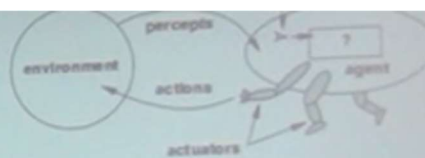


# Agents

- ▶ An **agent** is anything that can be viewed as
  - ▶ **Sensors**: perceive environment
  - ▶ **Actuators**: act upon environment
- ▶ Samples of agents
  - ▶ Human agent
    - ▶ Sensors: eyes, ears, and other organs for sensors
    - ▶ Actuators: hands, legs, vocal tract, and other movable or changeable body parts
  - ▶ Robotic agent
    - ▶ Sensors: cameras and infrared range finders
    - ▶ Actuators: various motors
  - ▶ Software agents
    - ▶ Sensors: keystrokes, file contents, received network packages
    - ▶ Actuators: displays on the screen, files, sent network packets

## Agents & environments



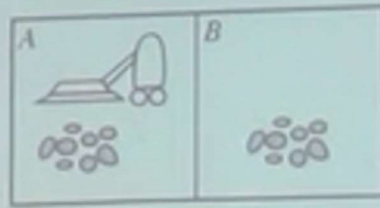
- ▶ Agent behavior can be described as an **agent function** that maps entire perception histories to actions:

$$f: P^* \rightarrow A$$

Percept sequence to date      Action set

- ▶ The **agent program** runs on the physical **architecture** to produce  $f$ 
    - ▶ Program is a concrete implementation of agent function
    - ▶ Architecture includes sensors, actuators, computing device
- agent = architecture + program

## Vacuum-cleaner world



- ▶ Percepts: **location** and **dirt/clean** status of its location
  - ▶ e.g., [A,Dirty]
- ▶ Actions: Left, Right, Suck, NoOp

## A vacuum-cleaner agent

Tabulation of the agent function

Percept Sequence	Action
[A, Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B, Dirty]	Suck
[A, Clean], [A, Clean]	Right
[A, Clean], [A, Dirty]	Suck
...	...
[A, Clean], [A, Clean], [A, Clean]	Right
[A, Clean], [A, Clean], [A, Dirty]	Suck
...	...

## Rational agents

- ▶ **"do the right thing"** based on the perception history and the actions it can perform.
- ▶ **Rational Agent:** For each possible percept sequence, a rational agent should select an action that is **expected to maximize** its performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has.

## Performance measure

- › Evaluates the sequence of environment states
- › Vacuum-cleaner agent: samples of performance measure
  - ✖ Amount of dirt cleaned up

## Rational agents (vacuum cleaner example)

- › Is this rational? If dirty then suck, otherwise move to the other square
  - › Depends on
    - Performance measure, e.g., Penalty for energy consumption?
    - Environment, e.g., New dirt can appear?
    - Actuators, e.g., No-op action?
    - Sensors, e.g., Only sense dirt in its location?

## Rationality vs. Omniscience

- › Rationality is distinct from omniscience (all-knowing with infinite knowledge, impossible in reality)
- › Doing actions in order to modify future percepts to obtain useful information
  - › information gathering or exploration (important for rationality)
    - e.g., eyeballs and/or neck movement in human to see different directions

## Autonomy

- › An agent is autonomous if its behavior is determined by its own experience (with ability to learn and adapt)
  - › Not just relies only on prior knowledge of designer
  - › Learns to compensate for partial or incorrect prior knowledge
    - › Benefit: changing environment
    - › Starts by acting randomly or base on designer knowledge and then learns from experience
  - › Rational agent should be autonomous
- › Example: vacuum-cleaner agent
  - › If dirty then suck, otherwise move to the other square
    - › Does it yield an autonomous agent?
  - › learning to foresee occurrence of dirt in squares

## PEAS Samples...

- › Agent: Automated taxi driver



- › Performance measure: Safe, fast, legal, comfortable trip, maximize profits, ...
- › Environment: Roads, other traffic, pedestrians, customers, ...



## PEAS Samples...

- ▶ Agent: Part picking robot



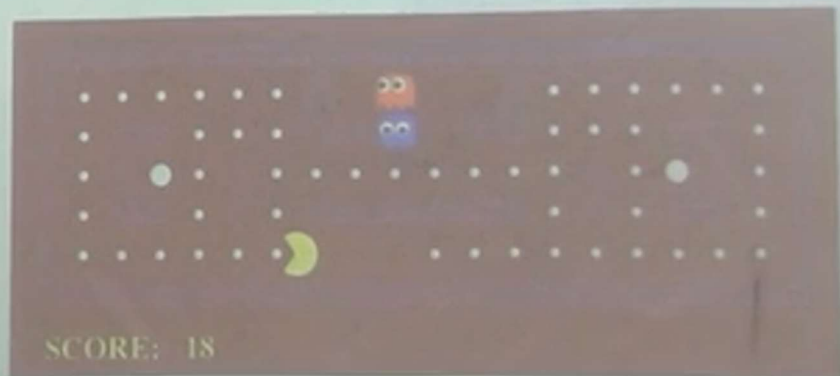
- ▶ Performance measure: Percentage of parts in correct bins

- ▶ Environment: Conveyor belt with parts, bins



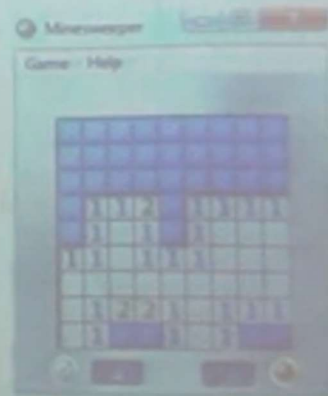
## PEAS Samples...

- ▶ Agent: Pacman



## Environment types

- ▶ **Fully observable** (vs. **partially observable**): Sensors give access to the complete state of the environment at each time
  - ▶ Sensors detect all aspects relevant to the choice of action
  - ▶ Convenient (need not any internal state)
  - ▶ Noisy and inaccurate sensors or missing parts of the state from sensors cause partially observability



## Environment types

- ▶ **Deterministic** (vs. **stochastic**): Next state can be completely determined by the current state and the executed action
  - ▶ If the environment is deterministic except for the actions of other agents, then the environment is **strategic** (we ignore this uncertainty)
  - ▶ Partially observable environment could appear to be stochastic.
  - ▶ Environment is uncertain if it is not fully observable or not deterministic

## Environment types

### ► Single agent (vs. multi-agent):

- Crossword puzzle is a single-agent game (chess is a multi-agent one)
- Is B an agent or just an object in the environment?
  - B is an agent when its behavior can be described as maximizing a performance measure whose value depends on A's behavior.
- Multi-agent: competitive, cooperative
  - Randomized behavior and communication can be rational

### ► Discrete (vs. continuous): A limited number of distinct, clearly defined states, percepts and actions, time steps

- Chess has finite number of discrete states, and discrete set of percepts and actions while Taxi driving has continuous states, and actions

## Environment types

### ► Episodic (vs. sequential): The agent's experience is divided into atomic "episodes" where the choice of action in each episode depends only on the episode itself.

- E.g., spotting defective parts on an assembly line (independency)
- In sequential environments, short-term actions can have long-term consequences
  - Episodic environment can be much simpler

### ► Static (vs. dynamic): The environment is unchanged while an agent is deliberating.

- Semi-dynamic: if the environment itself does not change with the passage of time but the agent's performance score does.
- Static (cross-word puzzles), dynamic (taxi driver), semi-dynamic (clock chess)



## Pacman game

- Fully observable?
- Single-agent?
- Deterministic?
- Discrete?
- Episodic?
- Static?
- Known?

