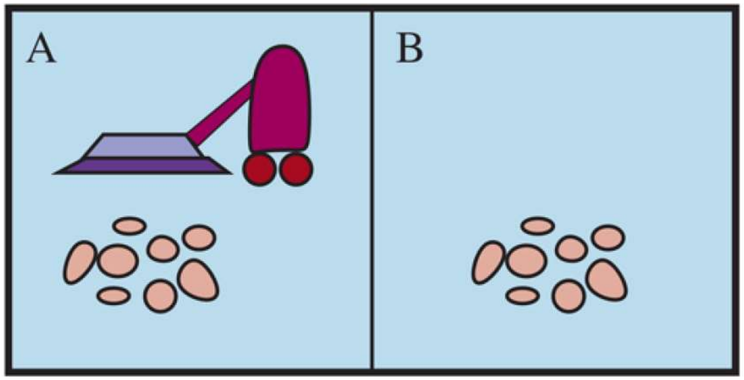
Artificial Intelligence

Environment and Agents



Fall 402
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Agent

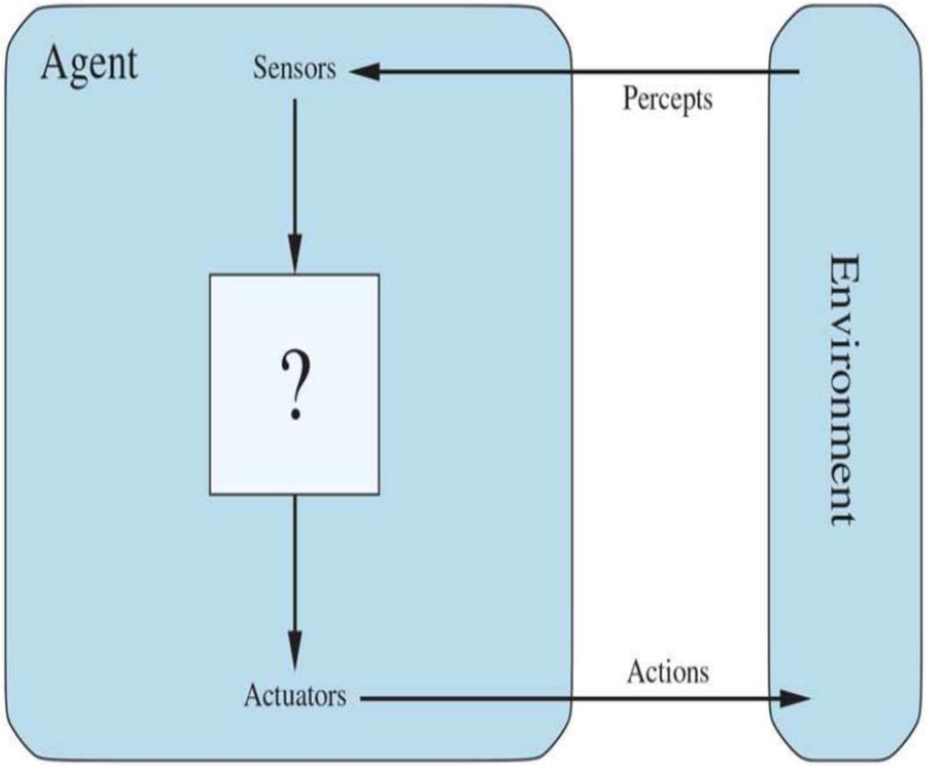
An **agent** is anything that can be viewed as **perceiving its environment** through **sensors** and **acting upon that environment** through **actuators**

- Human agent
- Robot agent
- Software agent

Environment could be everything. Maybe the entire universe!

In practice, that part of the universe whose states we care about

- what the agent perceives
- What is affected by the agents's actions.



Agent

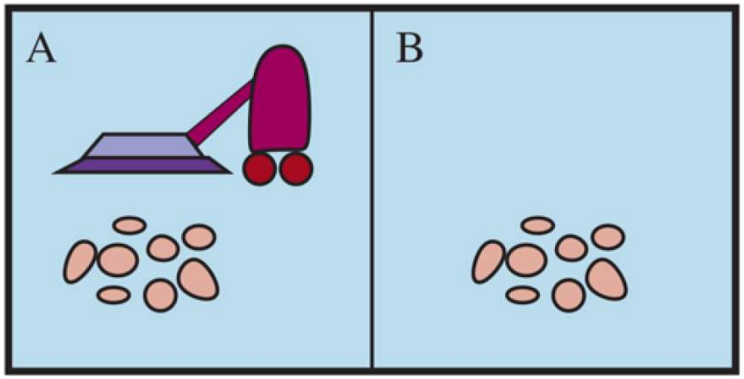
- **Percept**
  - content an agent’s sensors are perceiving
- **Percept sequence**
  - complete history of everything the agent has ever perceived

an agent’s choice of action at any given instant can depend on its built-in knowledge and on the entire percept sequence observed to date, but not on anything it hasn’t perceived

agent’s behavior is described by the **agent function** that maps any given percept sequence to an action.

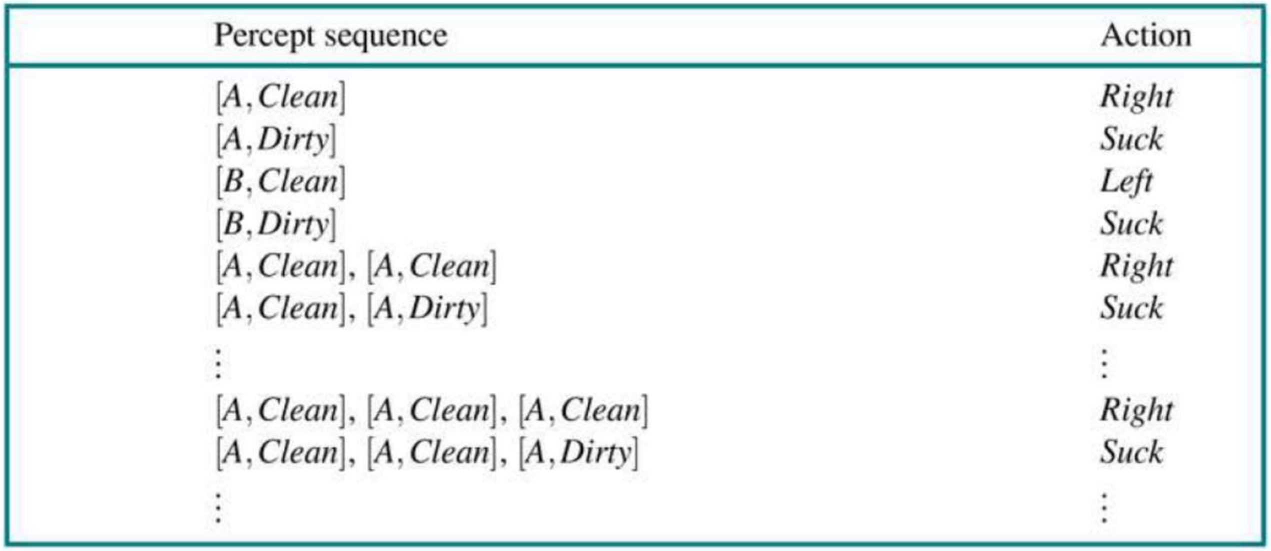
agent function for an artificial agent will be implemented by an **agent program**.

A vacuum-cleaner



Available Actions: move to right, move to left, suck, do noting

very simple agent function: if the current square is dirty, then suck; otherwise, move to the other square



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*
⋮	⋮

Rationality

- A **rational agent** is one that does the right thing
- evaluate an agent's behavior by its consequences
- Agent generates a sequence of actions according to the percepts it receives
- The sequence of actions causes the environment to go through a sequence of states
  - If the sequence is desirable, then the agent has performed well.
  - desirability is captured by a **performance measure** that evaluates any given sequence of environment states.

Performance measure

- Humans have desires and preferences of their own
- Machines, do *not* have desires and preferences of their own; the performance measure is, initially at least, in the mind of the designer of the machine, or the users the machine

- E.g. vacuum-cleaner agent :
  - amount of dirt cleaned up in a single eight-hour
  - It is good ?

  - One point could be awarded for each clean square at each time step
  - Perhaps with a penalty for electricity consumed and noise generated

As a general rule, it is better to design performance measures according to what one actually wants to be achieved in the environment, rather than according to how one thinks the agent should behave.

Rationality

What is rational at any given time depends on four things:

- The performance measure that defines the criterion of success
- The agent's prior knowledge of the environment.
- The actions that the agent can perform.
- The agent's percept sequence to date.

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

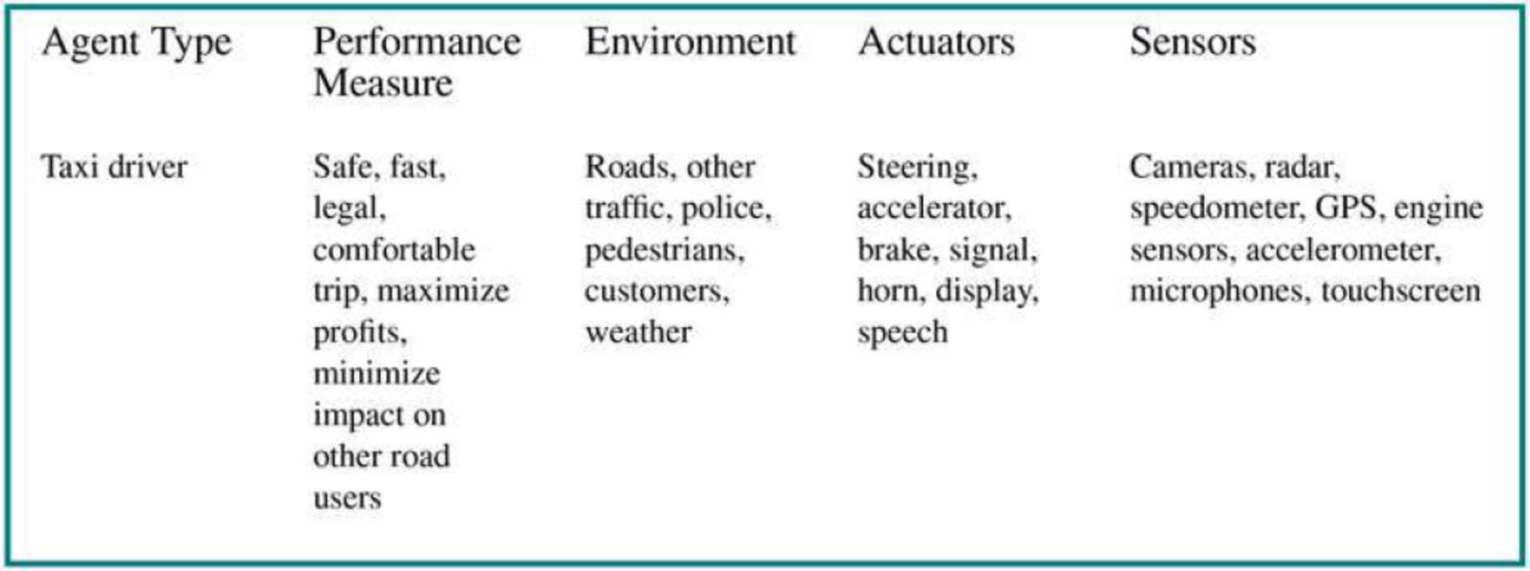
Is it rational ?

vacuum-cleaner agent that cleans a square if it is dirty and moves to the other square

PEAS

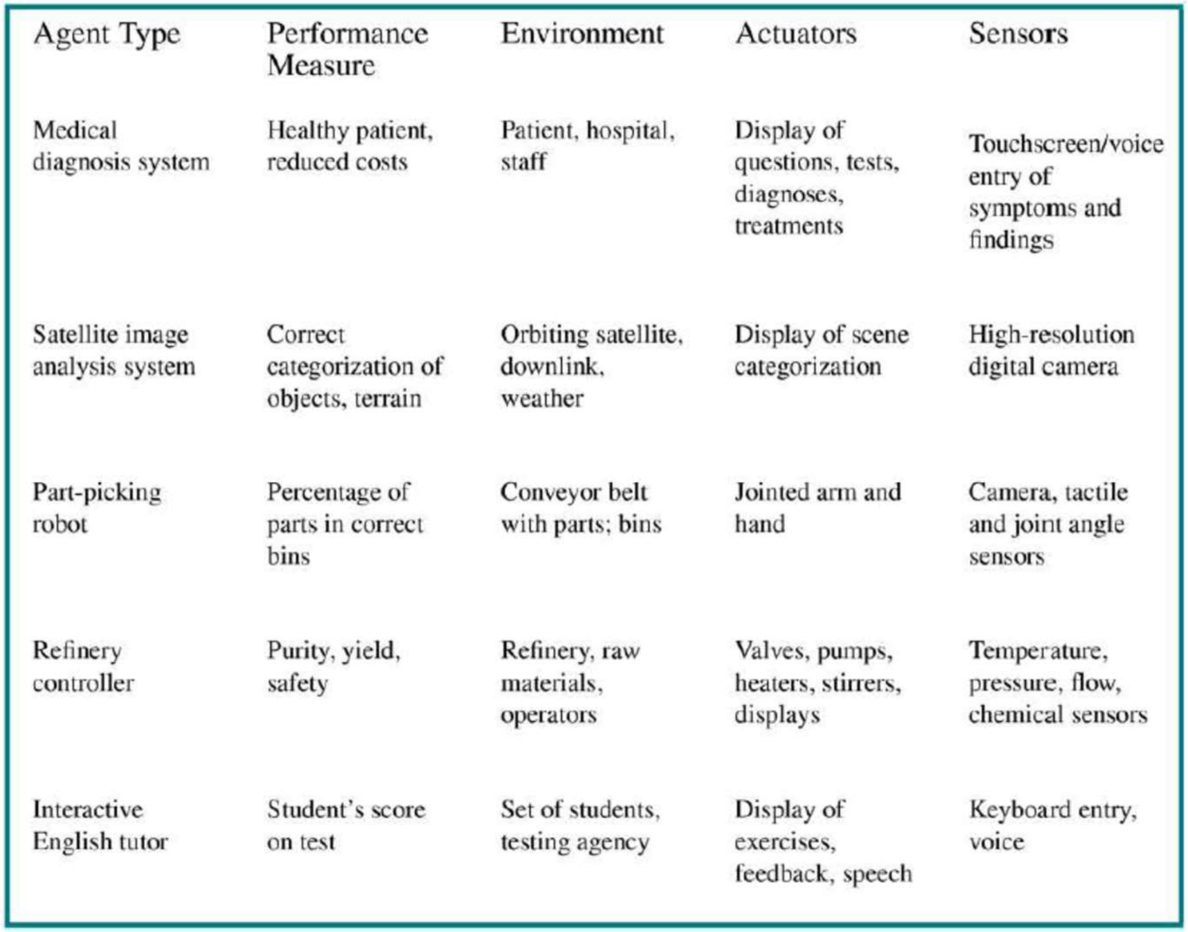
we had to specify the performance measure, the environment, and the agent’s actuators and sensors

PEAS (**P**erformance, **E**nvironment, **A**ctuators, **S**ensors)



Agent Type	Performance Measure	Environment	Actuators	Sensors
Taxi driver	Safe, fast, legal, comfortable trip, maximize profits, minimize impact on other road users	Roads, other traffic, police, pedestrians, customers, weather	Steering, accelerator, brake, signal, horn, display, speech	Cameras, radar, speedometer, GPS, engine sensors, accelerometer, microphones, touchscreen

PEAS description of the task environment for an automated taxi driver.



Agent Type	Performance Measure	Environment	Actuators	Sensors
Medical diagnosis system	Healthy patient, reduced costs	Patient, hospital, staff	Display of questions, tests, diagnoses, treatments	Touchscreen/voice entry of symptoms and findings
Satellite image analysis system	Correct categorization of objects, terrain	Orbiting satellite, downlink, weather	Display of scene categorization	High-resolution digital camera
Part-picking robot	Percentage of parts in correct bins	Conveyor belt with parts; bins	Jointed arm and hand	Camera, tactile and joint angle sensors
Refinery controller	Purity, yield, safety	Refinery, raw materials, operators	Valves, pumps, heaters, stirrers, displays	Temperature, pressure, flow, chemical sensors
Interactive English tutor	Student's score on test	Set of students, testing agency	Display of exercises, feedback, speech	Keyboard entry, voice

Examples of agent types and their PEAS descriptions

Properties of task environment

- **FULLY OBSERVABLE VS. PARTIALLY OBSERVABLE**
- **Fully observable**
  - agent’s sensors give it access to the complete state of the environment at each point in time
- Effectively fully observable
  - sensors detect all aspects that are *relevant* to the choice of action
- Fully observable environments are convenient because the agent need not maintain any internal state to keep track of the world

- **partially observable**
  - noisy and inaccurate sensors
  - parts of the state are simply missing from the sensor data
    - Vacuum agent with only a local dirt sensor
- **Unobservable**
  - the agent has no sensors at all

Properties of task environment

- SINGLE-AGENT VS. MULTIAGENT agent solving a crossword puzzle
  - e.g. by itself is clearly in a single-agent environment
  - E.g. agent playing chess is in a two-agent environment.
- Competitive vs competitive
- Deterministic vs. nondeterministic
  - Deterministic : next state of the environment is completely determined by the current state and the action executed by the agent
- an agent need not worry about uncertainty in a fully observable, deterministic environment
- the word **stochastic** is used by some as a synonym for “nondeterministic”

Properties of task environment

- **EPISODIC VS. SEQUENTIAL :**
  - episodic : the agent’s experience is divided into atomic episodes.
  - In each episode the agent receives a percept and then performs a single action
  - the next episode does not depend on the actions taken in previous episodes
  - Many classification tasks are episodic : an agent that has to spot defective parts on an assembly line bases each decision on the current part
- In sequential environments, on the other hand, the current decision could affect

all future decisions

- Episodic environments are much simpler than sequential environments because the agent does not need to think ahead

- **STATIC VS. DYNAMIC:**
  - Dynamic : environment can change while an agent is deliberating
  - Semidynamic : the environment does not change with the passage of time but the agent’s performance score does

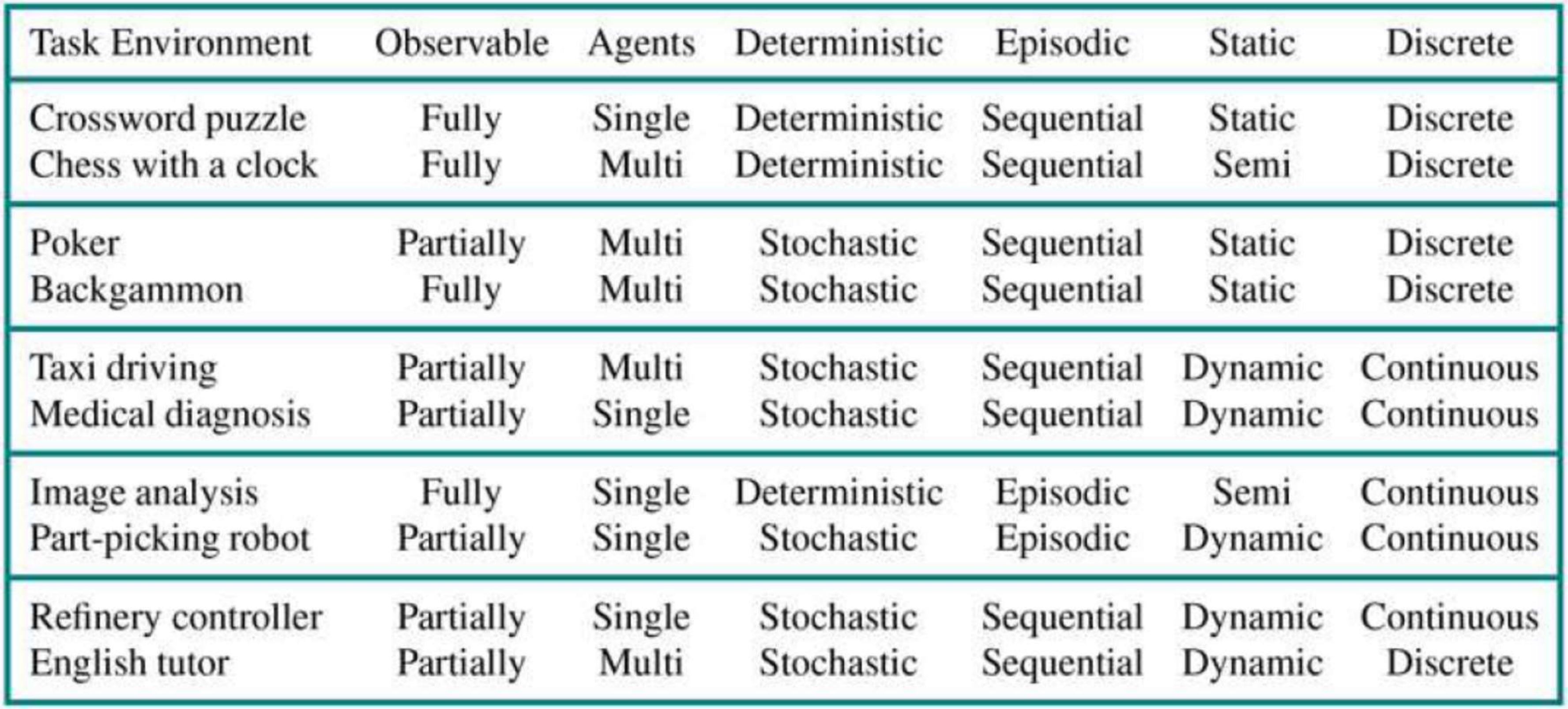
Properties of task environment

DISCRETE VS. CONTINUOUS :

- discrete/continuous distinction applies to the *state* of the environment, to the way *time* is handled and to the *percepts* and *actions* of the agent.
- chess environment has a finite number of distinct states (excluding the clock). Chess also has a discrete set of percepts and actions
- Taxi driving is a continuous-state and continuous-time problem

- **KNOWN VS. UNKNOWN :**
  - In a known environment, the outcomes (or outcome probabilities if the environment is nondeterministic) for all actions are given
  - if the environment is unknown, the agent will have to learn how it works in order to make good decisions
  - distinction between known and unknown environments is not the same as the one between fully and partially observable environments.
    - E.g. solitaire game

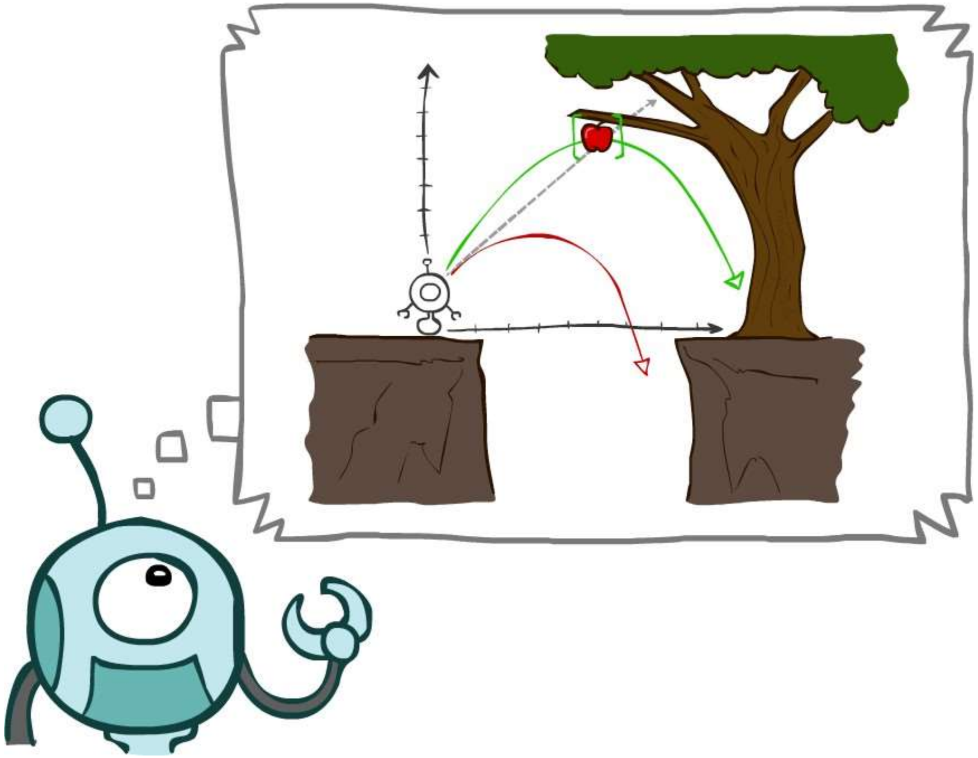
Properties of task environment



Task Environment	Observable	Agents	Deterministic	Episodic	Static	Discrete
Crossword puzzle	Fully	Single	Deterministic	Sequential	Static	Discrete
Chess with a clock	Fully	Multi	Deterministic	Sequential	Semi	Discrete
Poker	Partially	Multi	Stochastic	Sequential	Static	Discrete
Backgammon	Fully	Multi	Stochastic	Sequential	Static	Discrete
Taxi driving	Partially	Multi	Stochastic	Sequential	Dynamic	Continuous
Medical diagnosis	Partially	Single	Stochastic	Sequential	Dynamic	Continuous
Image analysis	Fully	Single	Deterministic	Episodic	Semi	Continuous
Part-picking robot	Partially	Single	Stochastic	Episodic	Dynamic	Continuous
Refinery controller	Partially	Single	Stochastic	Sequential	Dynamic	Continuous
English tutor	Partially	Multi	Stochastic	Sequential	Dynamic	Discrete

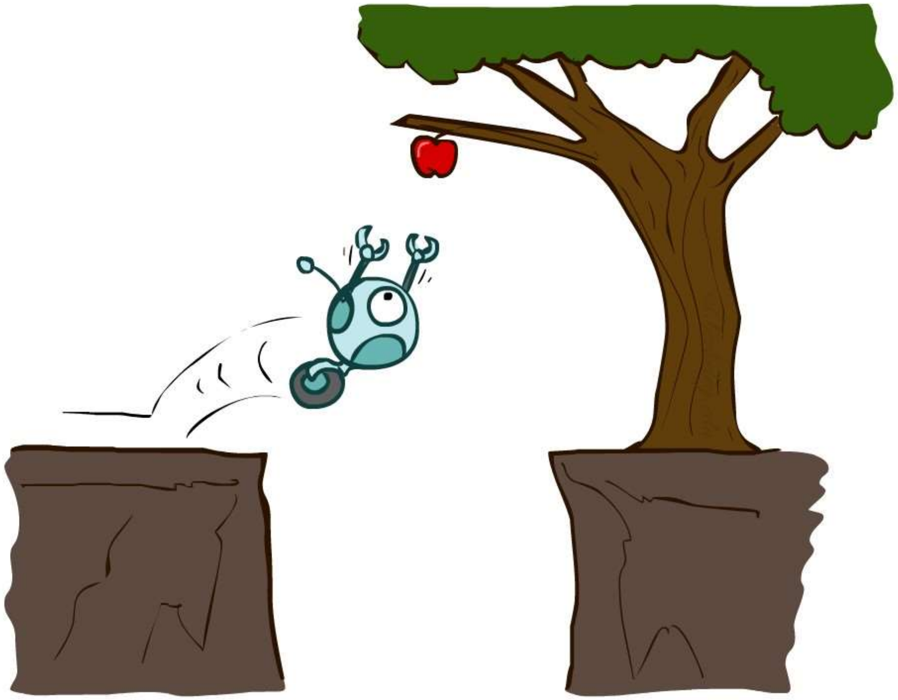
Examples of task environments and their characteristics.

Agents that Plan



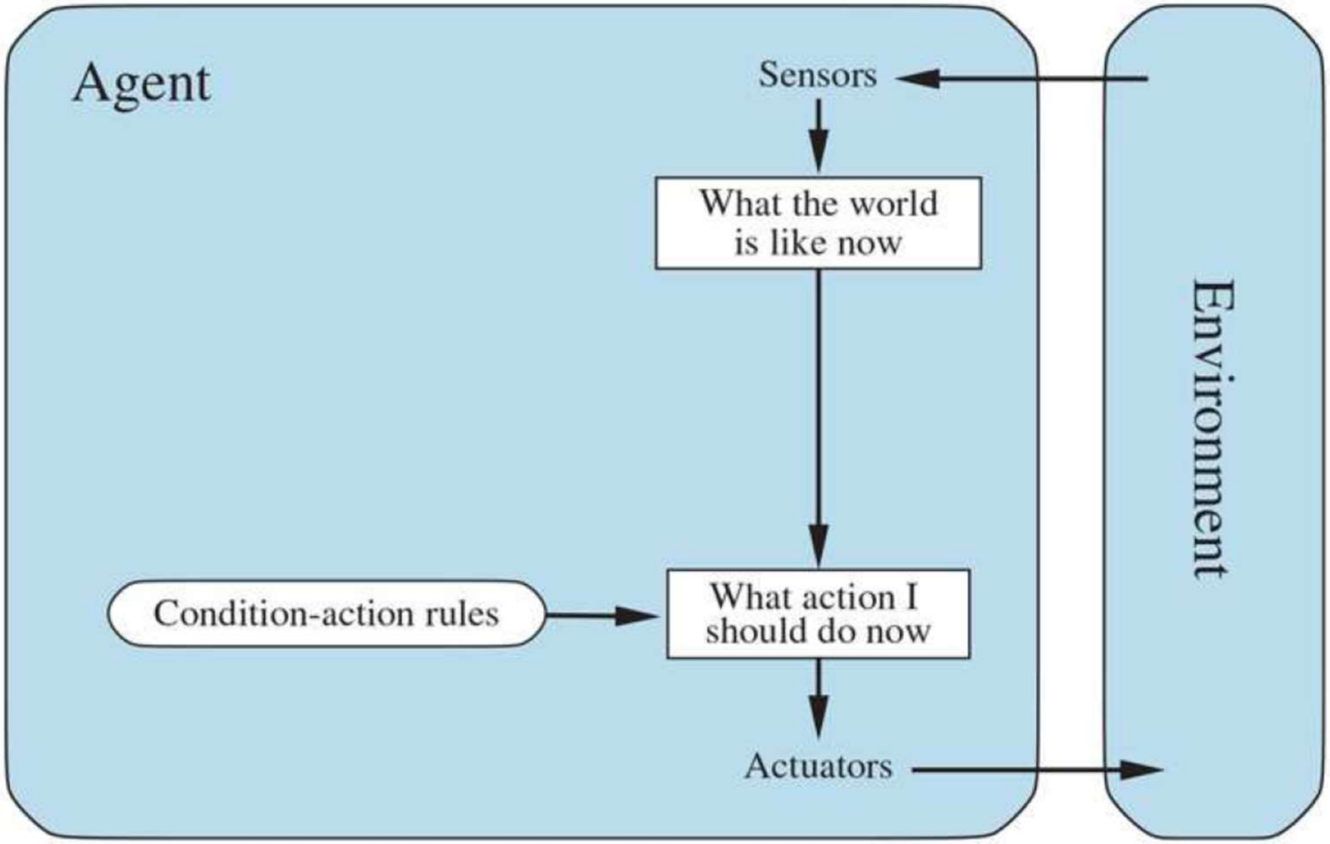
Reflex Agents

- 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?



[Demo: reflex optimal (L2D1)]
[Demo: reflex optimal (L2D2)]

Diagram of a simple reflex agent

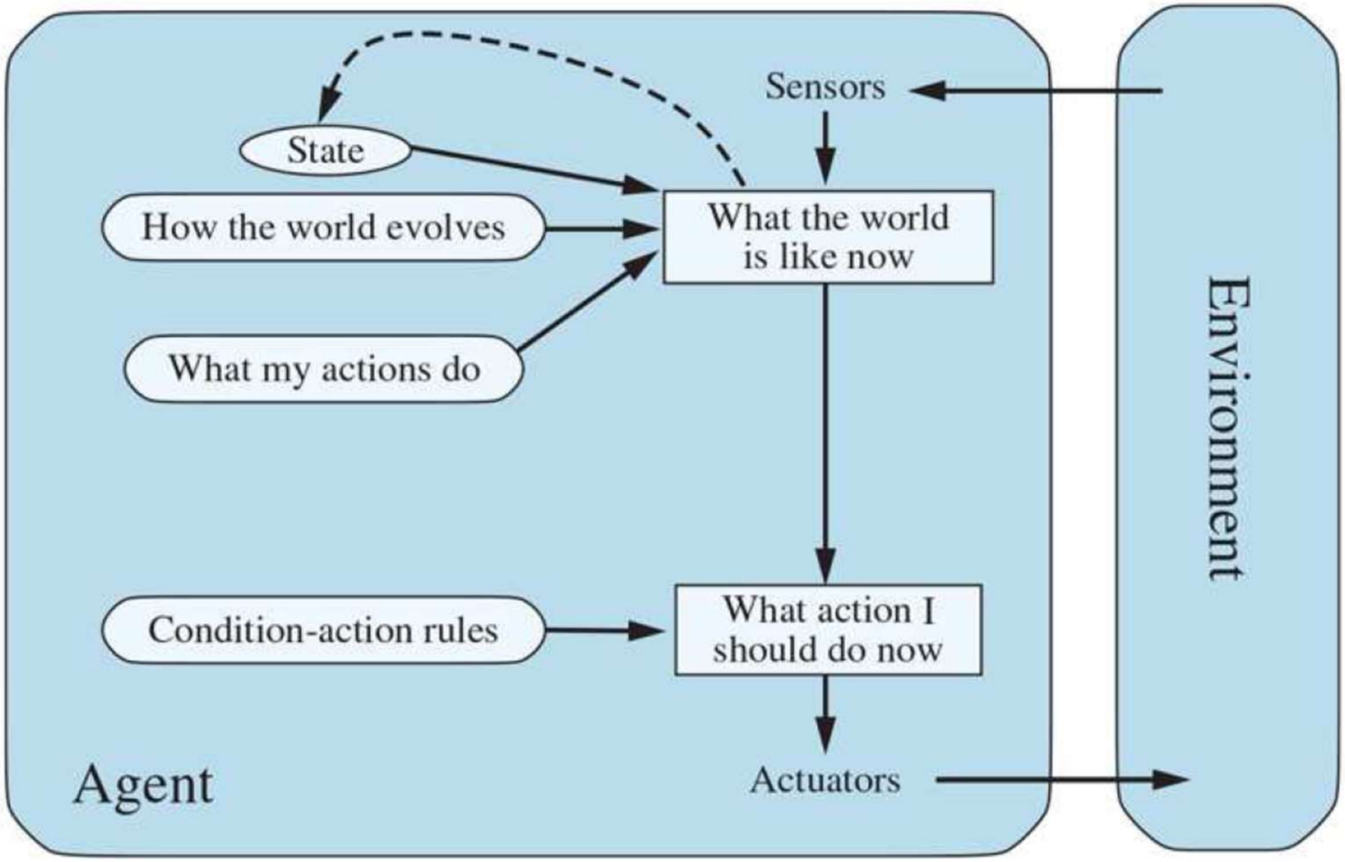


```
function REFLEX-VACUUM-AGENT([location,status]) returns an action
  if status = Dirty then return Suck
  else if location = A then return Right
  else if location = B then return Left
```

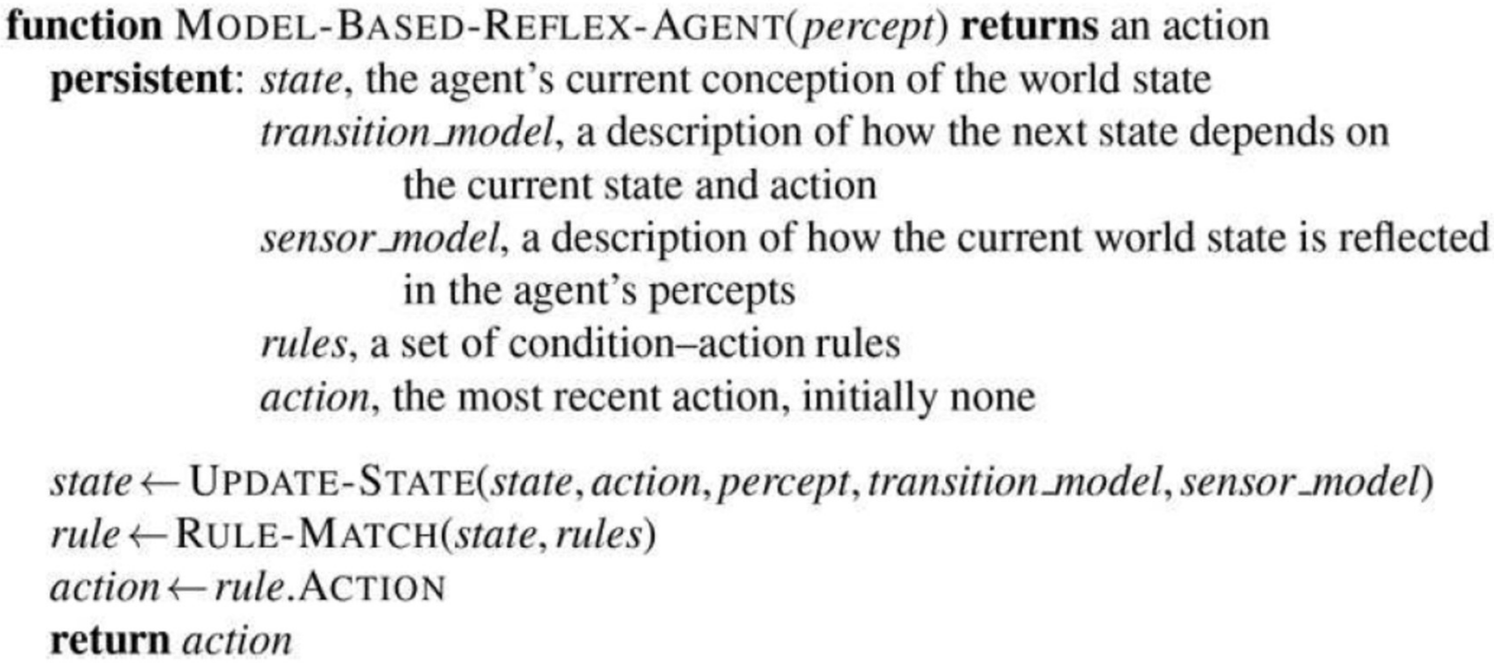
```
function SIMPLE-REFLEX-AGENT(percept) returns an action
  persistent: rules, a set of condition–action rules

  state ← INTERPRET-INPUT(percept)
  rule ← RULE-MATCH(state, rules)
  action ← rule.ACTION
  return action
```

Model based reflect agent



A model-based reflex agent

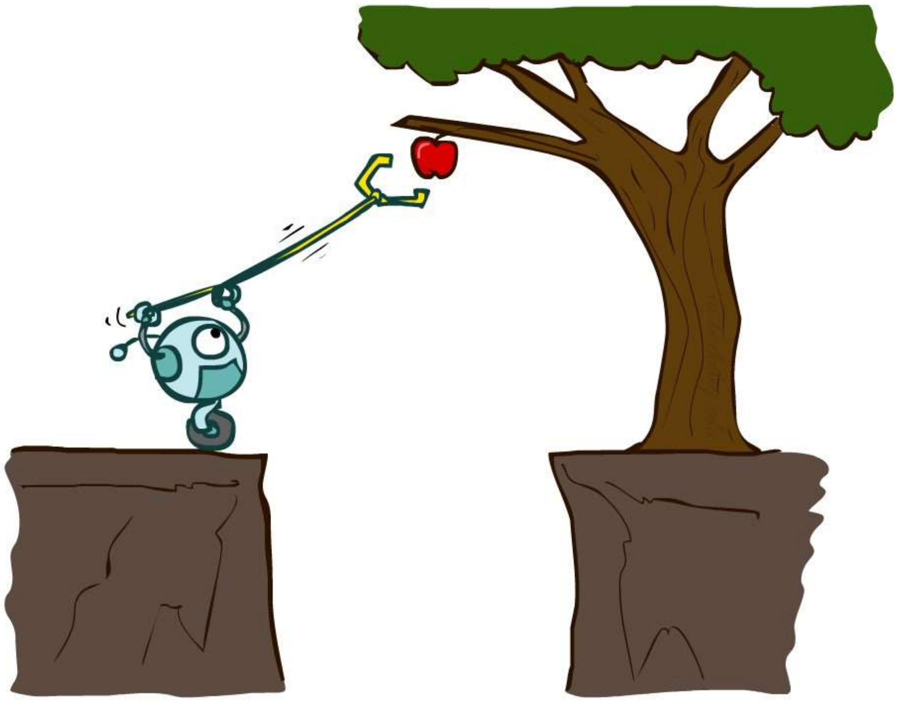


```
function MODEL-BASED-REFLEX-AGENT(percept) returns an action
  persistent: state, the agent's current conception of the world state
              transition_model, a description of how the next state depends on
                      the current state and action
              sensor_model, a description of how the current world state is reflected
                      in the agent's percepts
              rules, a set of condition–action rules
              action, the most recent action, initially none

  state ← UPDATE-STATE(state, action, percept, transition_model, sensor_model)
  rule ← RULE-MATCH(state, rules)
  action ← rule.ACTION
  return action
```

Planning Agents

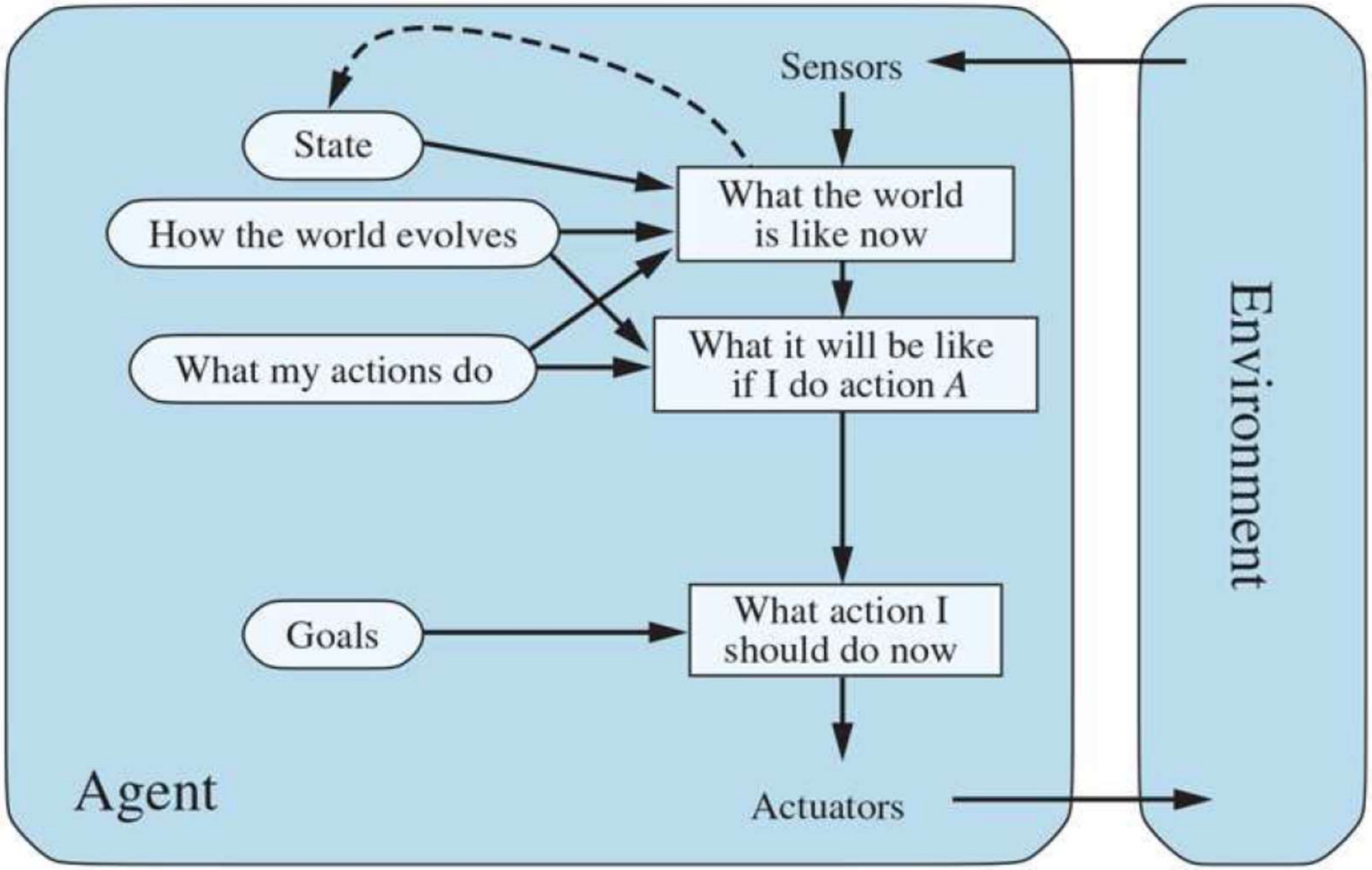
- Planning agents:
  - Ask “what if”
  - Decisions based on (hypothesized) consequences of actions
  - Must have a model of how the world evolves in response to actions
  - Must formulate a goal (test)
  - Consider how the world WOULD BE
- Optimal vs. complete planning
- Planning vs. replanning



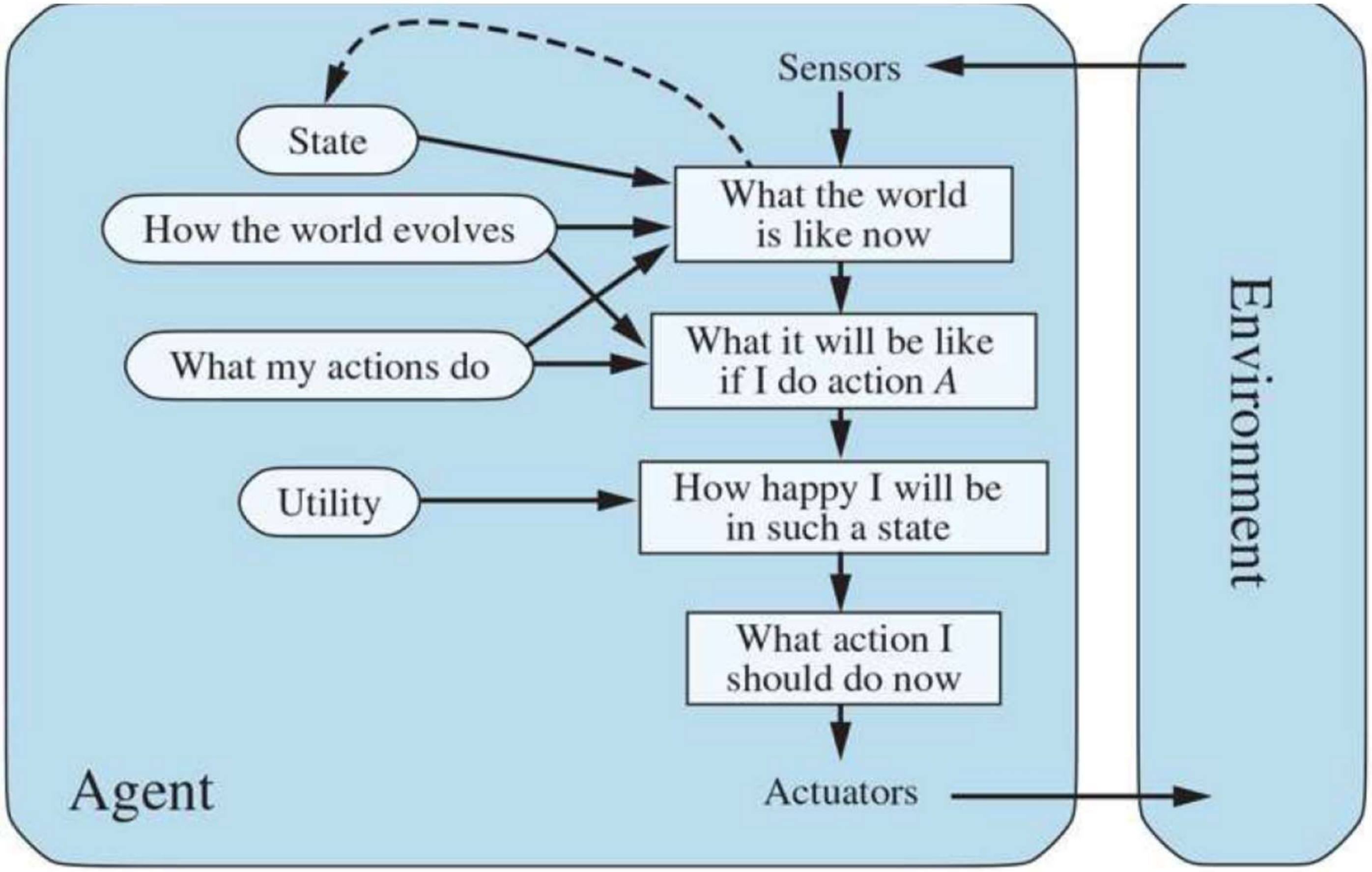
[Demo: re-planning (L2D3)]

[Demo: mastermind (L2D4)]

Model based, goal based agent


Sensors
State
What the world is like now
How the world evolves
What my actions do
What it will be like if I do action *A*
Goals
What action I should do now
Agent
Actuators
Environment

Model based utility based agent


Sensors
State
What the world is like now
How the world evolves
What my actions do
What it will be like if I do action *A*
Utility
How happy I will be in such a state
What action I should do now
Agent
Actuators
Environment