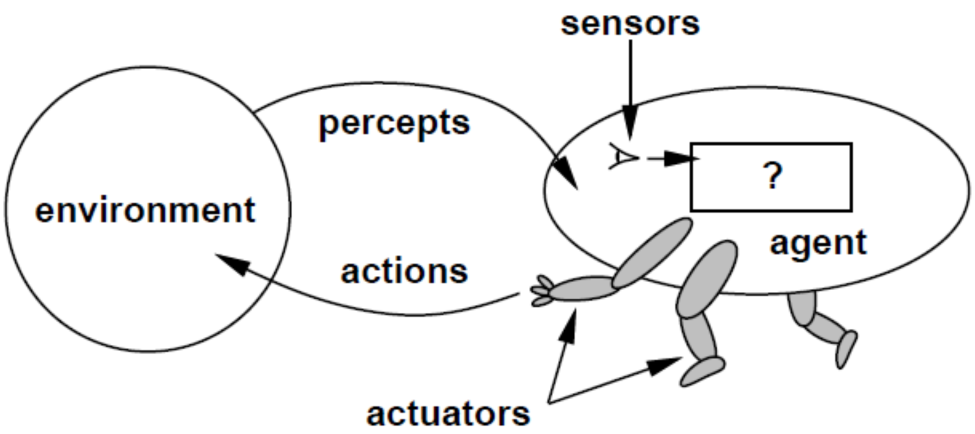
Chapter 2: Intelligent Agent

Agents

An *agent* is anything that can be viewed as

- *perceiving* its *environment* through *sensors* and
- *acting* upon that environment through *actuators*



Agents

- Agents include humans, robots, softbots,…etc
- Human agent:
  - Sensors: eyes, ears, ...
  - Actuators: hands, legs, mouth, …
- Robotic agent:
  - Sensors: cameras and infrared range finders
  - Actuators: various motors
- Software agent:
  - Sensors: keystrokes, file contents, and network packets
  - Actuators: screen, writing files, and sending network packets

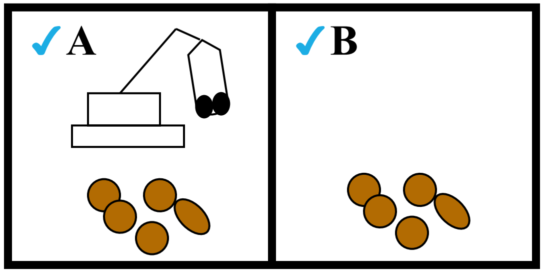
Agent function and agent program

- The agent function maps from percept histories to actions:

$$\mathcal{P}^* \rightarrow \mathcal{A}$$

- An agent program implements the agent function to run on a physical architecture.

Example: A Vacuum-cleaner agent



Percepts:location and contents, e.g. [***A, dirty]***

- *(Idealization: locations are discrete)*

Actions: ***LEFT, RIGHT, SUCK, NOP***

A Reflex Vacuum-Cleaner

```
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
```

Percept sequence	Action
$[A, Clean]$	$Right$
$[A, Dirty]$	$Suck$
$[B, Clean]$	$Left$
$[B, Dirty]$	$Suck$
$[A, Clean]$, $[A, Clean]$	$Right$
$[A, Clean]$, $[A, Dirty]$	$Suck$
⋮	⋮

Rationality

Rationality depends on:

- Performance measure
- Agent's (prior) knowledge
- Agent's percepts to date
- Available actions

- **Rational Agent Definition**

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.

Rational Agent

- Rational agent maximizes the expected utility.
- We take the expectation of the utility due to uncertainty in environment (stochastic and partially-observable).

Rational Agent

- Consider the simple vaccum cleaner that cleans a square if it is dirty and moves to the other square if not. Is it rational?
  - It depends!
- Assume that there is a penalty of one point for each movement left or right, is the this simple cleaner rational?
  - No, it would performs poorly as it oscillates between right and left locations after cleaning them.
- What if clean squares can become dirty again?
  - The agent should occasionally check and re-clean them if needed.

Rationality versus Omniscience

- A rational agent chooses whichever action maximizes the expected value of the performance measure given the percept sequence to date
- Rational ≠ omniscient
- An omniscient agent knows the actual outcomes of actions and acts accordingly.
- Rationality does not mean perfection!
- Rationality maximizes the *expected* performance, while perfection maximizes the *actual* performance.

Learning and autonomy

- An agent can learn from what it perceives.
- A rational agent should be autonomous—it should learn what it can to compensate for partial or incorrect prior knowledge.
- For example, a vacuum-cleaning agent that learns to forecast where and when additional dirt will appear will do better than one that does not

Task environment

To design a rational agent we need to specify a *task environment*

- a problem specification for which the agent is a solution

PEAS: ***to* specify a task environment**

- ***P***erformance measure
- ***E***nvironment
- ***A***ctuators
- ***S***ensors

PEAS: Specifying an automated taxi driver

Performance measure:

- ?

Environment:

- ?

Actuators:

- ?

Sensors:

- ?

PEAS: Specifying an automated taxi driver

_P_erformance measure:

- safety, speed, legal, comfortable, maximize profits

_E_nvironment:

- ?

_A_ctuators:

- ?

_S_ensors:

- ?

PEAS: Specifying an automated taxi driver

Performance measure:

- safe, fast, legal, comfortable, maximize profits

Environment:

- roads, other traffic, pedestrians, customers

Actuators:

- ?

Sensors:

- ?

PEAS: Specifying an automated taxi driver

Performance measure:

- safe, fast, legal, comfortable, maximize profits

Environment:

- roads, other traffic, pedestrians, customers

Actuators:

- steering, accelerator, brake, signal, horn

Sensors:

- ?

PEAS: Specifying an automated taxi driver

Performance measure:

- safe, fast, legal, comfortable, maximize profits

Environment:

- roads, other traffic, pedestrians, customers

Actuators:

- steering, accelerator, brake, signal, horn

Sensors:

- cameras, sonar, speedometer, GPS

PEAS: Internet Shopping Agent

- Performance measure: price, quality, appropriateness, efficiency
- Environment: current and future WWW sites, vendors, shippers
- Actuators: display to user, follow URL, fill in form
- Sensors: HTML pages (text, graphics, scripts)

PEAS: Spam Filtering Agent

- Performance measure: false positives, false negatives
- Environment: email client or server
- Actuators: mark as spam, delete,…
- Sensors: emails , traffic, etc.

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.

- Deterministic (vs. stochastic): The **next state** of the environment is **completely determined by the current state** and the **action** executed by the agent.
- In a fully-observable and deterministic environment the agent need not deal with uncertainty.

- Episodic (vs. sequential): An episodic environment means that **subsequent episodes do not depend on what actions occurred in previous episodes**. Such environments do not require the agent to plan ahead.

Environment Types

- Static (vs. dynamic): **An environment which does not change** while the agent is thinking is static.
- In a static environment the agent need not worry about the passage of time while he is thinking, nor does he have to observe the world while he is thinking.
- In static environments the time it takes to compute a good strategy does not matter.

- If the environment itself does not change with the passage of time but the agent's performance score does, then we say the environment is **semi-dynamic**.

Environment Types

Discrete (vs. continuous): : If the number of **distinct percepts and actions is limited the environment is discrete**, otherwise it is continuous.

Single agent (vs. multi-agent): An agent operating by itself in an environment.

○ If more than one agent exists consider cooperation, coordination, competition, communication or random behavior.

What’s the real world like?

Environment Types

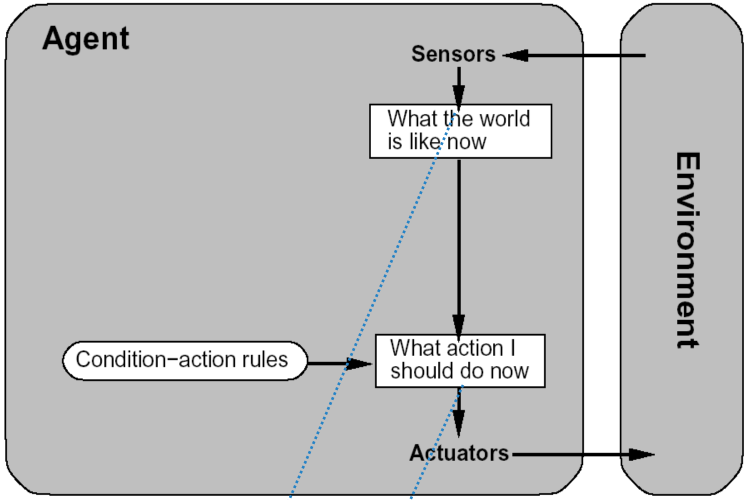
	Crossword puzzle	Back-gammon	Part-picking Robot	Taxi
Fully-Observable	✓	✓	✗	✗
Deterministic	✓	✗	✗	✗
Episodic	✗	✗	✓	✗
Static	✓	✓	✗	✗
Discrete	✓	✓	✗	✗
Single-Agent	✓	✗	✓	✗

- The environment type largely determines the agent design
- The real world is partially observable, stochastic, sequential, dynamic, continuous, multi-agent

Agent Structure

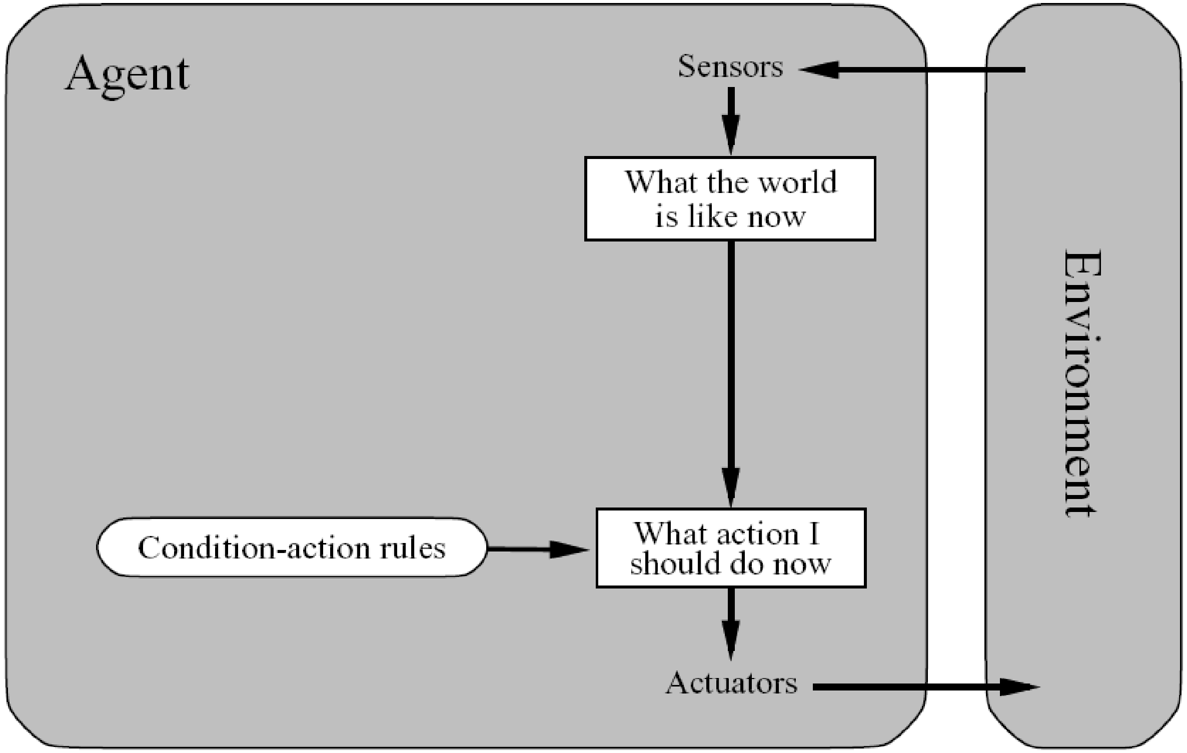
- Agent= Architecture+ Program
- The job of AI is to design the agent program that implements the agent function mapping percepts to actions.

Simple reflex agent



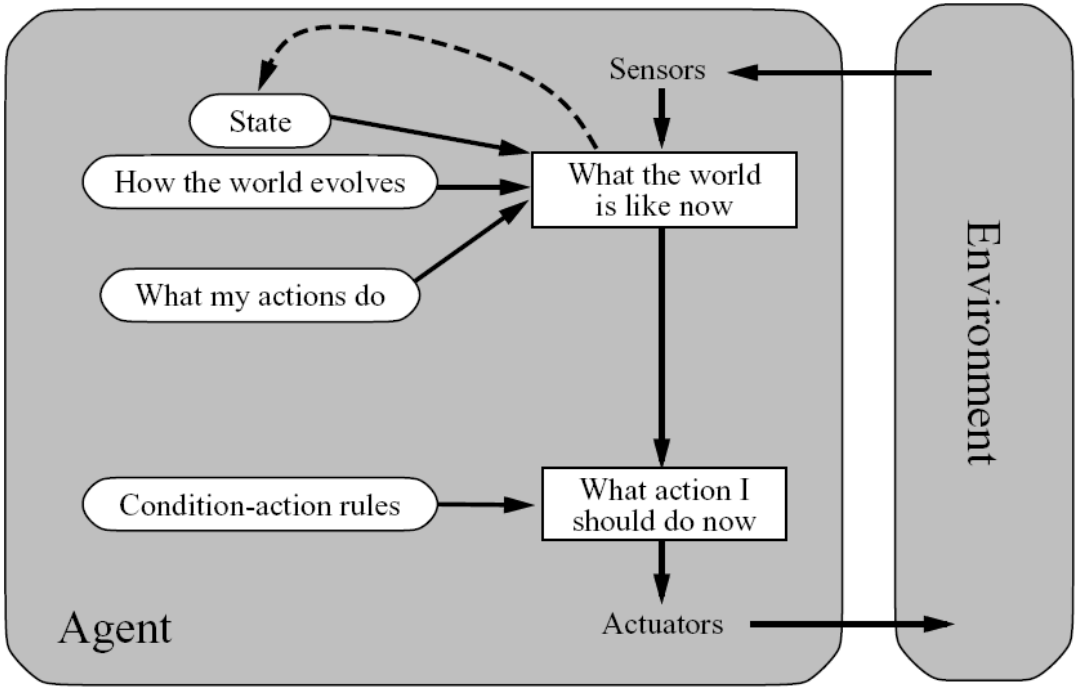
```
✓   function REFLEX_VACUUM_AGENT( percept )
✓           returns an action

✓           (location,status) = UPDATE_STATE( percept )

✓           if status = DIRTY then return SUCK;
✓           else if location = A then return RIGHT;
✓           else if location = B then return  LEFT;
```

Simple Reflex Agents



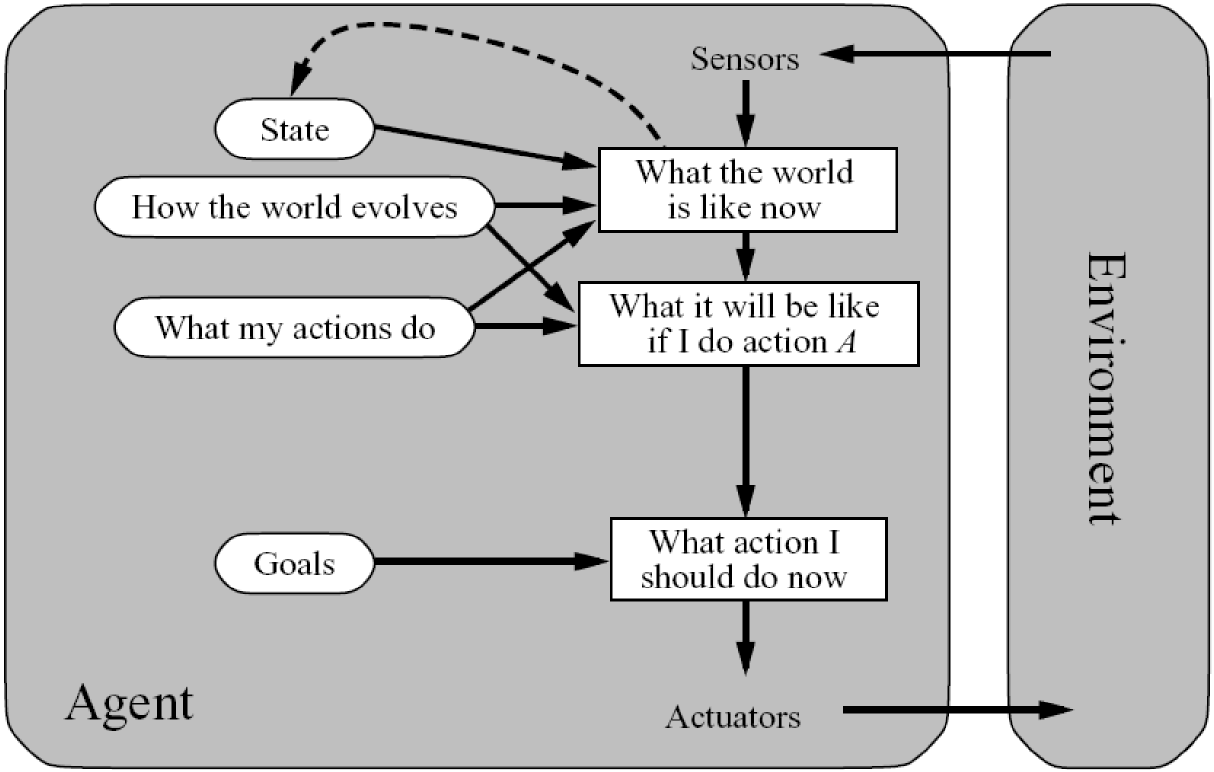
What is the problem of this design?

Reflex Agents with State (Model)



- Can handle partially observable environments.
- By keeping an internal state of the world (a model of the world) defining how the world evolves. Not exactly (uncertainty/inference).

Goal-Based Agents

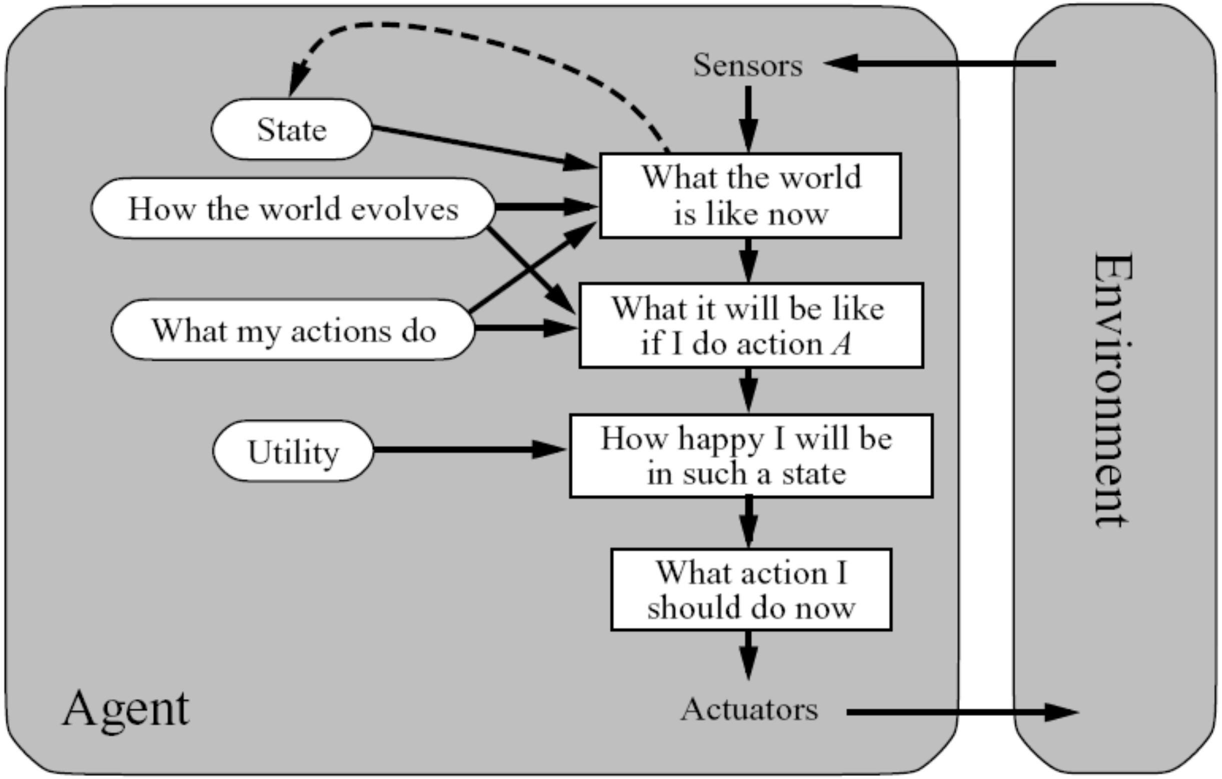


Goal-Based Agents

- Embed the goal info describing the agent desirable behavior.
- These agents usually first find plans then execute them.
- Examples: Search (Ch3-5) and planning (Ch10)

- More adaptive to different environments than reflex agents.

Utility-Based Agents

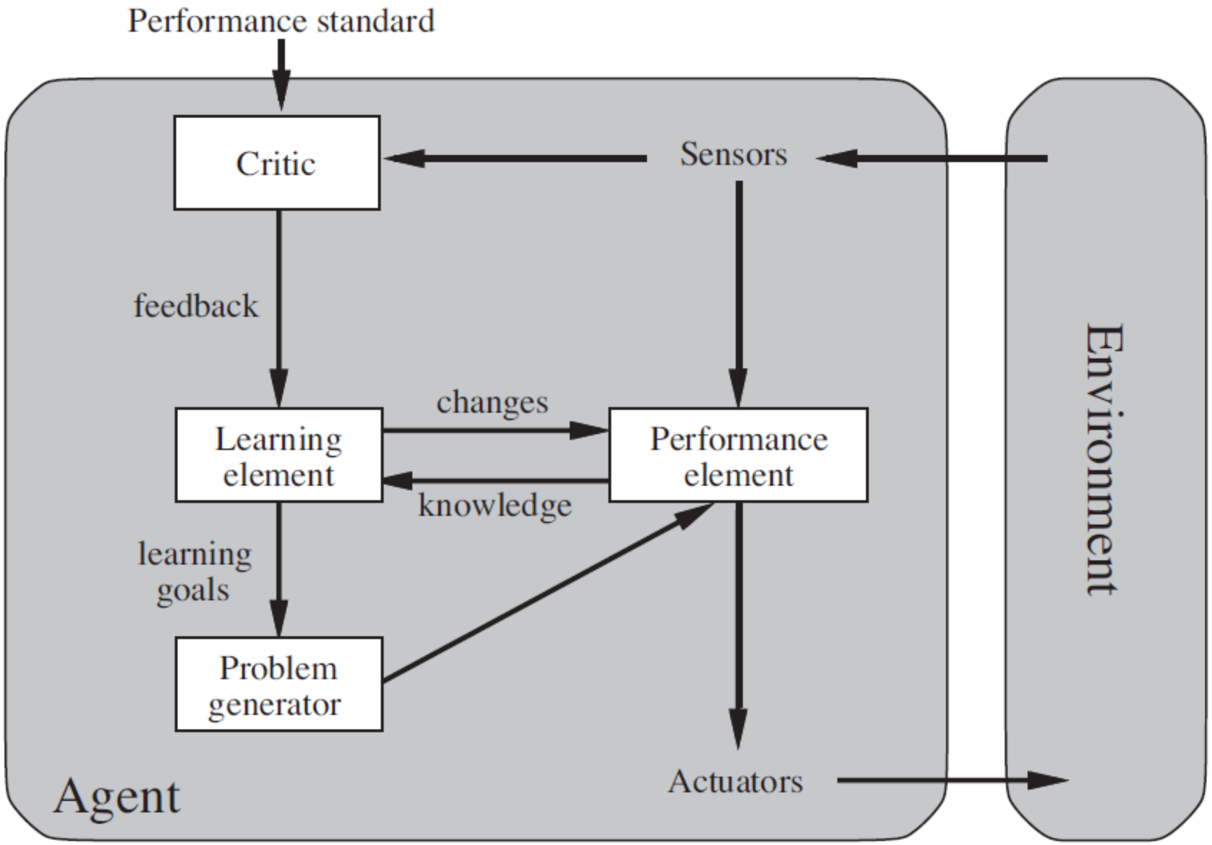

Sensors
State
How the world evolves
What my actions do
Utility
What the world is like now
What it will be like if I do action *A*
How happy I will be in such a state
What action I should do now
Actuators
Agent
Environment

- **How is this different from a goal-based agent?**

Utility-Based Agents (cont.)

- Goals alone are not enough to generate high-quality behavior in most environments
- The utility defines performance measure.
- Can combine multiple goals into a single utility function and can weight them according to their importance.
- For example: The auto driver agent, which way is safer/quicker.
- Simple and complex decisions (Ch16,17)

Learning Agent



Learning Agent

- The learning agent allows the agent to operate in initially unknown environments and it can adapt to different environments as well.
- The components of the learning agent:
  - **Learning element:** it improves the agent’s performance
  - P**erformance element**: it takes in percepts and decides on actions. (Agent itself in the previous structures)
  - **Critic:** It gives feedback to the learning element on how the agent is doing and determines how the performance element should be modified to do better in the future
  - **Problem generator**. It suggests actions that will lead to new and informative experiences. (exploration)

Summary

- Agents interact with environments through actuators and sensors
  - The agent function describes what the agent does in all circumstances
  - The agent program implements the agent function

- A rational agent maximizes expected performance
- PEAS descriptions define task environments
- Environments are categorized along several dimensions:
  - Observable? Deterministic? Episodic? Static? Discrete? Single-agent?
- Agent program types:
  - Simple reflex, model-based agents, reflex agents, goal-based agents, utility based agents, and learning agents