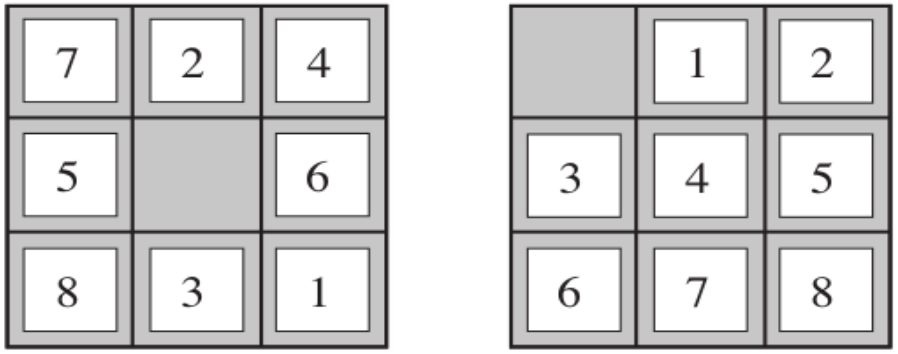


Start State



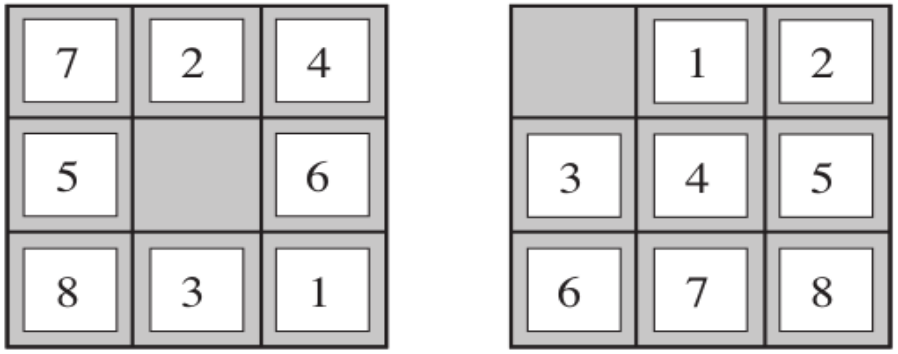
Goal State

The 8-puzzle



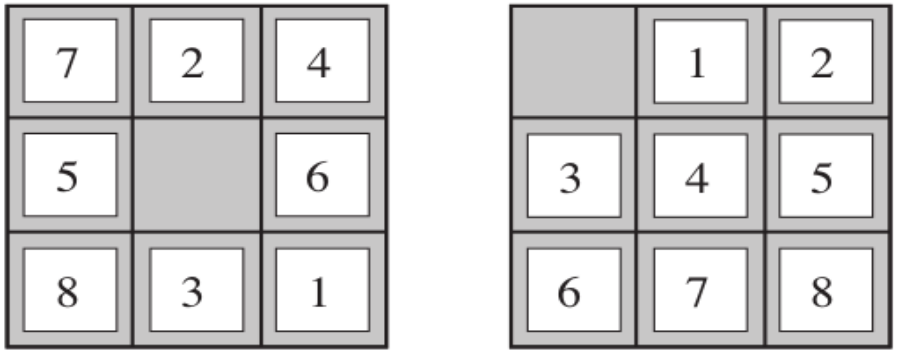
- What is a state?
  - Specify the location of each tile and the blank in one of the nine squares
  - Enumerate all squares and assign integers

The 8-puzzle



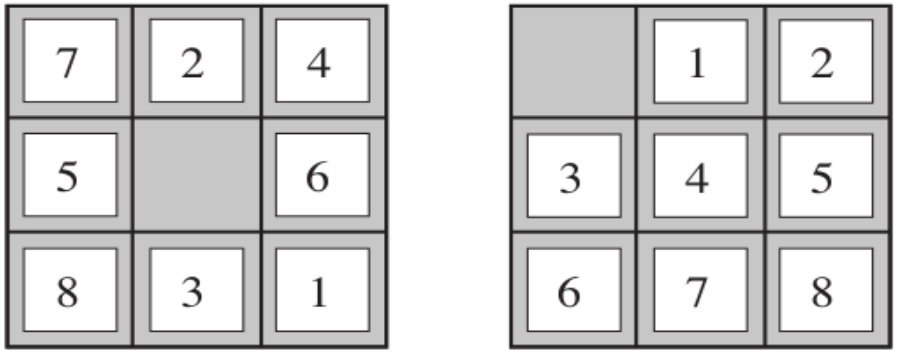
- Initial state
  - Any state
- Actions
  - Move tiles?
  - Move …
  - Restrictions (not all actions are available from every state)
    - If blank is *top-left* then right
    - If blank is *top-left* then down

The 8-puzzle



- Transition model
  - Given a state and action, return the resulting state.
  - Example:
    - The resulting state of executing *Left* from Start State has the 5 and blank switched

The 8-puzzle



- Goal test
  - Check whether state matches goal configuration

- Path cost
  - Each action costs 1 (uniform)

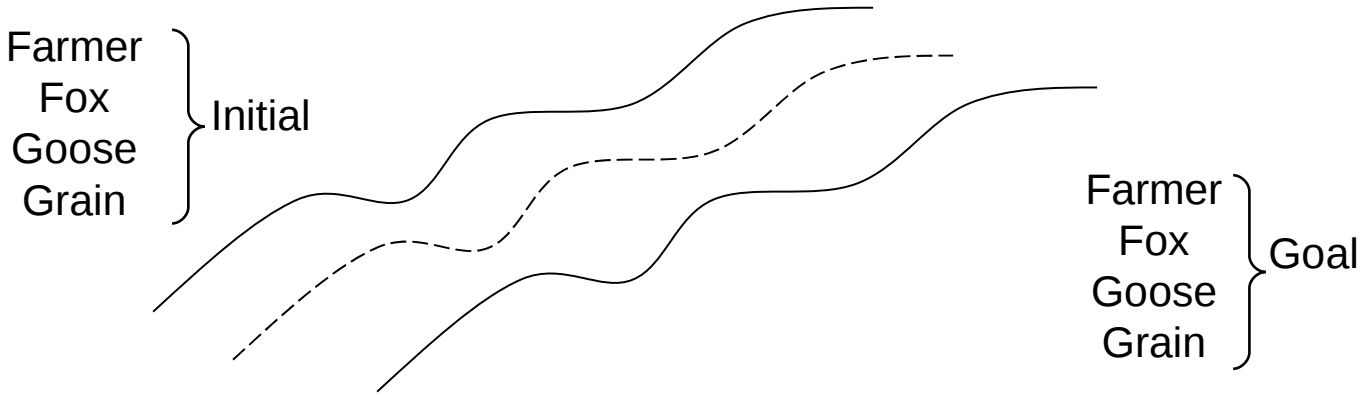
Water Jug Puzzle

- There are two empty jugs, one of 4 gallons and one of 3 gallons. Fill the 4-gallon jug with 2 gallons of water

  - Problem formulation
    - States
      - What do we need to keep track of?
    - Initial state
      - Where do we start?
    - Actions
      - How can we act?
    - Transition Model
      - What happens after each action?
    - Goal Test
      - When are we done?

The Farmer, Fox, Goose and Grain Puzzle

- A farmer wants to move himself, a fox, ans some grain across a river. His boat is tiny, he can only take one of his possessions across one trip.
  - An unattended fox will eat a goose
  - An unattended goose will eat the grain
  - What should the farmer do?



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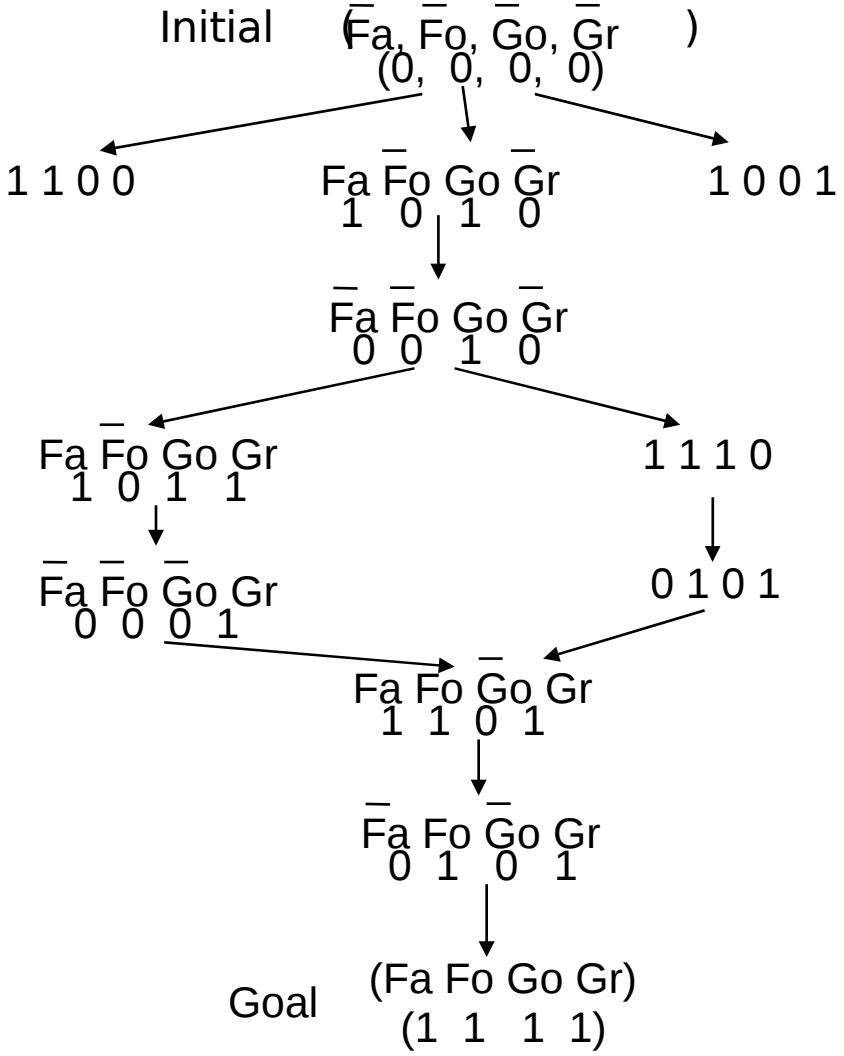
- State
- Initial state
- Actions
- Transition Model
- Goal Test

FFGG Puzzle – State Space Search



States

Fa	Fo	Go	Gr	
0	0	0	0	✓
0	0	0	1	✓
0	0	1	0	✓
0	0	1	1	✗
0	1	0	0	✓
0	1	0	1	✓
0	1	1	0	✗
0	1	1	1	✗
1	0	0	0	✗
1	0	0	1	✗
1	0	1	0	✓
1	0	1	1	✓
1	1	0	0	✗
1	1	0	1	✓
1	1	1	0	✓
1	1	1	1	✓

✓ safe
✗ unsafe