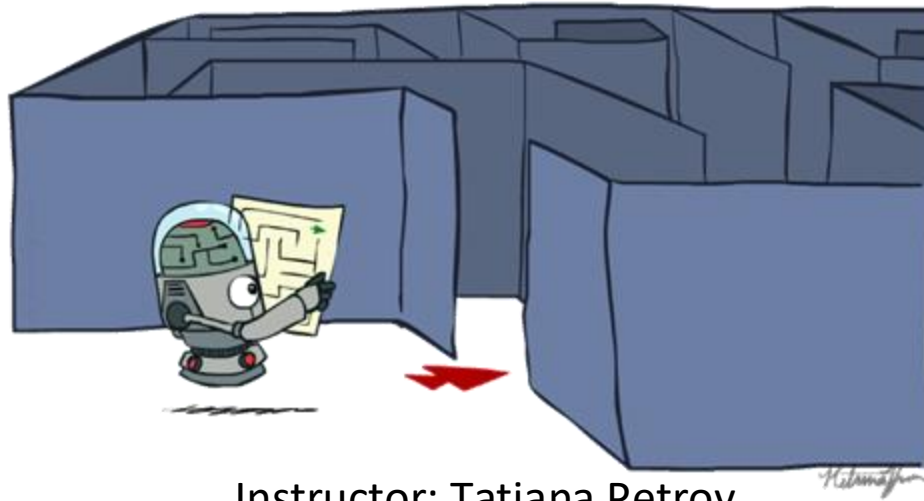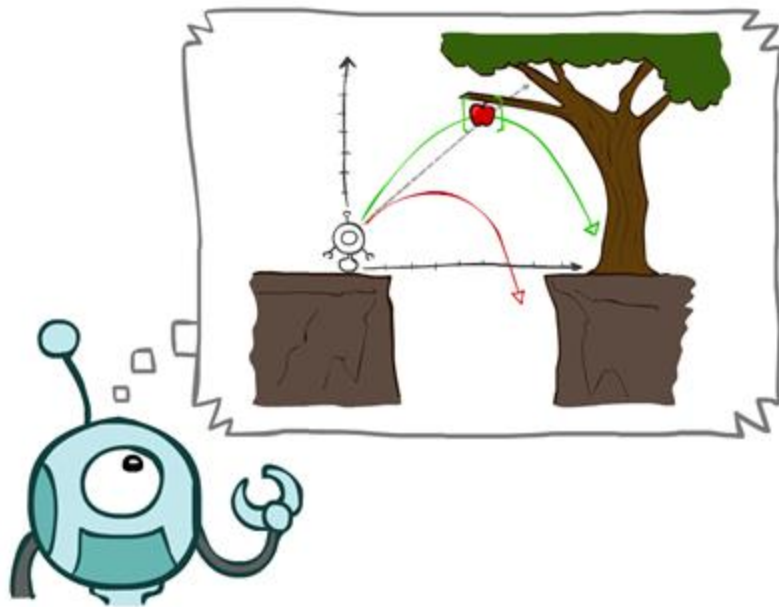# Introduction to Artificial Intelligence

Agents

Instructor: Tatjana Petrov

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Today

- Agents that Plan Ahead

AI as Designing Rational Agents

- An **agent** is an entity that *perceives* and *acts.*

- A **rational agent** selects actions that maximize its (expected) **utility**.

- Characteristics of the **sensors, actuators, and environment** dictate techniques for selecting rational actions

- **This course** is about:
  - Classical AI techniques for many problem types
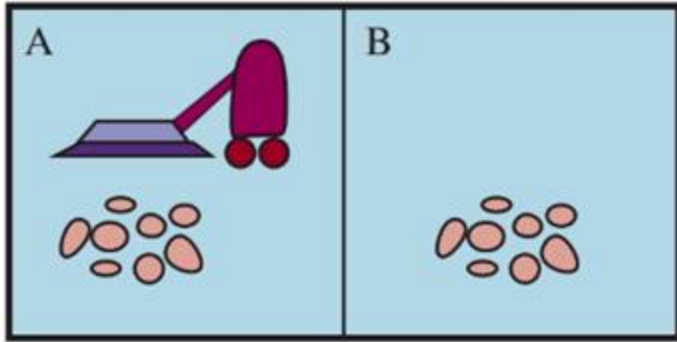 - Learning to choose and apply the technique appropriate for each problem
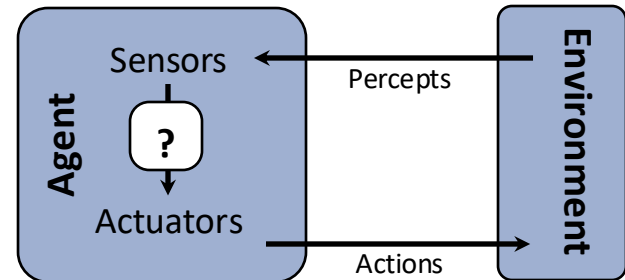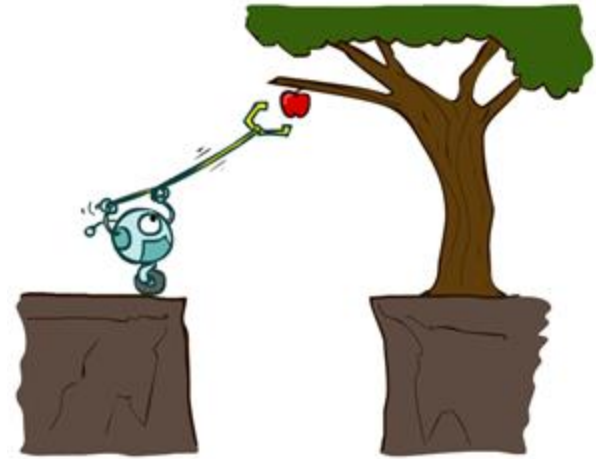
Agents and environments
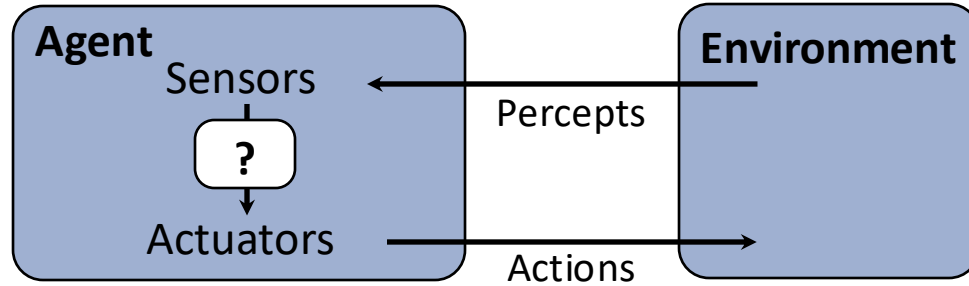
- An agent ***perceives*** its environment through ***sensors*** and ***acts*** upon it through ***actuators*** (or *effectors*, depending on whom you ask)
- The ***agent function*** maps percept sequences to actions
- It is generated by an ***agent program*** running on a ***machine***

A vacuum-cleaner world

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
⋮	⋮

A partial tabulation

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*

Performance measures

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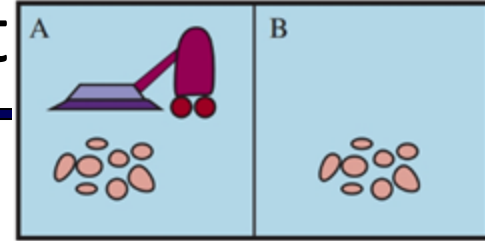
We assume that the performance measures can be specified correctly

Rational Agent

*For each possible percept sequence, a rational agent should select an **action** that is expected to maximize its **performance measures**, given the evidence provided by the **percept sequence** and whatever **built-in knowledge** the agent has.*

Example vacuum-cleaner agent

Is this a rational agent?

- Performance measure: 1 point, ∀ clean square, ∀ time step, for a "lifetime" of 1000 time steps.

- Known a priori: the "geography" of the environment but the dirt distribution and the initial location of the agent are not. Clean squares stay clean and sucking cleans the current square. The Right and Left actions move the agent one square except when this would take the agent outside the environment, in which case the agent remains where it is.

- Action: Right, Left, and Suck.

- Percepts: its location and whether that location contains dirt.

Rational Agent

*For each possible percept sequence, a rational agent should select an **action** that is expected to maximize its **performance measures**, given the evidence provided by the **percept sequence** and whatever **built-in knowledge** the agent has.*

Rational Agent

*For each possible percept sequence, a rational agent should select an **action** that is expected to maximize its (expected) **performance measures**, given the evidence provided by the **percept sequence** and whatever **built-in knowledge** the agent has.*

The sphex wasp

The sphex is unable to learn that its innate plan is failing, and thus will not change it.

Specifying the task environment

PEAS

Performance measure

Environment

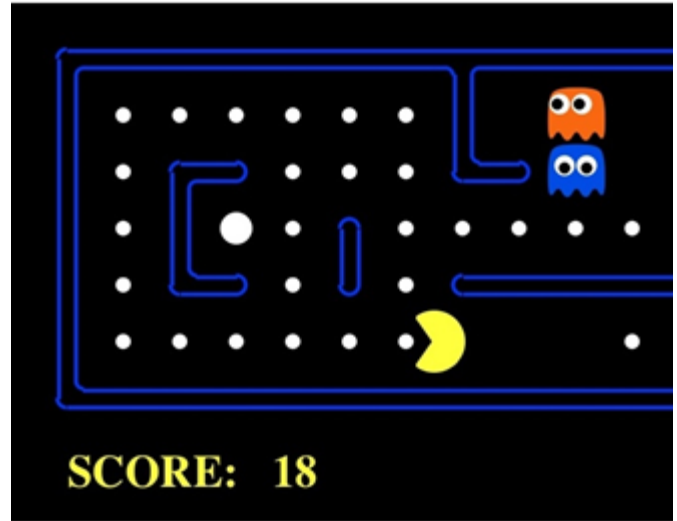**A**ctuators

Sensors

PEAS: Automated taxi

- ## Performance measure
  - Income, happy customer, vehicle costs, fines, insurance premiums
- ## Environment
  - streets, other drivers, customers, weather, police...
- ## Actuators
  - Steering, brake, gas, display/speaker
- ## Sensors
 - Camera, radar, accelerometer, engine sensors, microphone, GPS

Image: http://nypost.com/2014/06/21/how-google-might-put-taxi-drivers-out-of-business/

The task environment - PEAS

- **Performance measure**
  - -1 per step; + 10 food; +500 win; -500 die; +200 hit scared ghost
- **Environment**
  - Pacman dynamics (incl ghost behavior)
- **Actuators**
  - Left Right Up Down or NSEW
- **Sensors**
  - Entire state is visible (except power pellet duration)

SCORE: 18

PEAS: Medical diagnosis system

- **Performance measure**
  - Patient health, cost, reputation
- **Environment**
  - Patients, medical staff, insurers, courts
- **Actuators**
  - Screen display, email
- **Sensors**
  - Keyboard/mouse
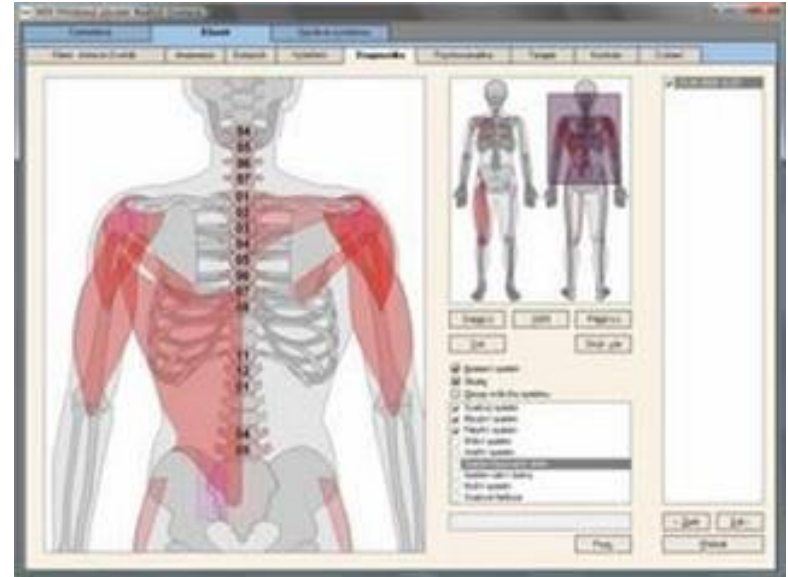
Properties of task environments

	Pacman	Backgammon	Diagnosis	Taxi
Fully or partially observable				
Single-agent or multiagent				
Deterministic or non deterministic or stochastic				
Static or dynamic				
Discrete or continuous				
Known physics/rules?				
Known perf. measure?				

Properties of task environments

	Pacman	Backgammon	Diagnosis	Taxi
Fully or partially observable	F/P	F	P	P
Single-agent or multiagent	S	M	S	M
Deterministic or non deterministic or stochastic	D/N	S	S	S
Static or dynamic	S/D	S	D	D
Discrete or continuous	D/C	D	C	C
Known physics/rules?	Yes	Yes	Yes	Yes
Known perf. measure?				

Agent design

- **The environment type largely determines the agent design**
  - *Partially observable* => agent requires *memory* (internal state)
  - *Stochastic* => agent may have to prepare for *contingencies*
  - *Multi-agent* => agent may need to behave *randomly*
  - *Static* => agent has time to compute a rational decision
  - *Continuous time* => continuously operating *controller*
  - *Unknown physics* => need for *exploration*
  - *Unknown perf. measure* => observe/interact with *human principal*

A vacuum-cleaner world
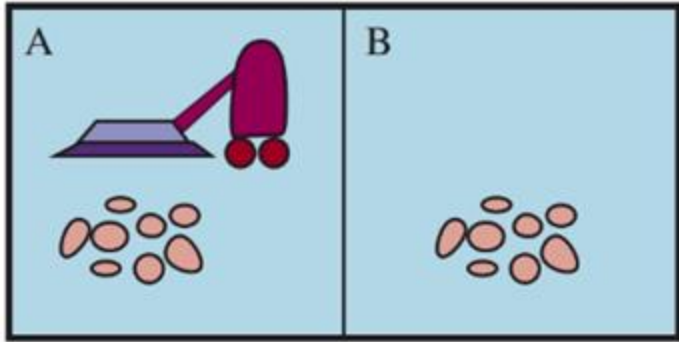
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[A, Clean], [A, Clean], [A, Clean]	Right
[A, Clean], [A, Clean], [A, Dirty]	Suck

$$\sum_{t=1}^{T} |\mathcal{P}|^{t}$$

function TABLE-DRIVEN-AGENT(*percept*) **returns** an action
   persistent: *percepts*, a sequence, initially empty
      table, a table of actions, indexed by percept sequences, initially fully specified

   append *percept* to the end of *percepts*
   action ← LOOKUP(*percepts*, *table*)
   return *action*

Figure 2.7 The TABLE-DRIVEN-AGENT program is invoked for each new percept and returns an action each time. It retains the complete percept sequence in memory.

The structure of the Agents

- Simple reflex agents

- Model-based reflex agents

- Goal-based agents

- Utility-based agents.

Agent types

- Simple reflex agents

- Model-based reflex agents

- Goal-based agents

- Utility-based agents.

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?
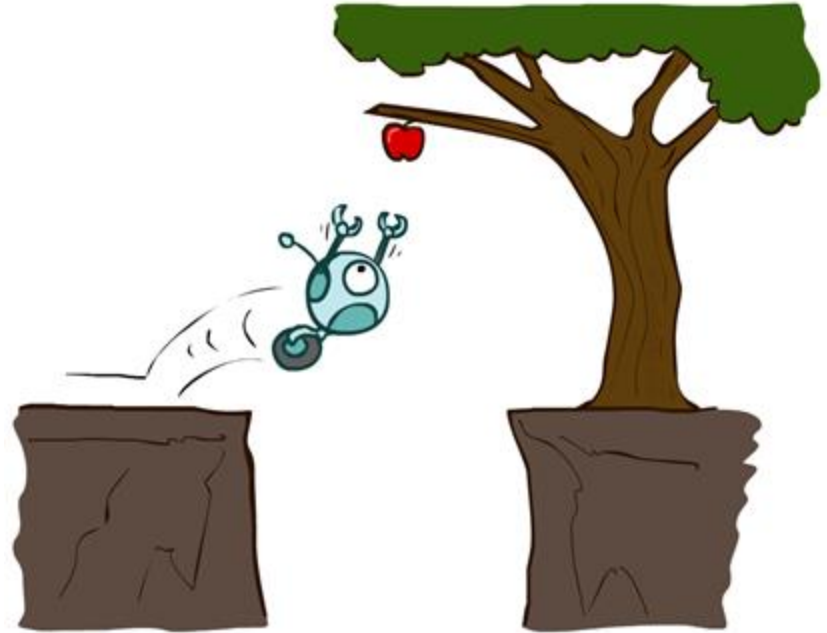
Simple reflex agents
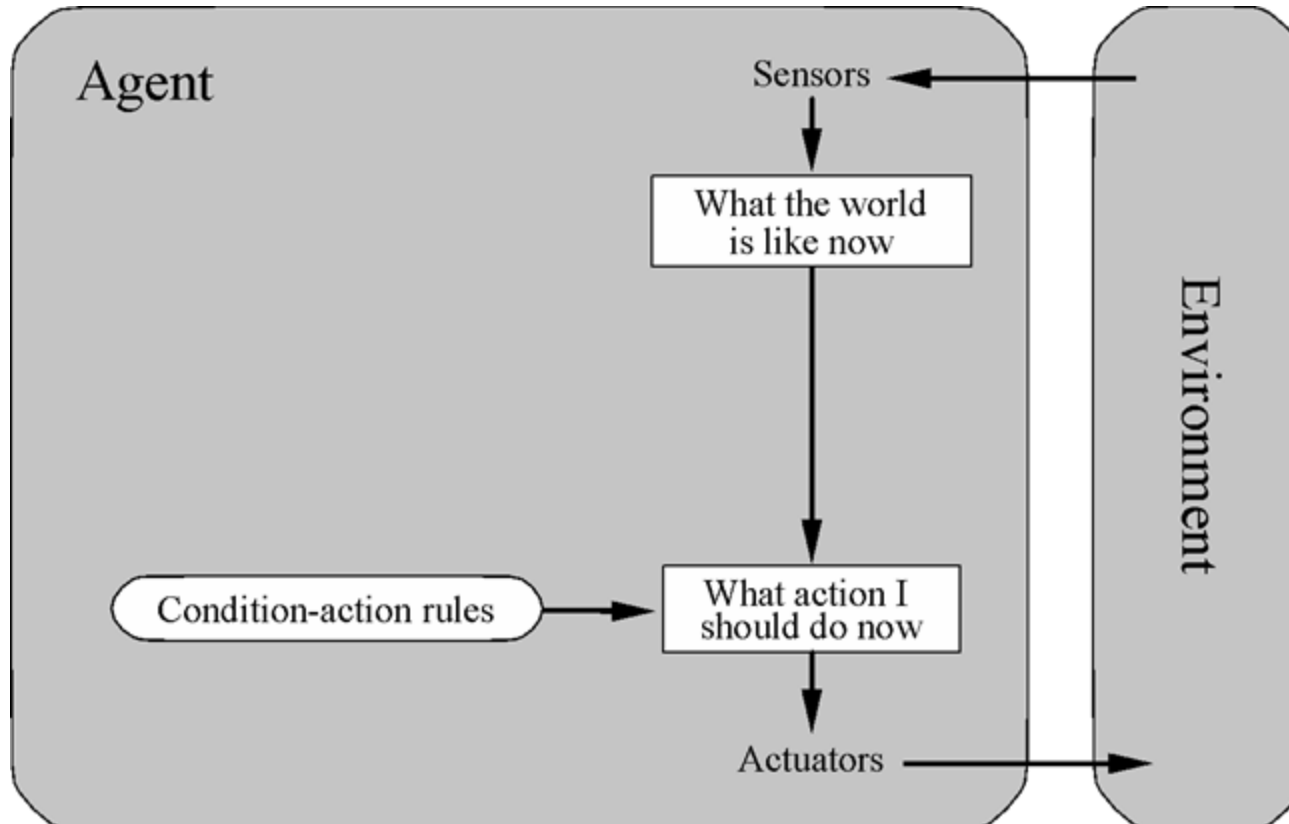
Simple reflex agents

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

    $state \leftarrow$ INTERPRET-INPUT(*percept*)
    $rule \leftarrow$ RULE-MATCH(*state*, *rules*)
    $action \leftarrow rule$.ACTION
    return *action*

Based on condition-action rule:
    if *happen X* ***then*** *action A*

Eat adjacent dot, if any
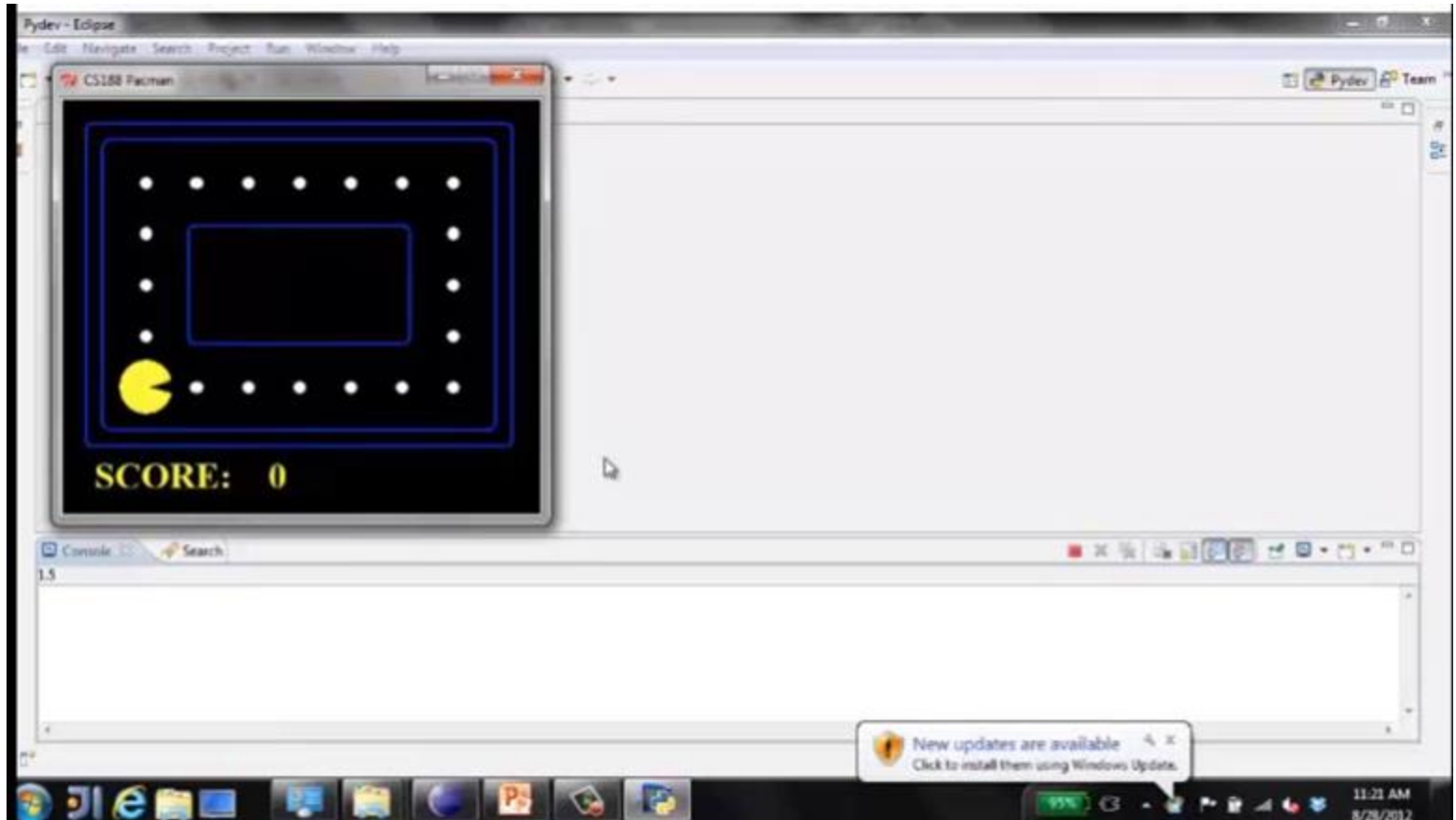
Eat adjacent dot, if any
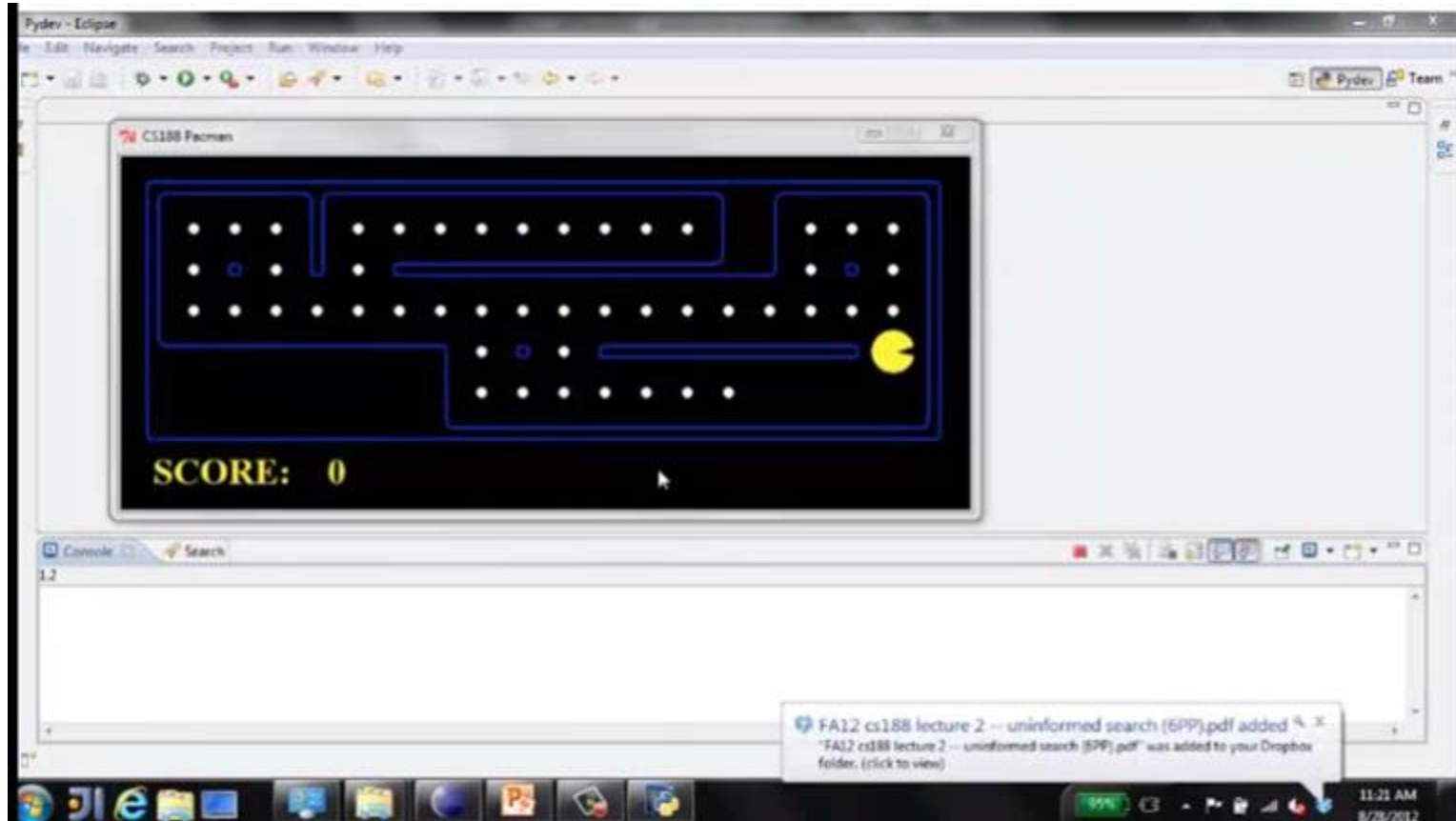
Pacman agent contd.

- Can we (in principle) extend this reflex agent to behave well in all standard Pacman environments?
  - No – Pacman is not quite fully observable (power pellet duration)
  - Otherwise, yes – we can (*in principle*) make a lookup table…..
  - *How large would it be?*

Agent types

- Simple reflex agents

- Model-based reflex agents

- Goal-based agents

- Utility-based agents.

Model-based Reflex agents
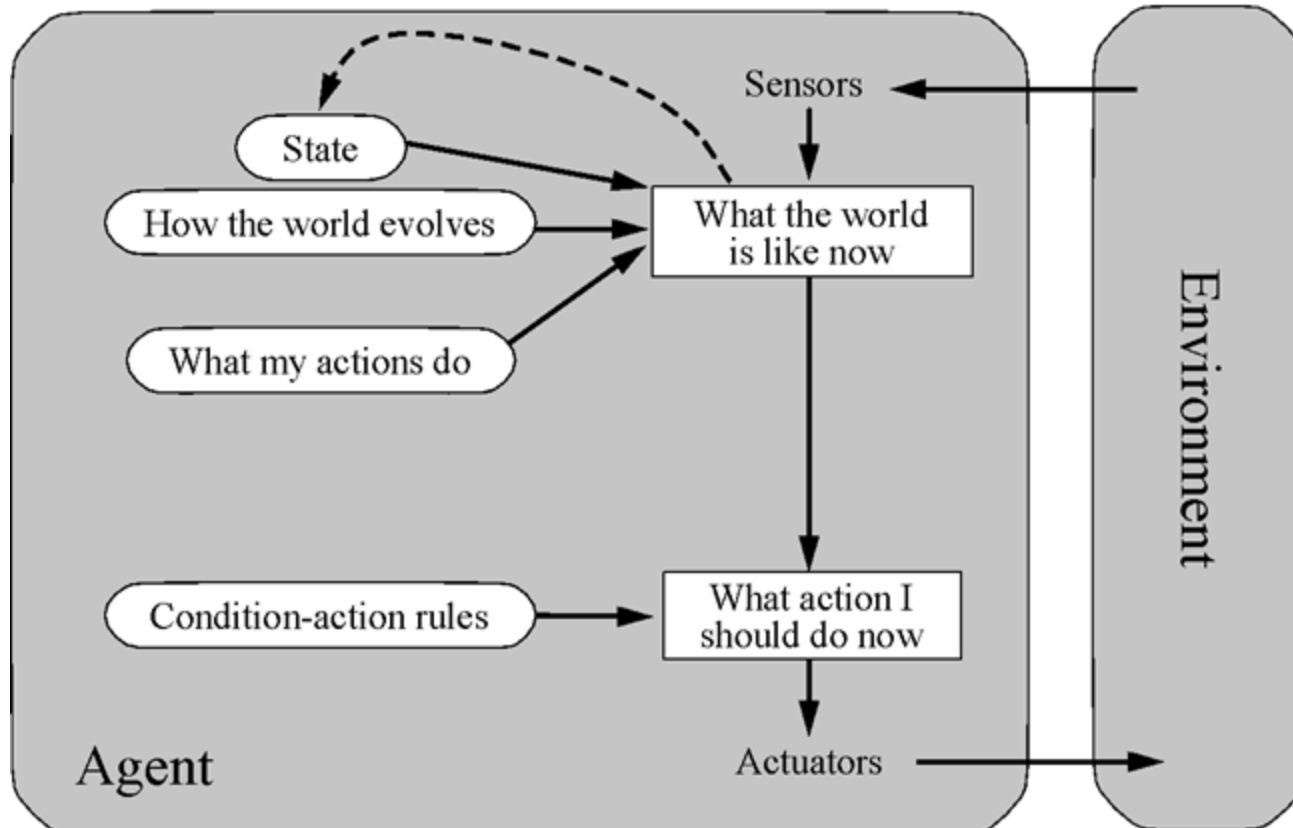
Agents that Plan
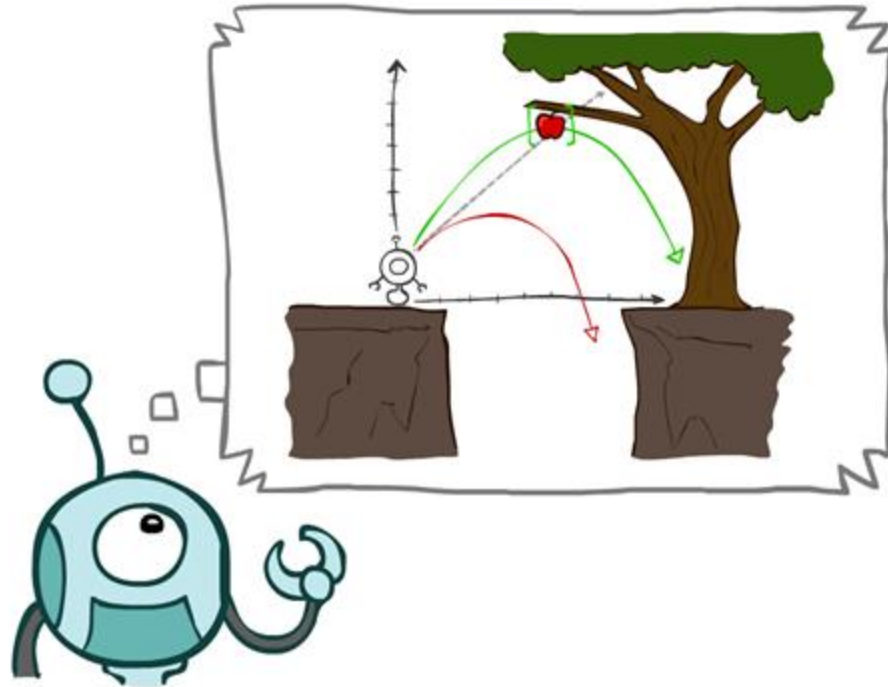
(model-based), goal-based agents

- **goal-based agents:**
  - Ask "what if"
  - Decisions based on (hypothesized) consequences of actions
  - Must have a model of how the world evolves in response to actions
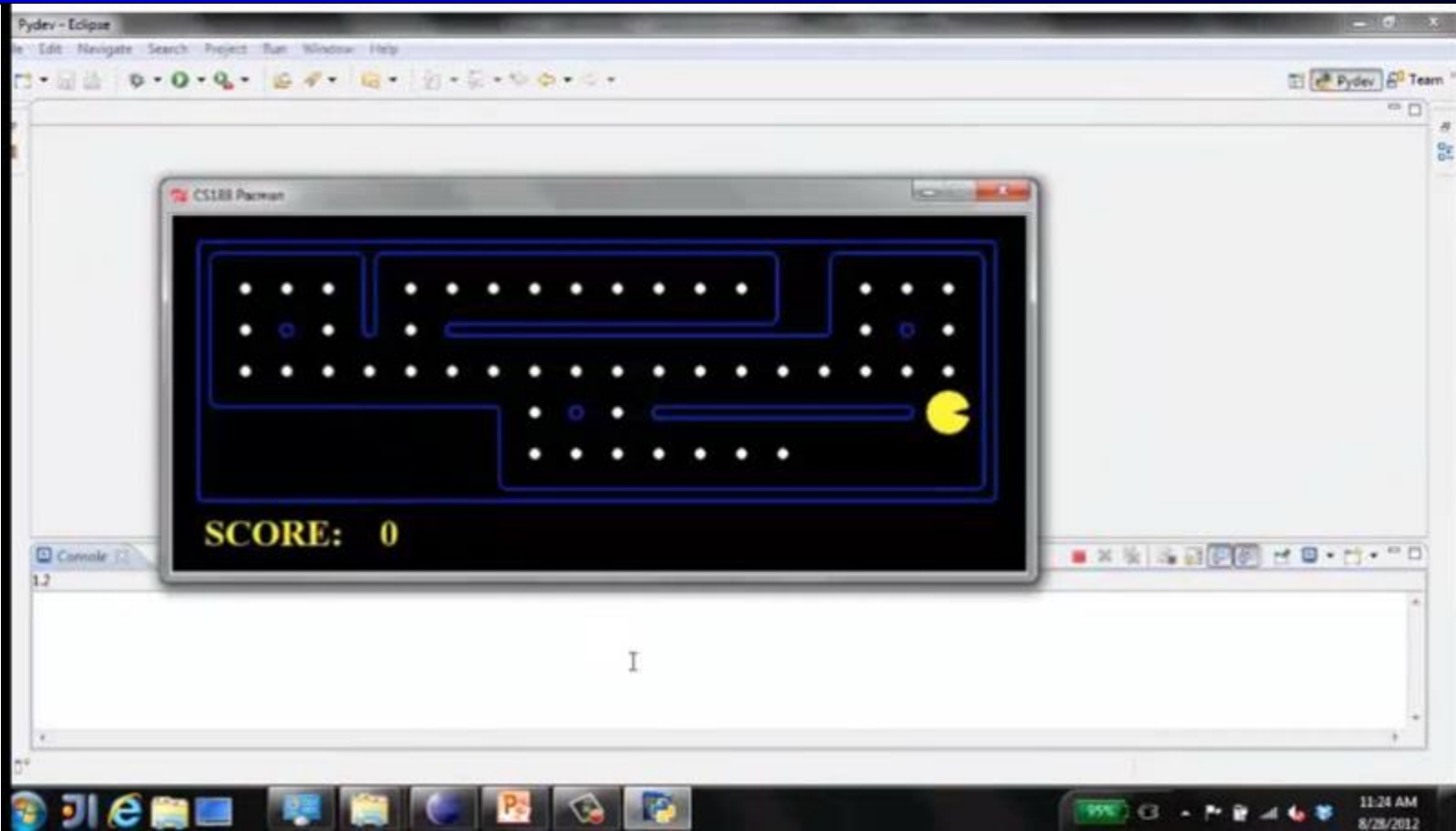 - Must formulate a goal (test)
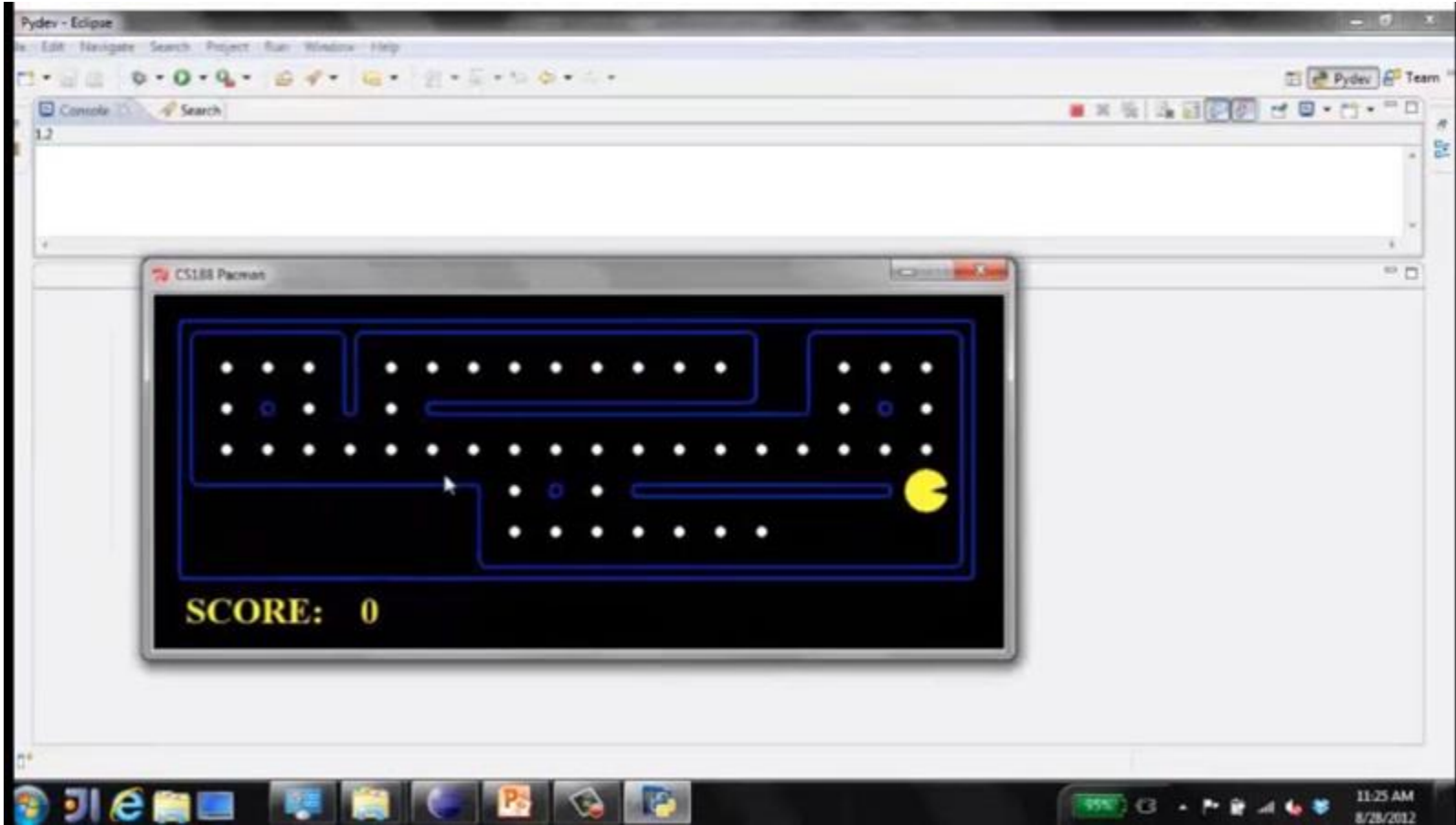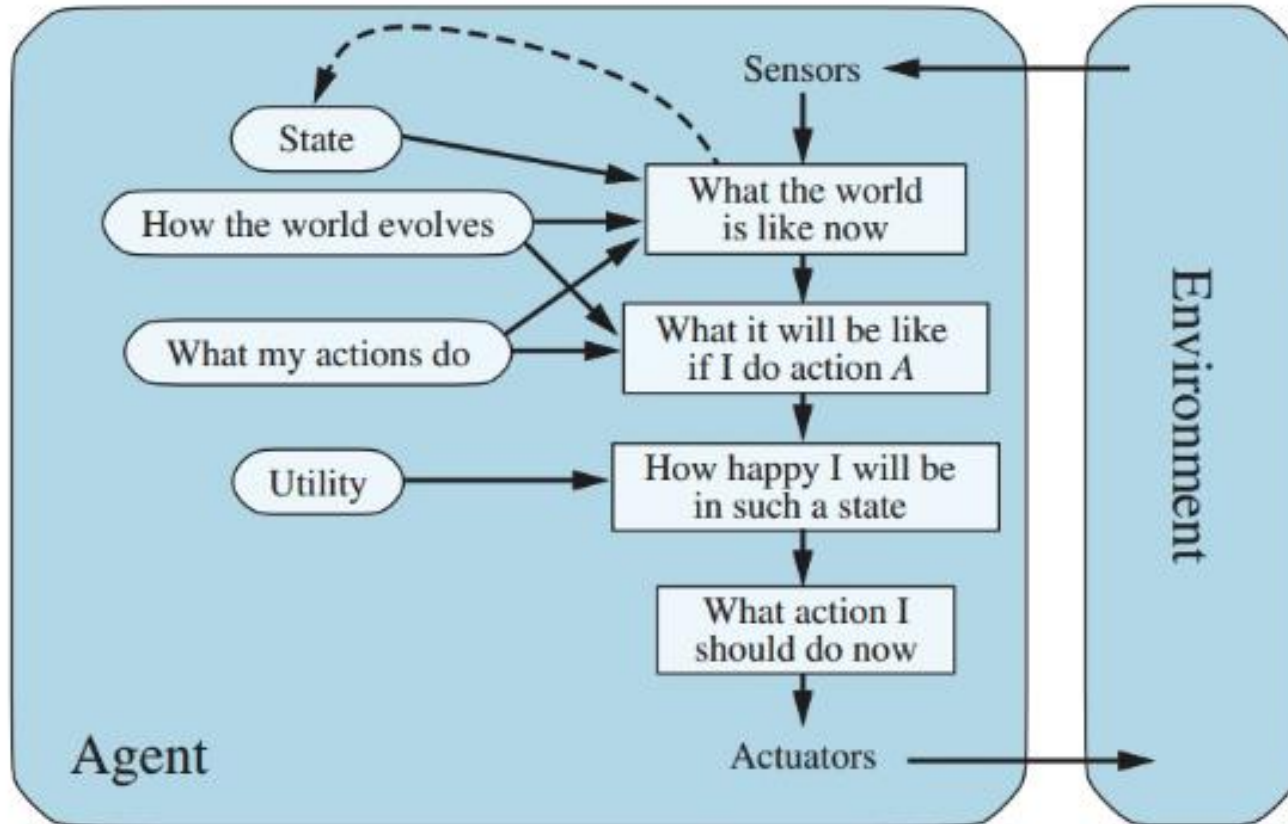 - Consider how the world WOULD BE
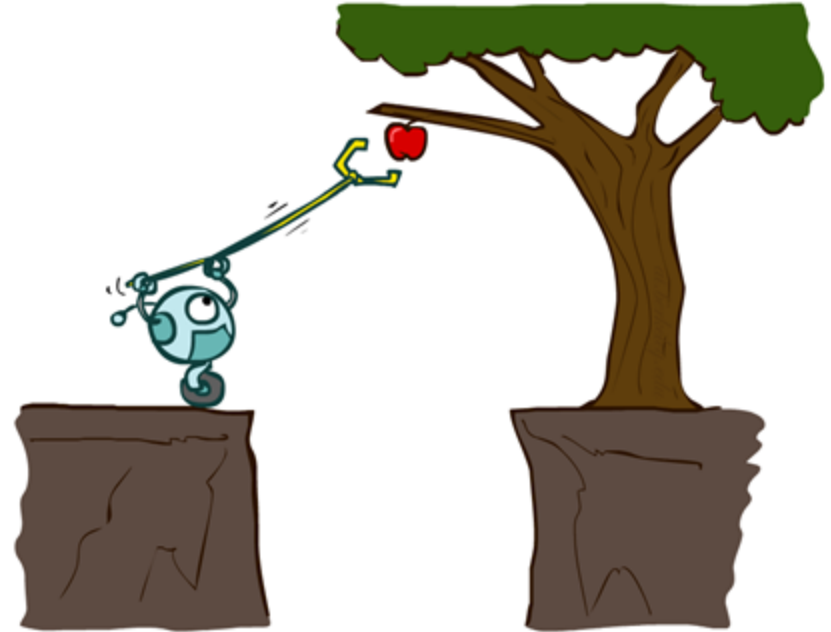
(model-based), goal-based agents
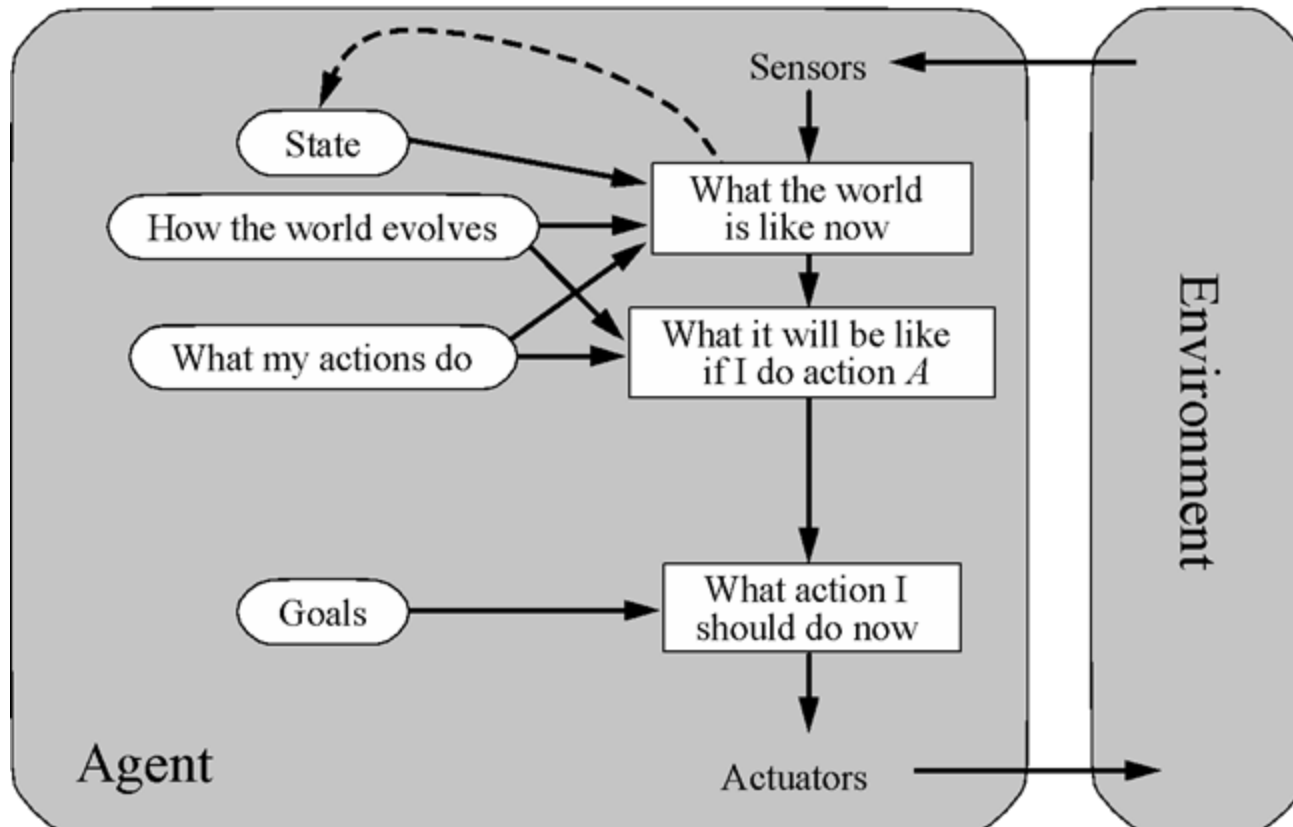
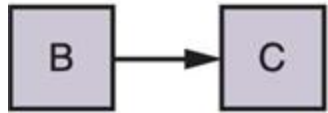# Video of Demo Replanning

Video of Demo Mastermind

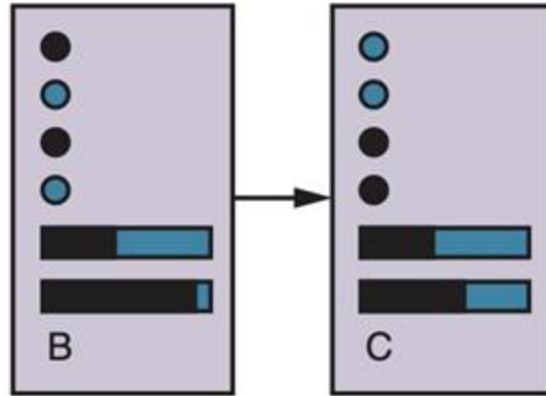# (model-based, goal-based), utility-based agents

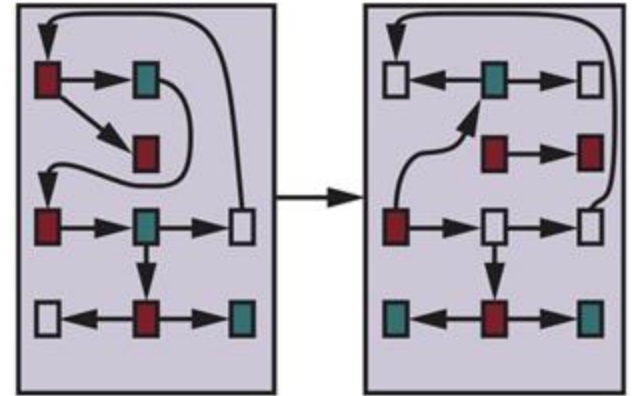# Spectrum of representations

(a) Atomic   (b) Factored   (c) Structured

Outline of the course