# Agent Architectures

## Introduction to Artificial Intelligence

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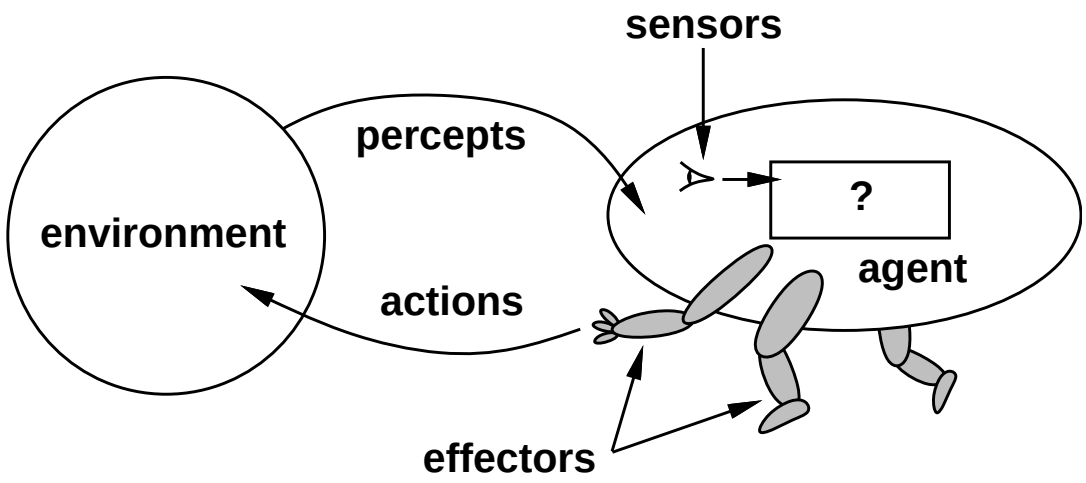
# Architecture of Rational Agents




- The agent perceives the environment and
- acts according to a *performance criteria*.

Note: Performance criteria are domain dependent.

# Example: Autonomous Vacuum Cleaner

Possible performance criteria:

- $m^2$ per hour
- how clean is the room after vacuuming
- power consumption
- noise emission
- security (e.g. does not run over babys)

Note: Optimality often impossible

- not all relevant information available
- computational cost may be too high

# Ideal Rational Agent 1

Acting rationally depends on

- Performance measure
- Percept sequence
- World knowledge
- possible actions

Ideal rational agent:

> *The agent chooses an action which maximizes its performance for a given percept sequence and knowledge about the world.*

Active sensing necessary to avoid trivialization, e.g.

Crossing a road requires looking to the left and right.

# Ideal Rational Agent 2

Ideal mapping

$$\text{Percept Sequences} \times \text{World Knowledge} \longrightarrow \text{Actions}$$

Normally not representable as a table, often not necessary, e.g. Square-Root Agent:

| Percept $x$ | Action $z$ |
|---|---|
| 1.0 | 1.000000000000000 |
| 1.1 | 1.048808848170152 |
| 1.2 | 1.095445115010332 |
| 1.3 | 1.140175425099138 |
| 1.4 | 1.183215956619923 |
| 1.5 | 1.224744871391589 |
| 1.6 | 1.264911064067352 |
| 1.7 | 1.303840481040530 |
| 1.8 | 1.341640786499874 |
| 1.9 | 1.378404875209022 |
| ⋮ | ⋮ |

**function** SQRT($x$)
  $z \leftarrow 1.0$ /* *initial guess* */
  **repeat until** $|z^2 - x| < 10^{-15}$
    $z \leftarrow z - (z^2 - x)/(2z)$
  **end**
  **return** $z$

# Categorization of Agents

4 kinds: Percepts, Actions, Goals, Environment

| Agent Type | Percepts | Actions | Goals | Environment |
|---|---|---|---|---|
| Medical diagnosis system | Symptoms, findings, patient's answers | Questions, tests, treatments | Healthy patient, minimize costs | Patient, hospital |
| Satellite image analysis system | Pixels of varying intensity, color | Print a categorization of scene | Correct categorization | Images from orbiting satellite |
| Part-picking robot | Pixels of varying intensity | Pick up parts and sort into bins | Place parts in correct bins | Conveyor belt with parts |
| Refinery controller | Temperature, pressure readings | Open, close valves; adjust temperature | Maximize purity, yield, safety | Refinery |
| Interactive English tutor | Typed words | Print exercises, suggestions, corrections | Maximize student's score on test | Set of students |

# A Basic Agent Program

**function** SKELETON-AGENT( *percept*) **returns** action
  **static**: *memory*, the agent's memory of the world

  *memory* ← UPDATE-MEMORY(*memory*, *percept*)
  *action* ← CHOOSE-BEST-ACTION(*memory*)
  *memory* ← UPDATE-MEMORY(*memory*, *action*)
  **return** *action*

# A Table-Lookup Agent

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

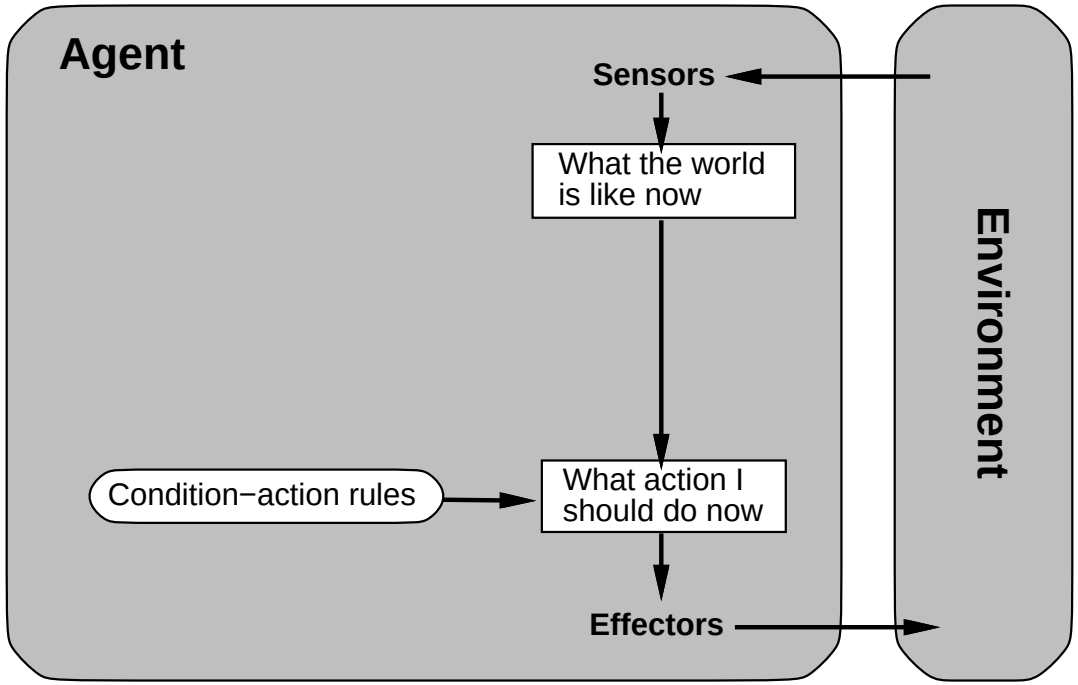
  append *percept* to the end of *percepts*
  *action* ← LOOKUP( *percepts*, *table*)
  **return** *action*

Why is this a bad idea in general?

e.g Chess: about $35^{100}$ table entries

- too complex (memory)
- too inflexible

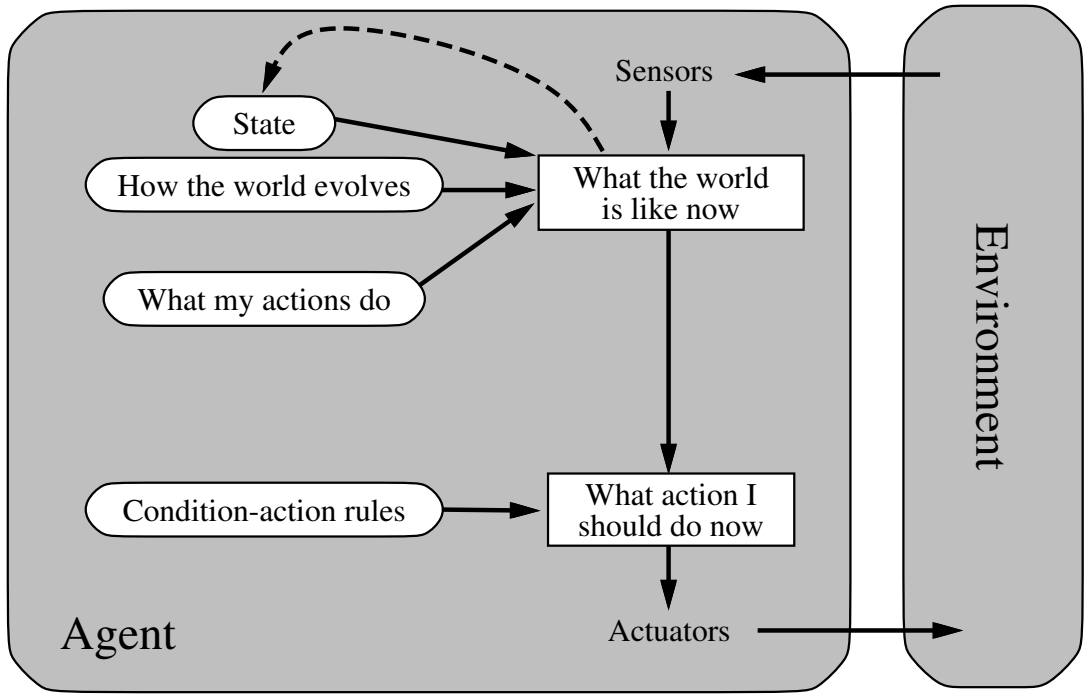
# Reflexive Agents




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

*state* ← INTERPRET-INPUT(*percept*)
*rule* ← RULE-MATCH(*state*, *rules*)
*action* ← RULE-ACTION[*rule*]
**return** *action*

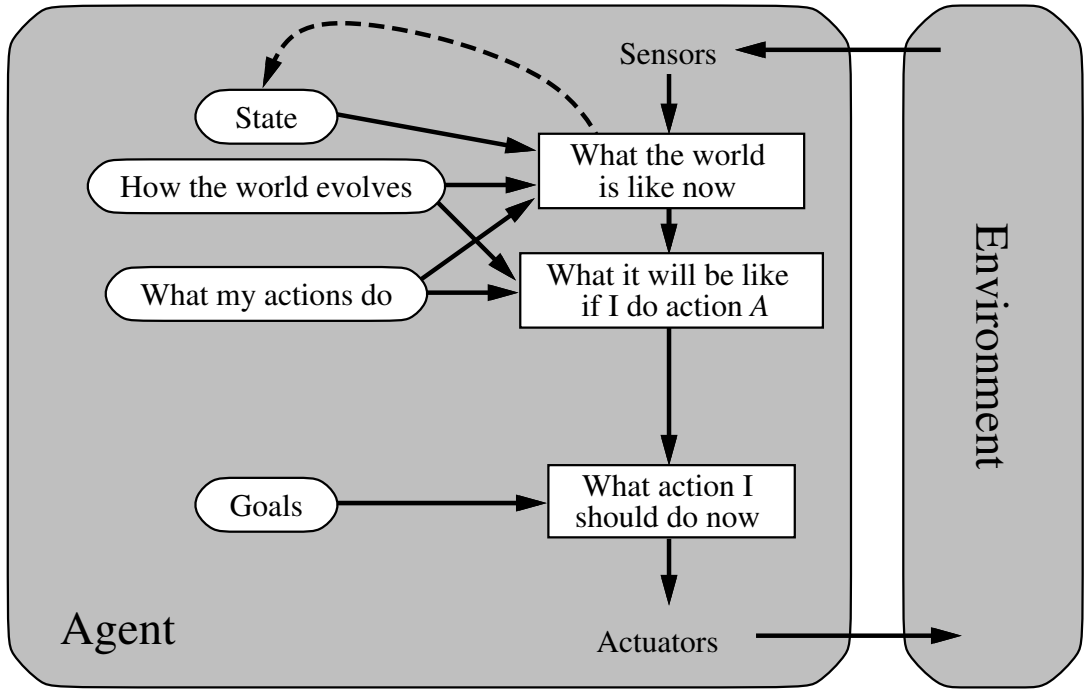
# Agents with an Internal World Model



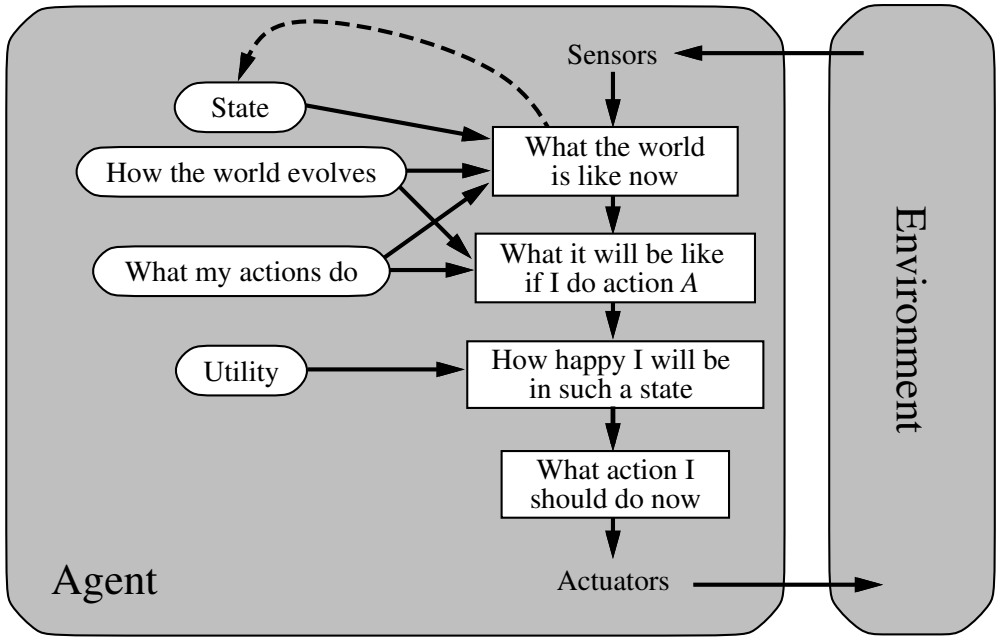

**function** REFLEX-AGENT-WITH-STATE(*percept*) **returns** *action*
  **static**: *state*, a description of the current world state
    *rules*, a set of condition-action rules

  *state* ← UPDATE-STATE(*state*, *percept*)
  *rule* ← RULE-MATCH(*state*, *rules*)
  *action* ← RULE-ACTION[*rule*]
  *state* ← UPDATE-STATE(*state*, *action*)
  **return** *action*

# Agents with explicit goals

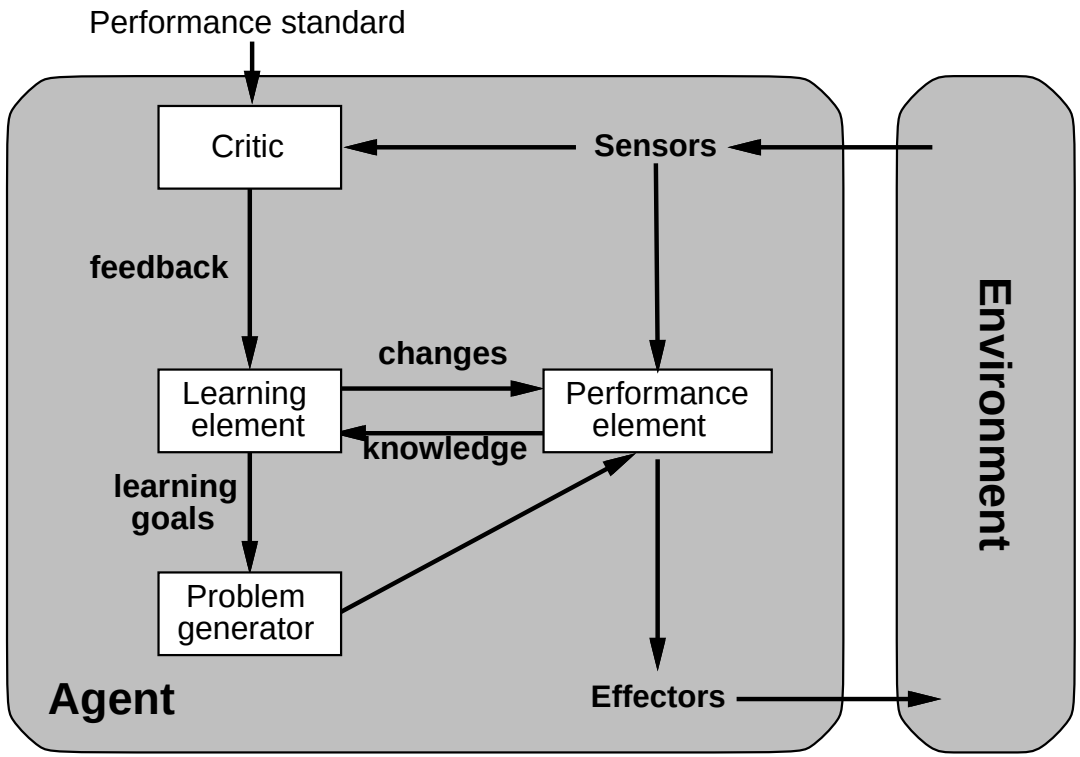


# Utility-based Agents



# Learning Agents

The goal of learning: Optimize future behavior on the basis of the history of percepts, actions, and knowledge about the world.




Performance Element: Agent in the old sense.
Critic: Tells the system how good or bad it is performing.
Learning Element: Improves the system.
Problem Generator: Suggests actions to test performance.

# Properties of Environments

- accessible vs. nonaccessible
  Are all relevant aspects of the world accessible to the sensors?
- deterministic vs. nondeterministic/stochastic
  Does the next state depend completely on the current state and the action chosen.
- episodic vs. nonepisodic
  Does the choice of an action depend only on the current state or also on the past?
- static vs. dynamic
  Can the world change while deciding on the next action?
- discrete vs. continuous
  Is the world discrete (as in chess) or not (mobile robots)?

# Example Environments

| Environment | Accessible | Deterministic | Episodic | Static | Discrete |
|---|---|---|---|---|---|
| Chess with a clock | Yes | Yes | No | Semi | Yes |
| Chess without a clock | Yes | Yes | No | Yes | Yes |
| Poker | No | No | No | Yes | Yes |
| Backgammon | Yes | No | No | Yes | Yes |
| Taxi driving | No | No | No | No | No |
| Medical diagnosis system | No | No | No | No | No |
| Image-analysis system | Yes | Yes | Yes | Semi | No |
| Part-picking robot | No | No | Yes | No | No |
| Refinery controller | No | No | No | No | No |
| Interactive English tutor | No | No | No | No | Yes |