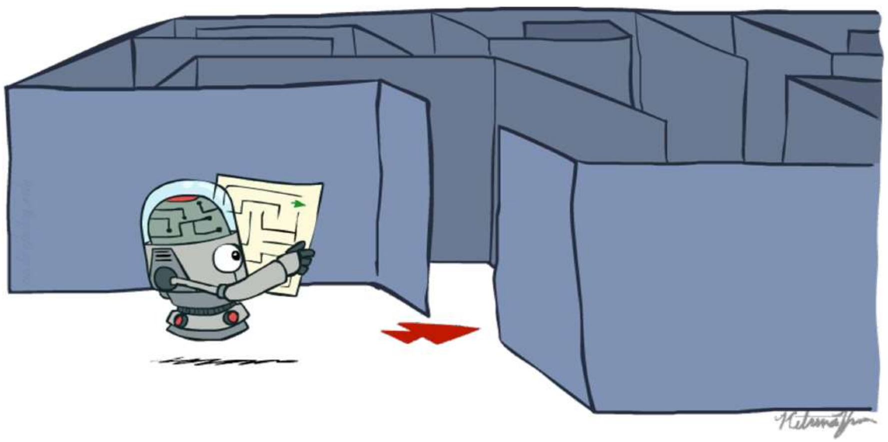
# Advanced Artificial Intelligence

# Task Environments - Agents




Spring 402

Fatemeh Mansoori

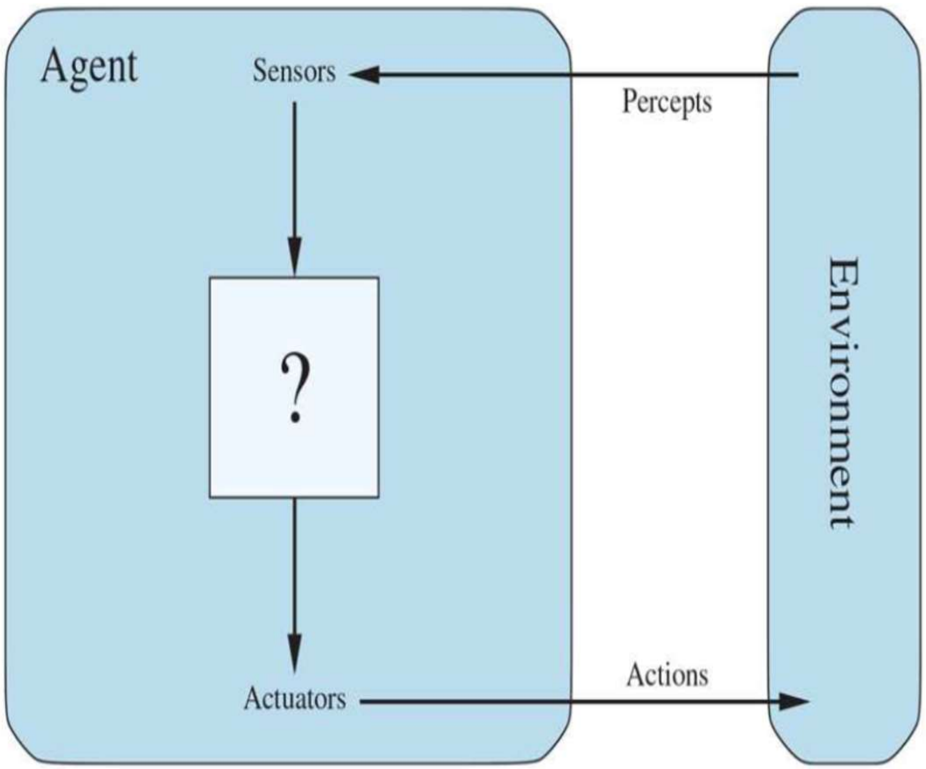
University of Isfahan


[These slides are based of  the slides created by Dan Klein and Pieter Abbeel for CS188 Intro to AI at UC Berkeley  (ai.berkeley.edu).]

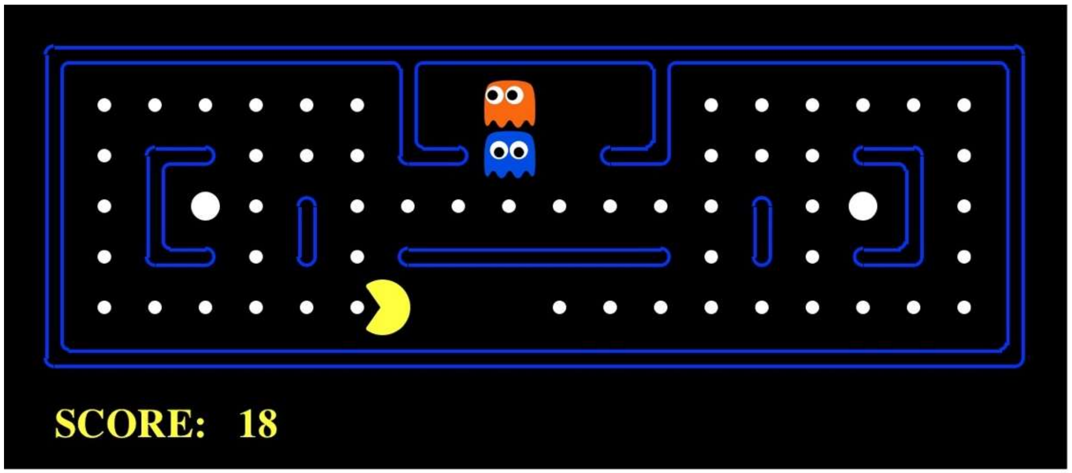
# Agent

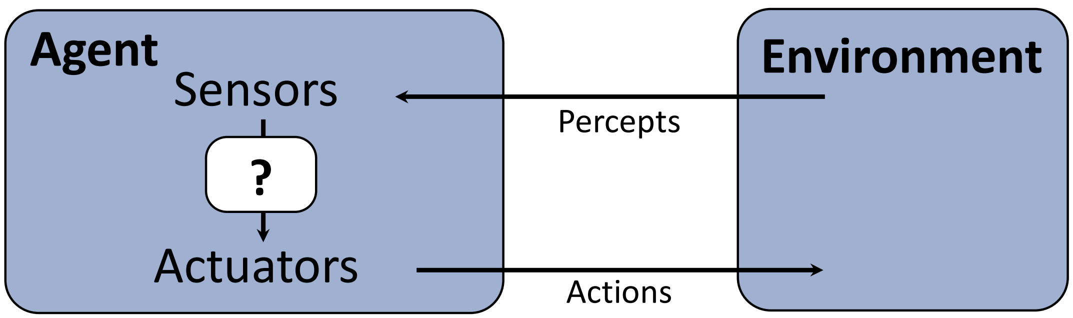
- An **agent** is anything that can be viewed as **perceiving its environment** through **sensors** and **acting upon that environment** through **actuators**
    - Human agent
    - Robot agent
    - Software agent

- 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.



# Pac-Man as an Agent




Pac-Man is a registered trademark of Namco-Bandai Games, used here for educational purposes

Demo1: pacman-l1.mp4 or L1D2

# Agent

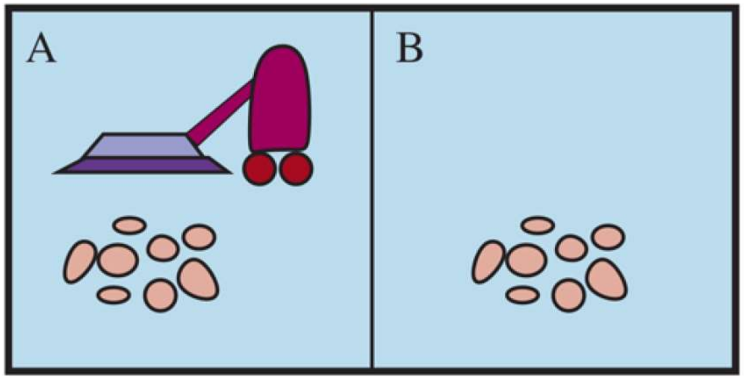
- **Percept**
  - content an agent's sensors are perceiving
- **Percept sequence**
  - complete history of everything the agent has ever perceived

- *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



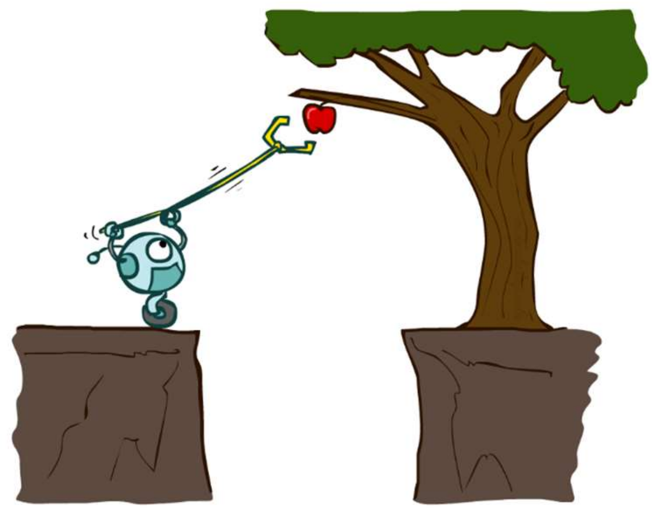

Available Actions: move to right, move to left, suck, do noting

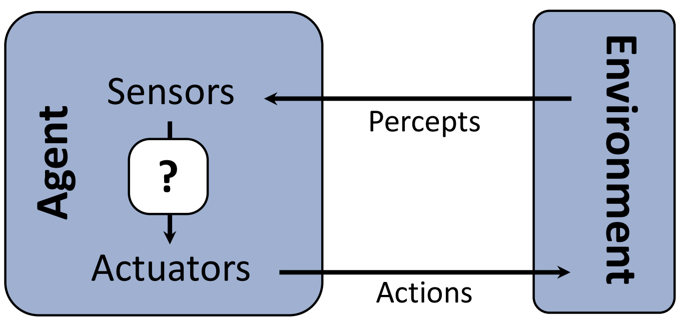
very simple agent function: if the current square is dirty, then suck; otherwise, move to the other square

| 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* |
| ⋮ | ⋮ |

# Rational Agents

- An **agent** is an entity that *perceives* and *acts*.
- Abstractly, an agent is a function from percept histories to actions :
  - $f : \mathcal{P}^* \rightarrow \mathcal{A}$
- For any given class of environments and tasks, we seek the agent (or class of agents) with the best (expected) performance (or utility)
- A **rational agent** selects actions that maximize its (expected) **utility**.
- Caveat: computational limitations make perfect rationality unachievable
- design best program for given machine resources





# 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

# Task Environment

- In rationality of the simple vacuum-cleaner agent, we had to specify
  - the performance measure
  - the environment
  - the agent’s actuators and sensors.
- We group all these under the heading of the **task environment**

- we call this the **PEAS** (**P**erformance, **E**nvironment, **A**ctuators, **S**ensors)
- In designing an agent, the first step must always be to specify the task environment as fully as
- possible.

# PEAS

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

- **PEAS** (**P**e

| 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


vs.

# 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 **cooperative**


VS.

# Properties of task environment

- **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"

vs.

# 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

vs.

# 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

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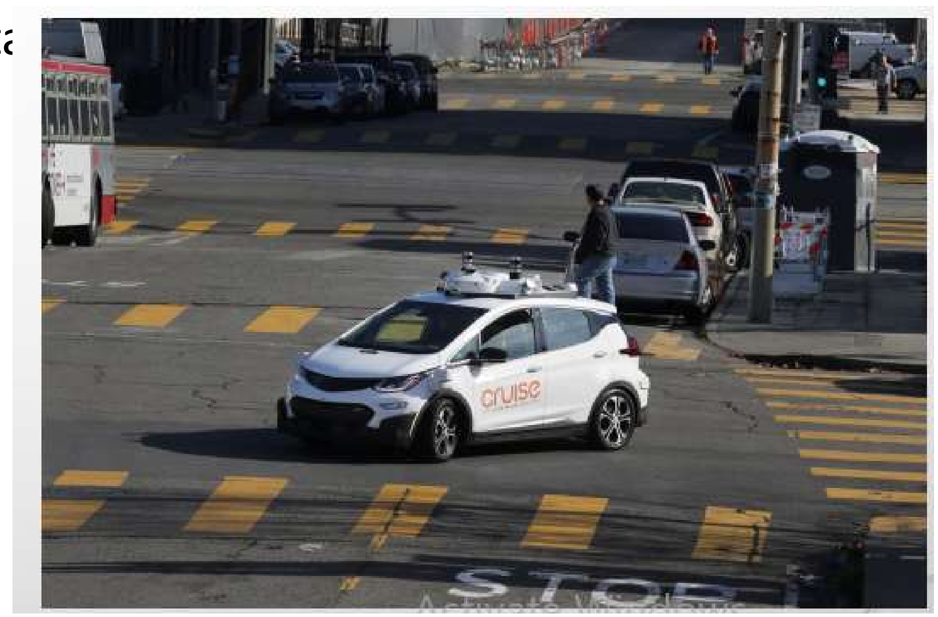
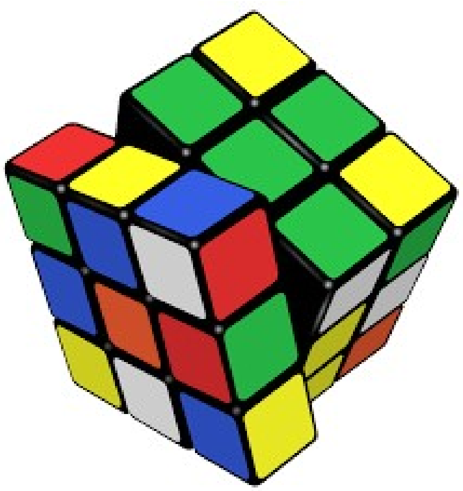
vs.



# Properties of task environment

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



**VS**

- **KNOWN VS. UNKNOWN :**
  - is not strictly a property of the environment
  - 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.
  - A *known* environment can be *partially* observable :
    - E.g. solitaire game I know the rules but am still unable to see the cards that have not yet been turned over
  - An *unknown* environment can be *fully* observable :
    - in a new video game, the screen may show
    - the entire game state but I still don’t know what the buttons do until I try them.

# 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 |

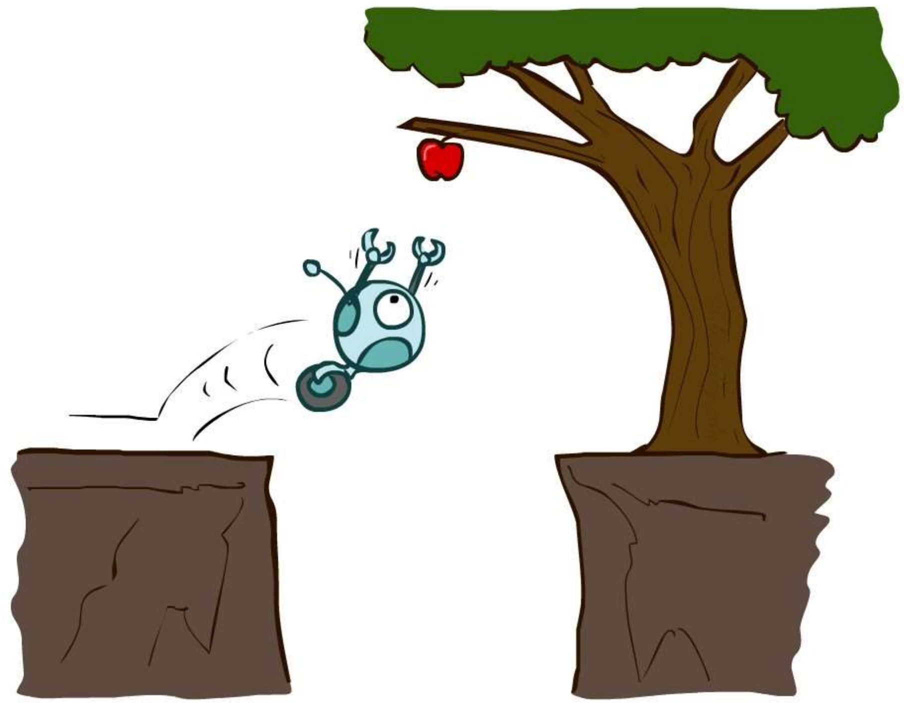
Examples of task environments and their characteristics.

- AGENTS

# 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?

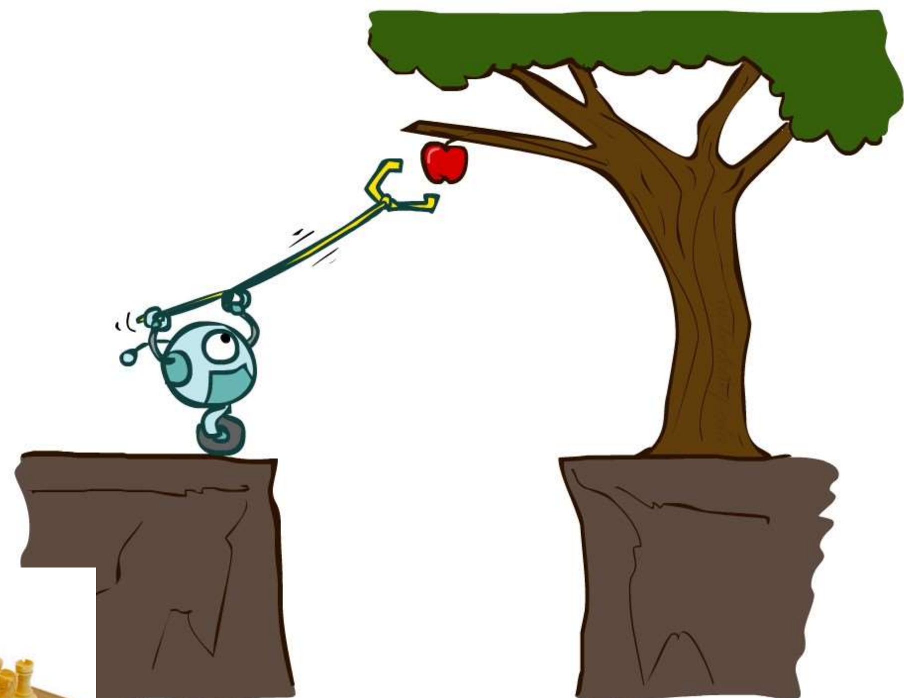



[Demo: reflex optimal (L2D1)]
[Demo: reflex optimal (L2D2)]

# 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

- Optimal vs. complete planning
- Planning vs. replanning



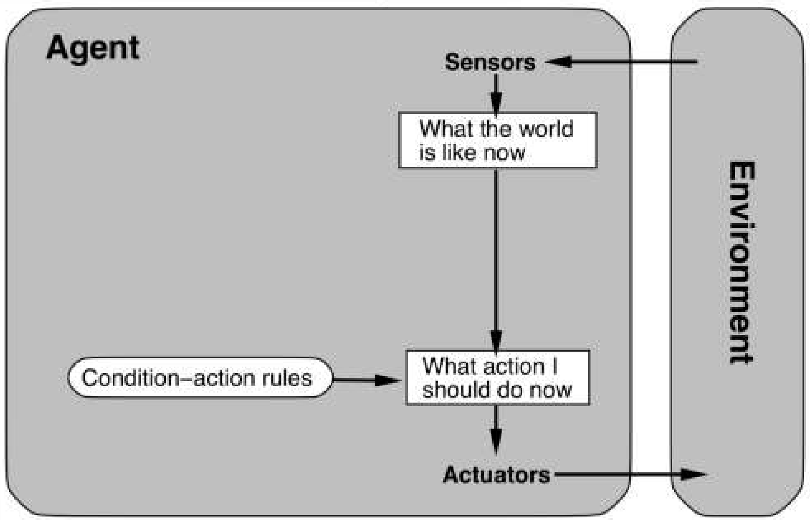
[Demo: re-planning (L2D3)]
[Demo: mastermind (L2D4)]

# Utility based agent

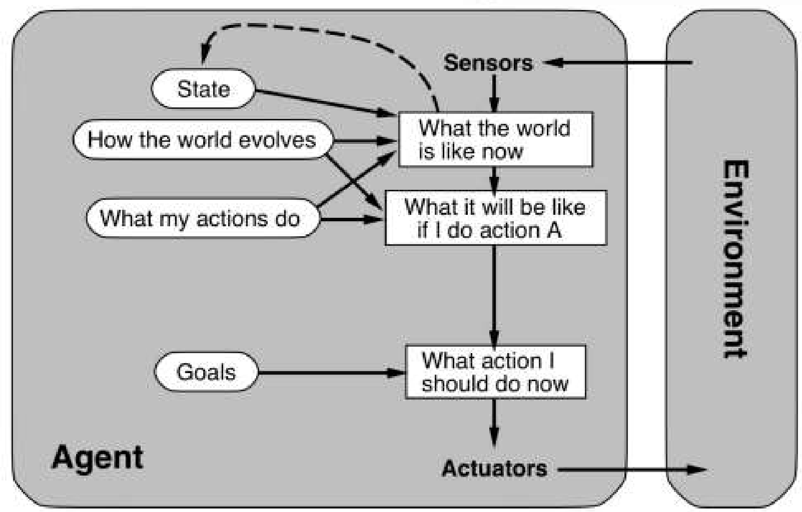
**Utility Based Agents:**

- Like goal-based, but
- Trade off multiple goals
- Reason about probabilities of outcomes
- Act on how the world will **LIKELY** be

## Reflex Agent




## Goal-based Agent




## Utility-based Agent