Outline

- Intelligent Agents (IA) and Environments
- Rationality
- Task Environments
- Environment Types
- IA Types
- Summary

Intelligent Agents

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators.
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- Human agent: eyes, ears, and other organs for sensors and hands, legs, mouth, and other body parts for actuators.
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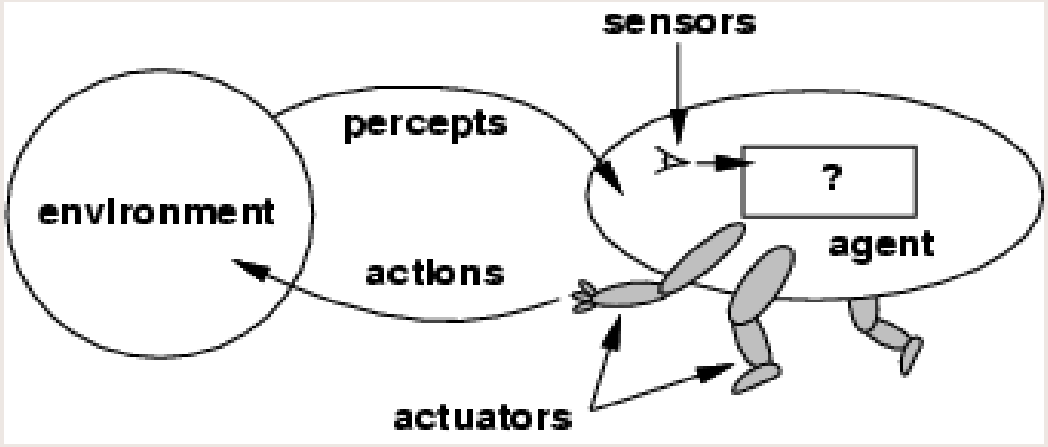
- Robotic agent: cameras and infrared range finders for sensors and various motors for actuators.
- Software agent: Keystrokes, file contents, and network packets as sensors and displaying on the screen, writing files, and sending network packets as actuators.

Intelligent Agents and Environments



- The agent function maps from percept histories to actions:
- $[f: P^* \rightarrow A]$
- The agent program runs on the physical architecture to produce *f*
- agent = architecture + program

Intelligent Agents and Artificial Intelligence

- Human mind is a network of thousands or millions of agents working in parallel. To produce real artificial intelligence, we should build computer systems that also contain many agents and systems for arbitrating among the agents' competing results.

Rational Agents

- Rational behavior: doing the right thing, which means maximization of goal achievement with the available information.
- An agent is an entity that perceives and acts.
- In brief, a rational agent shows the rational behavior, i.e., it does the right thing.
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- 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.
- The course AI is about designing rational agents.
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- Computational limitations make perfect rationality unachievable.
  → design best program for given machine resources.

Rational Agents

- An agent should strive to "do the right thing," based on what it can perceive and the actions it can perform. The right action is the one that will cause the agent to be most successful.
- Performance measure: An objective criterion for success of an agent's behavior.

Rational Agents

Rationality indicates doing the right thing, which means maximization of goal achievement with the available information.

Rationality depends on the following four things:

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

Rational Agents

- Rationality is distinct from omniscience (all-knowing with infinite knowledge)
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- Agents can perform actions in order to modify future percepts so as to obtain useful information (information gathering, exploration)
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- An agent is autonomous if its behavior is determined by its own experience (with ability to learn and adapt)
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PEAS of Rational Agents

- PEAS: Performance measure, Environment, Actuators, Sensors.
- Must first specify the setting for intelligent agent design.
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- Consider, e.g., the task of designing an automated taxi driver:
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  - Performance measure
  -
  - Environment
  - Actuators

PEAS Description for an Automated Taxi

Agent Type	Performance Measure	Environment	Actuators	Sensors
Taxi driver	Safe, fast, legal, comfortable trip, maximize profits	Roads, other traffic, pedestrians, customers	Steering, accelerator, brake, signal, horn, display	Cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors, keyboard

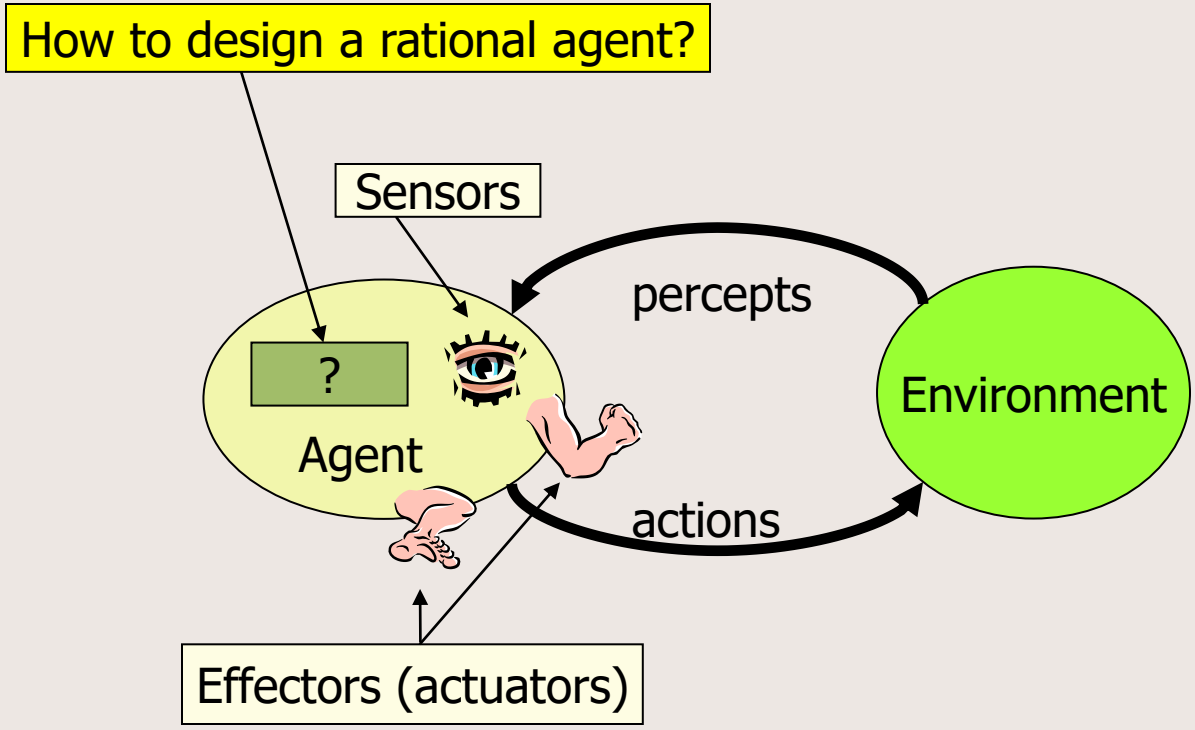
Figure 2.4 PEAS description of the task environment for an automated taxi.

PEAS Descriptions

Agent Type	Performance Measure	Environment	Actuators	Sensors
Automated Taxi				
Taxi driver	Safe, fast, legal, comfortable trip, maximize profit	Roads, other traffic, pedestrians, customers	Steering, accelerator, brake, signal horn, display	Cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors, key board
Medical Diagnosis System				
Medical diagnosis system	Healthy patient, minimize costs, lawsuits	Patient, hospital, staff	Display, questions, tests, diagnoses, treatments, referrals	Key board entry of symptoms, findings, patient's answers

Task Environments

Task environments, which are essentially the problems to which *rational agents* are the solutions.



Environment Types

- Fully observable (vs. partially observable): An agent's sensors give it access to the complete state of the environment at each point in time.
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- Deterministic (vs. stochastic): The next state of the environment is completely determined by the current state and the action executed by the agent. (If the environment is deterministic except for the actions of other agents, then the environment is strategic).
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- Episodic (vs. sequential): The agent's experience is divided into atomic "episodes" (each episode consists of the agent perceiving and then performing a single action), and the choice of action in each episode depends only on the episode itself.

Environment Types

- Static (vs. dynamic): The environment is unchanged while an agent is deliberating. (The environment is semi-dynamic if the environment itself does not change with the passage of time but the agent's performance score does).
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- Discrete (vs. continuous): A limited number of distinct, clearly defined percepts and actions.
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- Single agent (vs. multiagent): A single agent operating by itself in an environment.
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Environment Types

	Chess with a clock	Chess without a clock	Taxi driving
Fully observable	Yes	Yes	No
Deterministic	Strategic	Strategic	No
Episodic	No	No	No
Static	Semi	Yes	No
Discrete	Yes	Yes	No
Single agent	No	No	No

- The environment type largely determines the agent design.
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- The real world's characteristics are (of course) partially observable, stochastic, sequential, dynamic, continuous and multi-agent.
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Towards Autonomous Vehicles

http://iLab.usc.edu

http://beobots.org

Interacting Agents

Collision Avoidance Agent (CAA)

- Goals: Avoid running into obstacles
- Percepts: Obstacle distance, velocity, trajectory
- Sensors: Vision, proximity sensing
- Effectors (Actuators): Steering Wheel, Accelerator, Brakes, Horn, Headlights
- Actions: Steer, speed up, brake, blow horn, signal (headlights)
- Environment: Freeway

Interacting Agents

Lane Keeping Agent (LKA)

- Goals: Stay in current lane
- Percepts: Lane center, lane boundaries
- Sensors: Vision
- Effectors: Steering Wheel, Accelerator, Brakes
- Actions: Steer, speed up, brake
- Environment: Freeway

Conflict Resolution by Action
(Selection of Agents in muli-agent environment)

- **Override:** CAA overrides LKA
- **Arbitrate:** if Obstacle is Close then CAA
  else LKA
- **Compromise:** Choose action that satisfies both agents
- **Challenges:** Doing the right thing

Behavior and performance of IAs

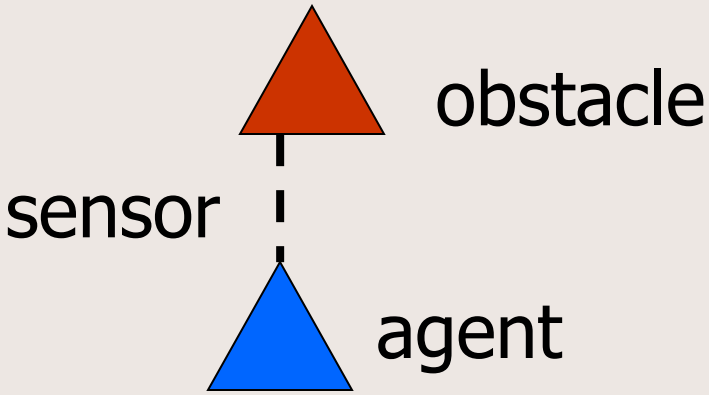
- **Perception** (sequence) to **Action Mapping:** f: P* $\rightarrow$ A
  - **Ideal mapping:** specifies which actions an agent ought to take at any point in time
  - **Description:** Look-Up-Table, Closed Form, etc.

- **Performance measure:** a *subjective* measure to characterize how successful an agent is (e.g., speed, power usage, accuracy, money, etc.)

- (degree of) **Autonomy:** to what extent is the agent able to make decisions and take actions on its own?

Look up table (Collision Avoidance Agent (CAA))

Distance	Action
10	No action
5	Turn left 30 degrees
2	Stop



How is an Agent different from other software?

- Agents are **autonomous**, that is, they act on behalf of the user.
- Agents contain some level of **intelligence**, from fixed rules to learning engines that allow them to adapt to changes in the environment.
- Agents don't only act **reactively**, but sometimes also **proactively.**

How is an Agent different from other software?

- Agents have **social ability**, that is, they communicate with the user, the system, and other agents as required.
- Agents may also **cooperate** with other agents to carry out more complex tasks than they themselves can handle .
- Agents may **migrate** from one system to another to access remote resources or even to meet other agents.

Agent types

Four basic kinds of intelligent agents:

- Simple reflex agents responds directly what it percepts.

- Model-based reflex agents maintain internal state to track aspects of the world that are not evident in the current percept.

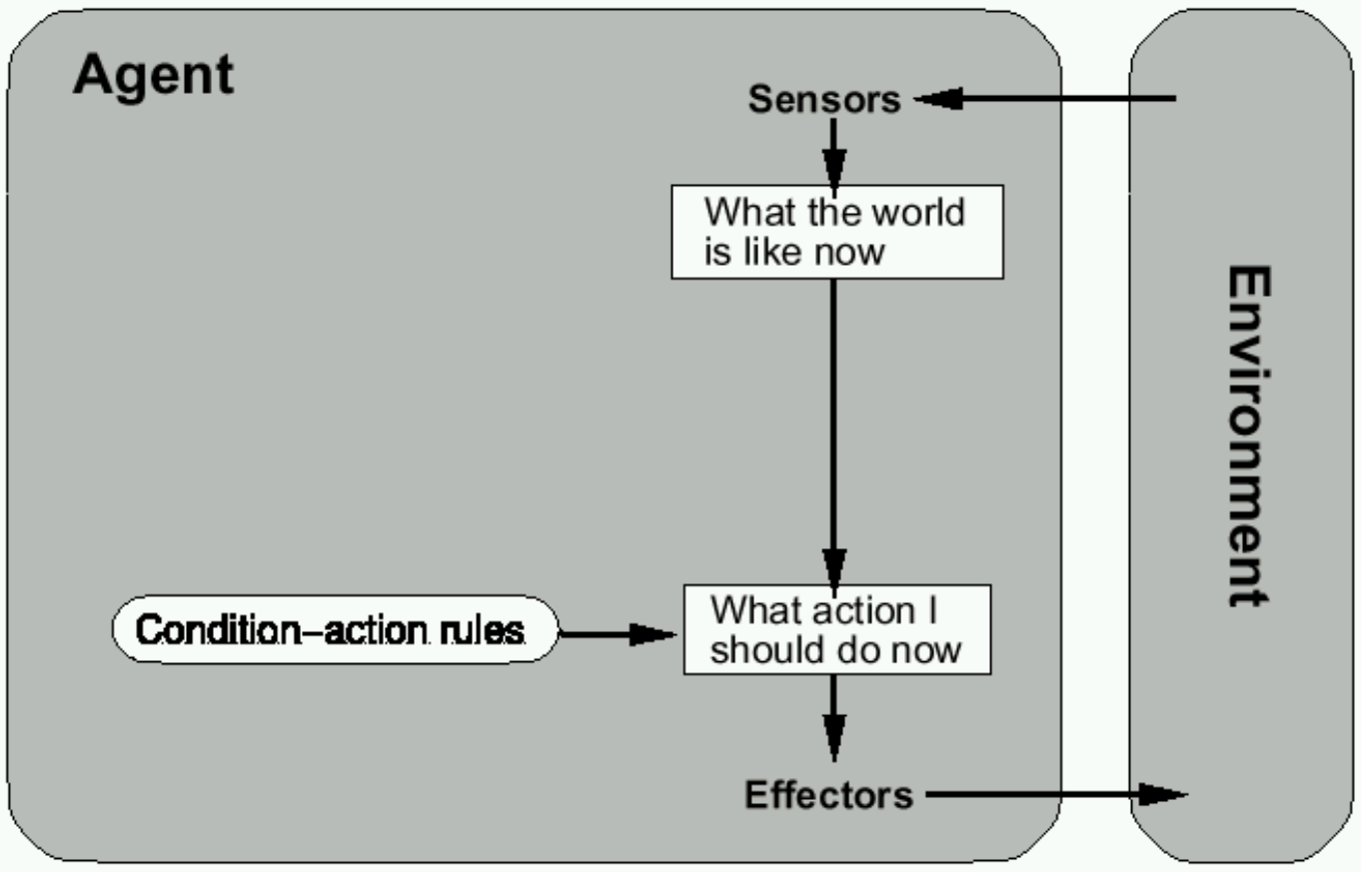
  For example: brake lights of vehicles at night.

- Goal-based agents act to achieve their goals.
  - Goal information needed to make decisions

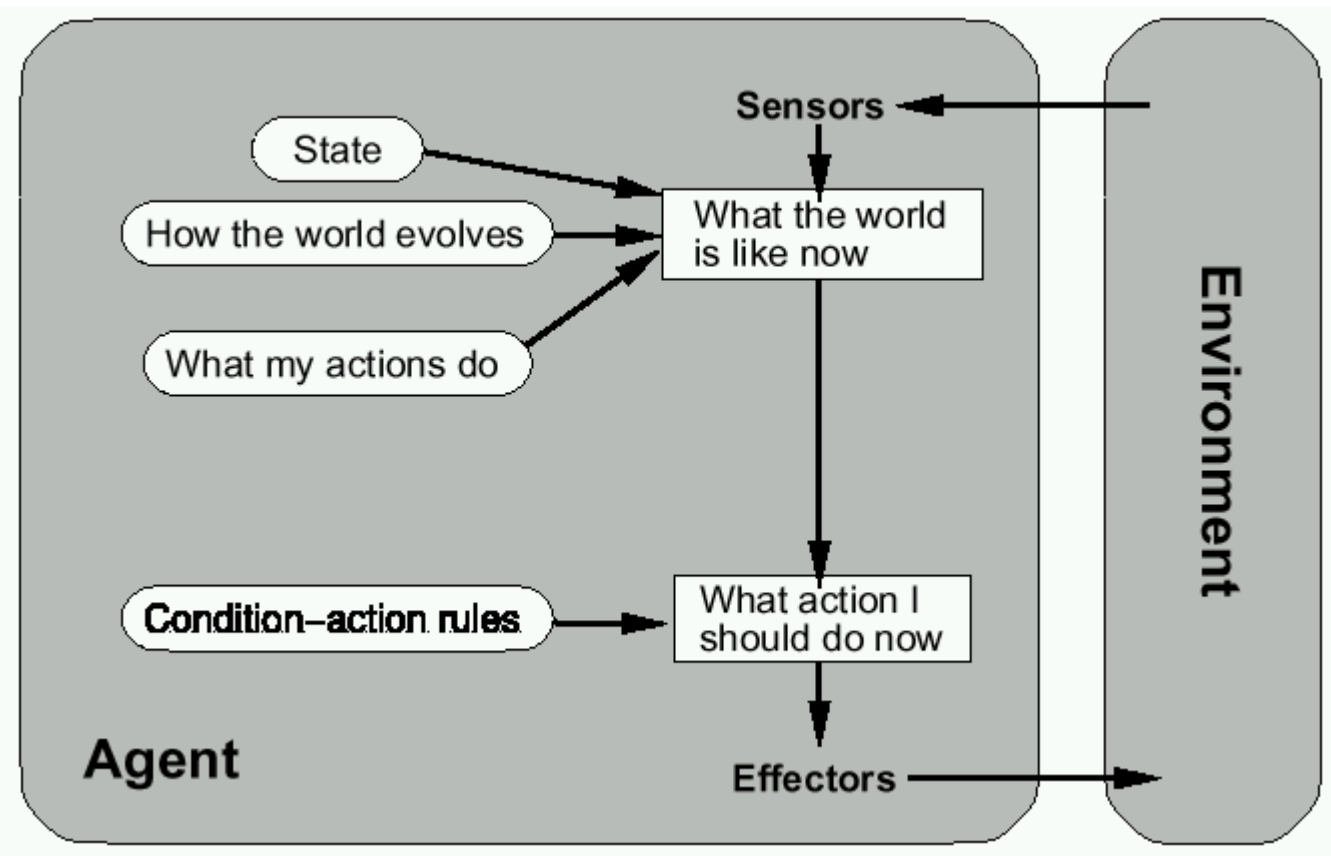
- Utility-based agents try to maximize their own expected "happiness"
  - How well can the goal be achieved (degree of happiness)
  - What to do if there are conflicting goals?
  - Which goal should be selected if several can be achieved?

All agents can improve their performance through learning.

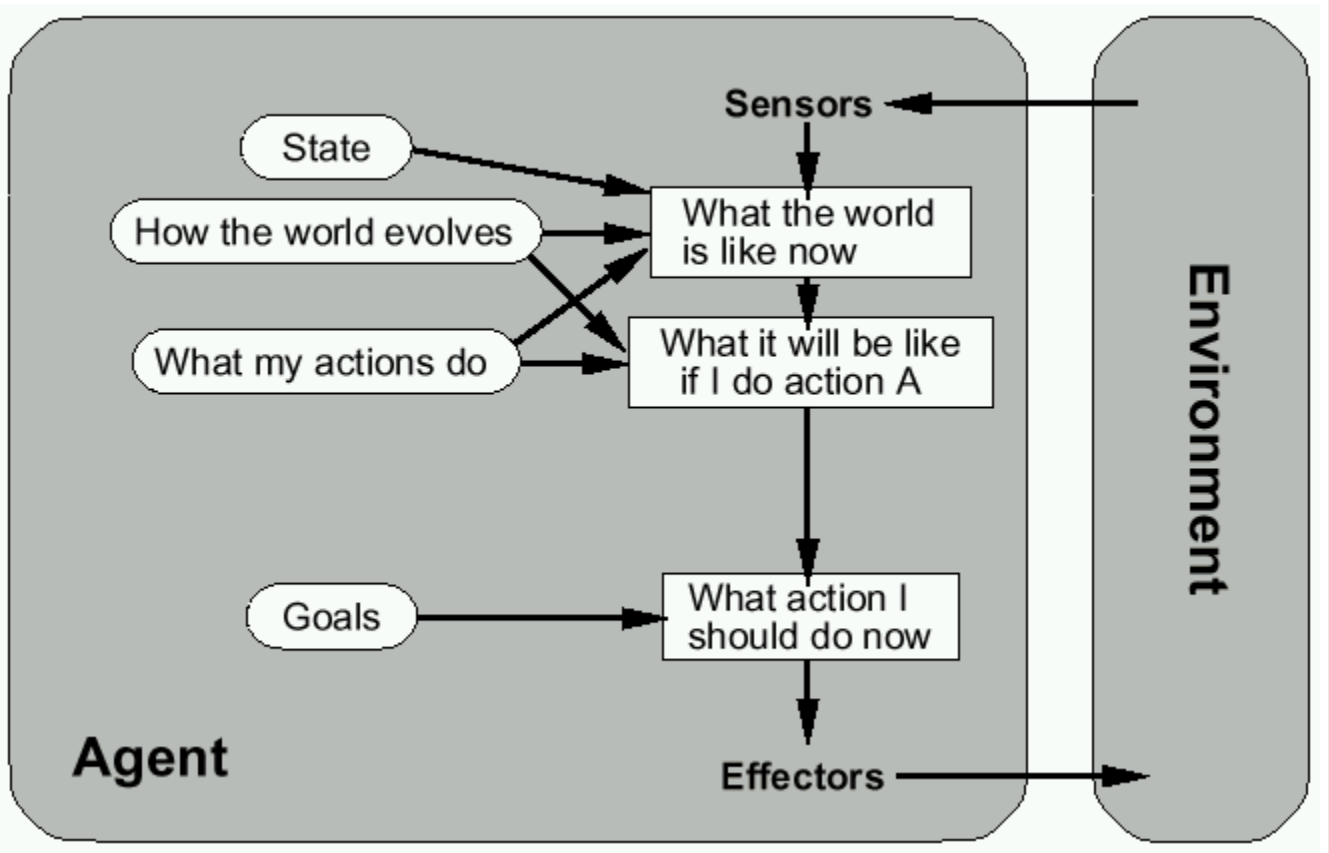
Simple Reflex Agents



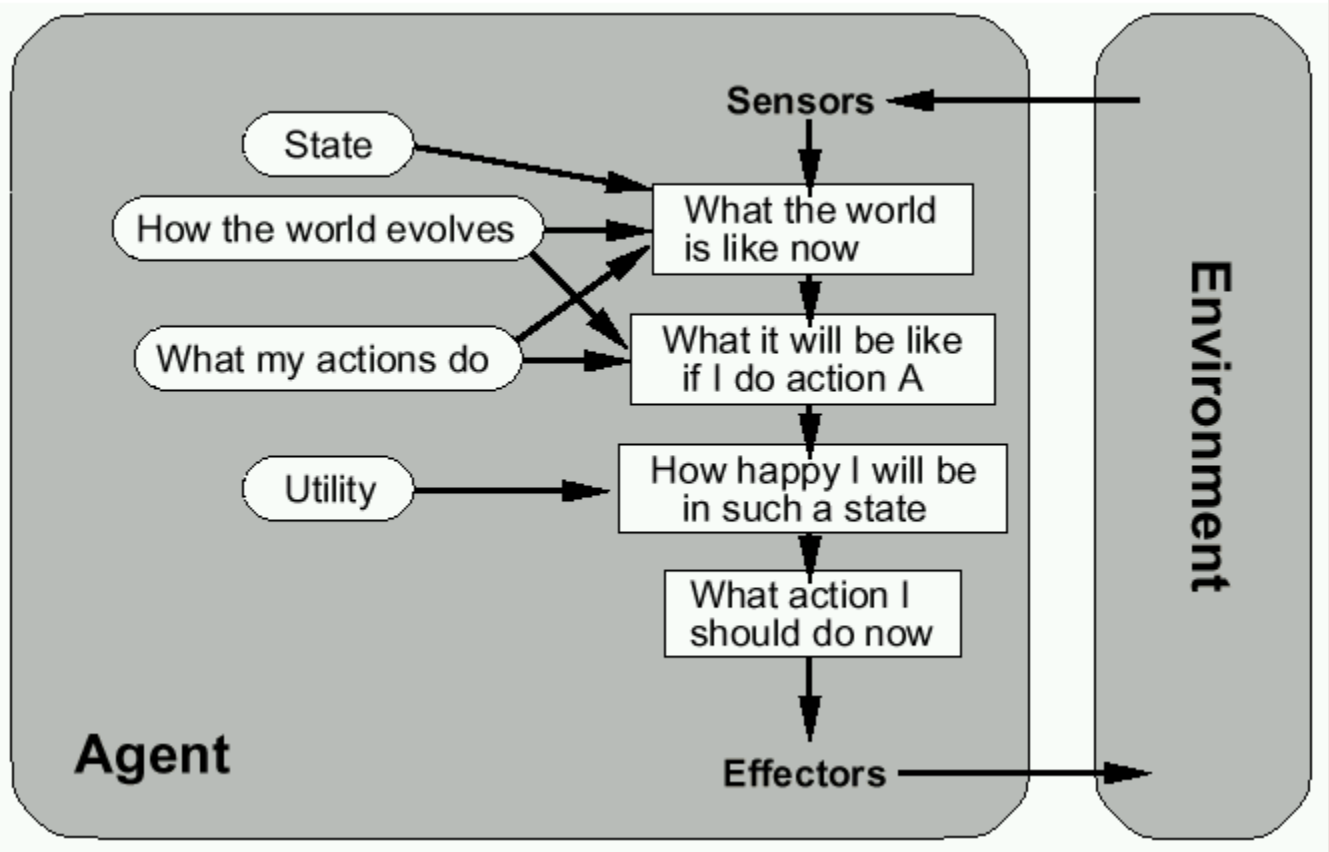
Model-Based Reflex Agents



Goal-based agents



Utility-based agents



Summary

- **Intelligent Agents:**
  - Anything that can be *viewed as* **perceiving** its **environment** through **sensors** and **acting** upon that environment through its **effectors** to maximize progress towards its **goals**.
  - Percepts, Actions, Goals, Environment
  - Described as a Perception (sequence) to Action Mapping:

    $f: P^* \rightarrow A$
  - Using look-up-table, closed form, etc.

- **Rational Action:** The action that maximizes the expected value of the performance measure given the percept sequence to date
- **Agent Types:** Simple reflex, model-based reflex, goal-based, utility-based.