Make Change

- Starting with 0 cents, we want to reach some number of cents between [0, 5, 10, 15, 20, …, 500] using the least number of coins.

- We can add 5, 10, 25, 100, or 200.

- Solve this problem using search?

Make Change

- States:

- Actions:

Make Change

- States: Integers between 0 and 500 that are divisible by 5.

- Actions: Add 5, 10, 25, 100, or 200.

Example

- Initial state 0
- Goal state (365)

- BFS
- DFS
- UCS?
- A*?

Logistics World

- Set of Cities
- For each City a set of locations in that city.
- Some locations are Airports.
- Set of Trucks, each truck is in some city.
- Set of Airplanes
- Trucks can move between any location in the same city.
- Airplanes can move between any two airport.
- Set of packages each in some city at some location.
- Packages can be loaded into a truck or airplane if that vehicle is at the same location at the package.
- If a package is in a vehicle it is moved when the vehicle is moved.

Logistics World

- Aim is to pickup a bunch of packages and deliver them to some goal locations.

Logistics World

- State Space

- Actions

Logistics World

- State Space: Location for every vehicle. And for every package either a location where it is, or a vehicle that it is in.

- Actions:

1. If a truck is at location locA, we can move it to location locB if locB is in the same city as locA
2. If a truck is at location locA, we can move it to location locB if locB is an airport.
3. If package P1 is at location locA, and a vehicle V1 is also at location locA, we can load P1 into V1. P1 is now in V1.
4. If a package P1 is in a vehicle V1 and V1 is at location locA, we can unload P1. P1 now is at location locA
5. Costs vary—cost of moving a vehicle depends on distance traveled. Loading and unloading package has fixed (low cost).

Logistics World

- Initial state: a set of packages and vehicles and their locations.

- Goal state: a set of destination locations for some of the packages.

- BFS?
- UCS?
- A*?

Vacuum World

- In the previous examples, a state in the search space corresponded to a unique state of the world (modulo details we have abstracted away).
- However, states need not map directly to world configurations. Instead, a state could map to knowledge states.

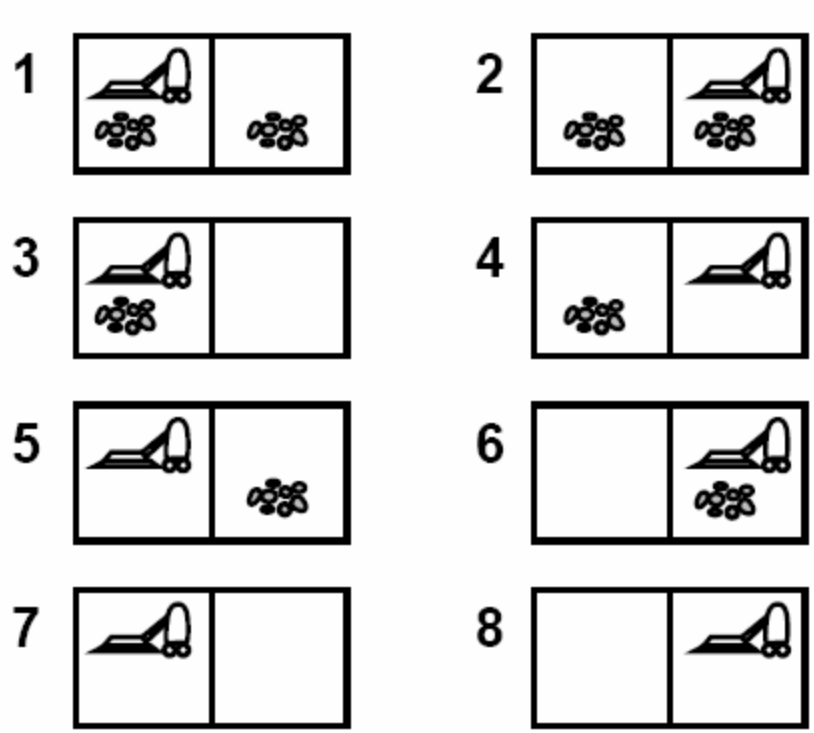
- If you know the exact state of the world your knowledge state is a single unique state.
- If you don't know some things, then your knowledge state is a set of world states.

Vacuum World

- A knowledge state will include every world state that might be possible.

Example 3. Vacuum World

- We have a vacuum cleaner and two rooms.
- Each room may or may not be dirty.
- The vacuum cleaner can move left or right *(the action has no effect if there is no room to the right/left).*
- The vacuum cleaner can suck; this cleans the room (*even if the room was already clean).*

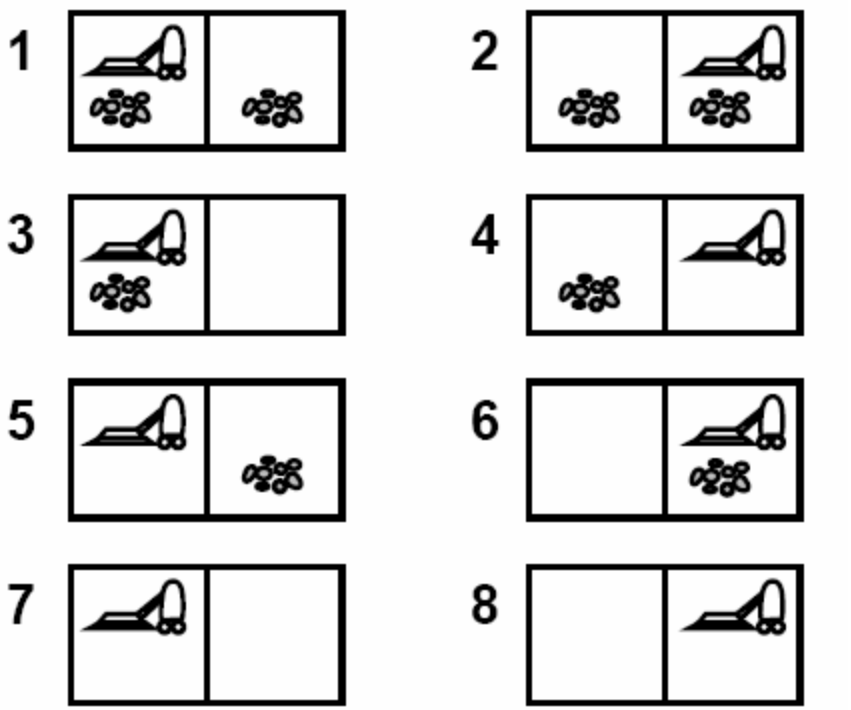


Physical states

Example 3. Vacuum World

Knowledge-level State Space

- Each state can consist of a set of possible world states. The agent knows that it is in one of these states, but doesn't know which.



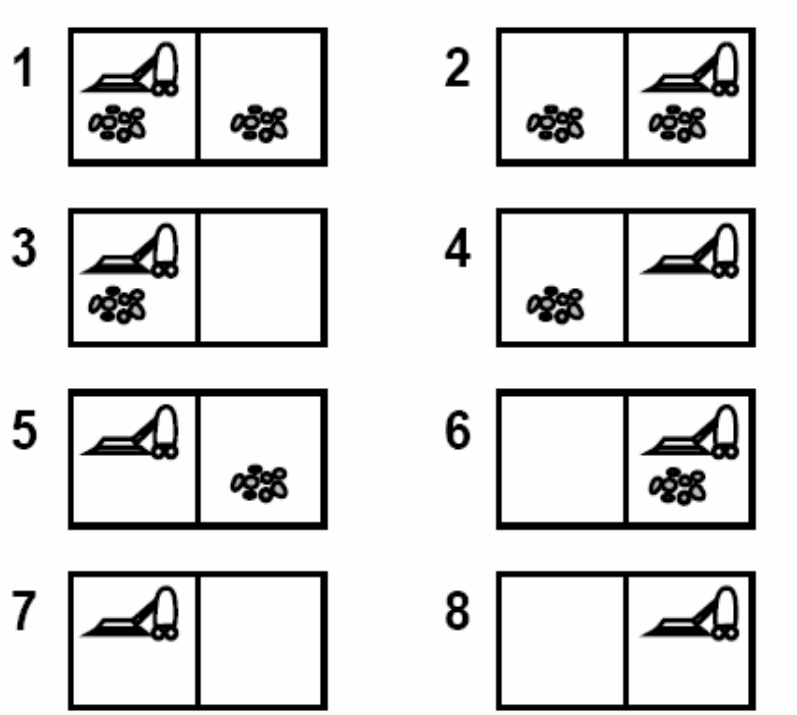
Goal is to have all rooms clean.

Example 3. Vacuum World

Knowledge-level State Space

- Complete knowledge of the world: agent knows exactly which physical state it is in. Then the states in the agent's state space consist of single physical states.
- Start in {5}:

  <right, suck>

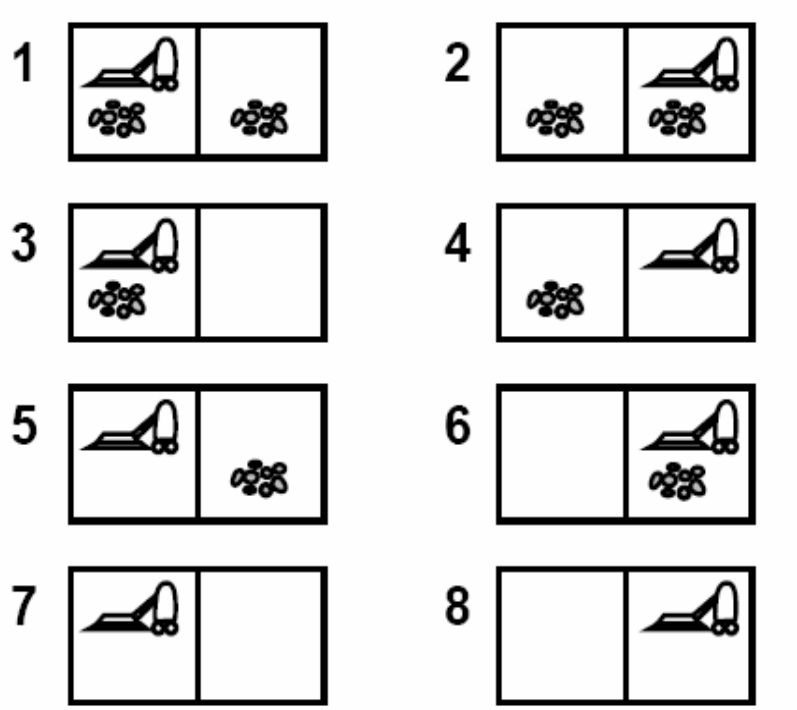


Goal is to have all rooms clean.

Example 3. Vacuum World

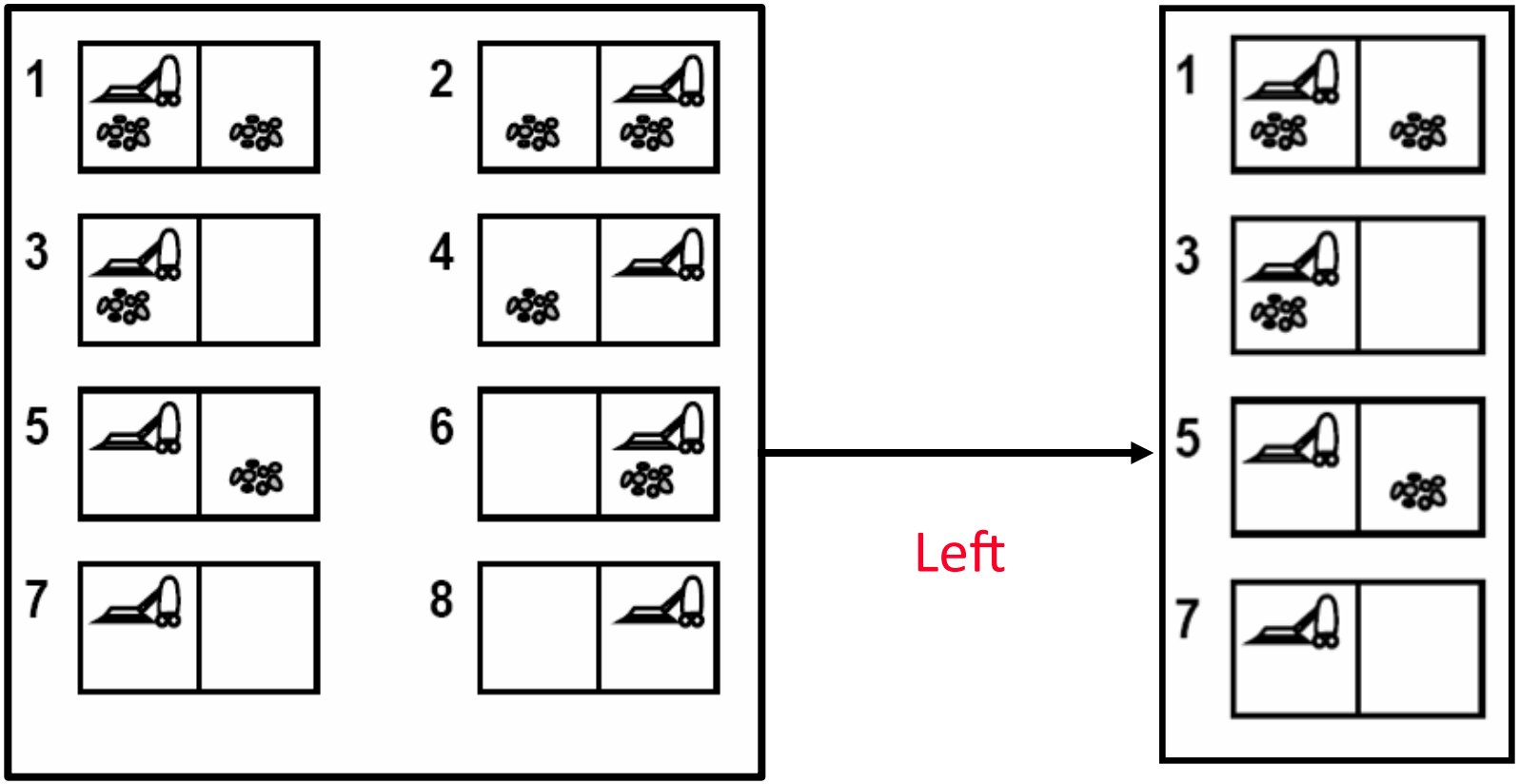
Knowledge-level State Space

- No knowledge of the world: Agent's states consist of *sets of world states*.
- E.g. starting in {1,2,3,4,5,6,7,8}, the agent doesn't have any knowledge of where it is.
- Nevertheless, the action sequence <right, suck, left, suck> achieves the goal.



Goal is to have all rooms clean.

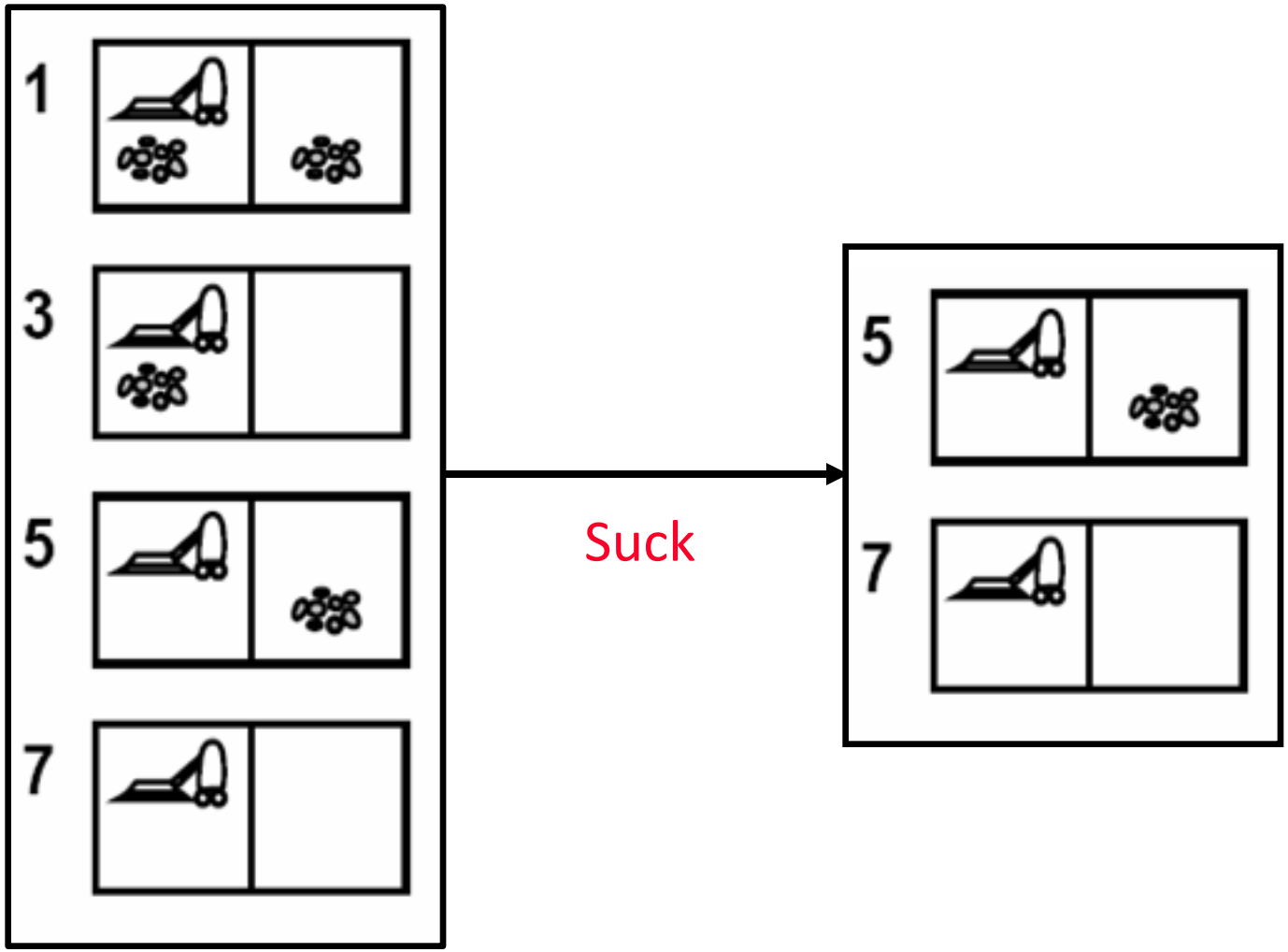
Example 3. Vacuum World



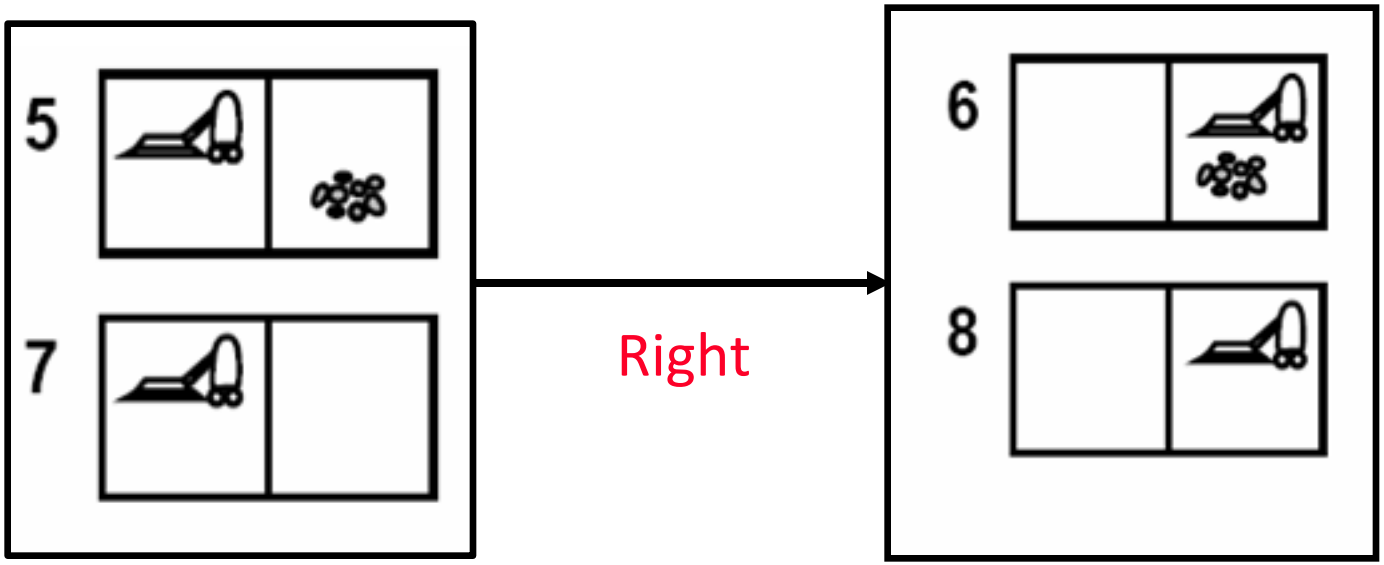
Initial state.

{1,2,3,4,5,6,7,8}

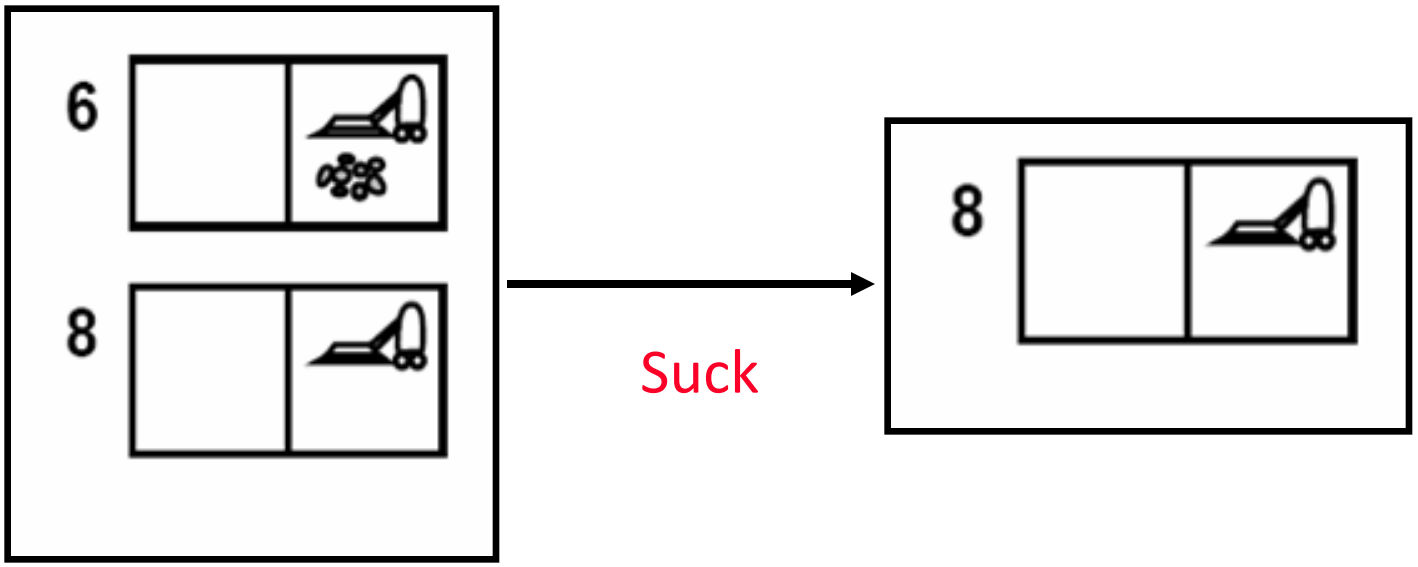
Example 3. Vacuum World



Example 3. Vacuum World



Example 3. Vacuum World



More complex situations

- The agent might be able to perform some sensing actions. These actions change the agent's mental state, not the world configuration.
- With sensing can search for a contingent solution: a solution that is contingent on the outcome of the sensing actions
  - <right, **if** dirt **then** suck>
- Now the issue of interleaving execution and search comes into play.