Intelligent Agent

LESSON 1

Reading

Chapter 1

Chapter 2

Outline

- What is AI?
- Agents and environments
- Rationality
- PEAS (Performance measure, Environment, Actuators, Sensors)
- Environment types
- Agent types

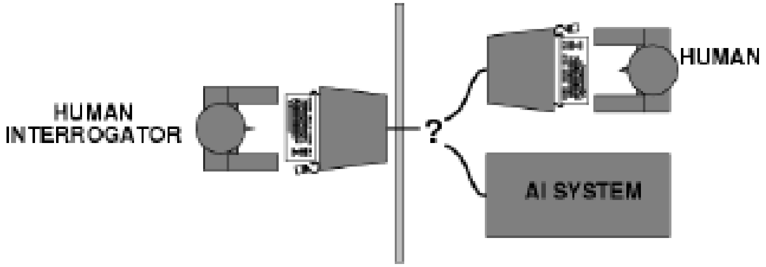
What is AI?
Views of AI fall into four categories

Thinking humanly	Thinking rationally
Acting humanly	Acting rationally

- The textbook advocates “acting rationally”

Acting humanly: Turing test

- Turing (1950) "Computing machinery and intelligence":
- "Can machines think?" -> "Can machines behave intelligently?"
- Operational test for intelligent behavior: the Imitation Game



- Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes
- Anticipated all major arguments against AI in following 50 years
- uggested major components of AI: knowledge, reasoning, language understanding, learning

Thinking humanly: cognitive modeling

- 1960s "cognitive revolution": information processing psychology
- Requires scientific theories of internal activities of the brain
  - How to validate? Requires

    1) Predicting and testing behavior of human subjects (topdown)

    or 2) Direct identification from neurological data (bottomup)
- Both approaches (roughly, Cognitive Science and Cognitive Neuroscience) are now distinct from AI

Thinking rationally: "laws of thought"

- Aristotle: what are correct arguments/thought processes?
- Several Greek schools developed various forms of *logic*: *notation* and *rules of derivation* for thoughts; may or may not have proceeded to the idea of mechanization
- Direct line through mathematics and philosophy to modern AI
- Problems:
  1. Not all intelligent behavior is mediated by logical deliberation
  2. What is the purpose of thinking? What thoughts should I have?

Acting rationally: rational agent

- Rational behavior: doing the right thing
- The right thing: that which is expected to maximize goal achievement, given the available information
- Doesn't necessarily involve thinking – e.g., blinking reflex – but thinking should be in the service of rational action

Rational agents

- An agent is an entity that perceives and acts
- This course is about designing rational agents
- Abstractly, an agent is a function from percept histories to actions:

  [*f*: P* -> A]

- For any given class of environments and tasks, we seek the agent (or class of agents) with the
- best performance
- Caveat: computational limitations make perfect rationality unachievable design best program for given machine resources

AI prehistory

Philosophy	Logic, methods of reasoning, mind as physical system foundations of learning, language, Rationality
Mathematics	Formal representation and proof algorithms, computation, (un)decidability, (in)tractability, probability
Economics	utility, decision theory
Neuroscience	physical substrate for mental activity
Psychology	phenomena of perception and motor control, experimental techniques
Computer engineering	building fast computers
Control theory	design systems that maximize an objective function over time
Linguistics	knowledge representation, grammar

Abridged history of AI

1943 McCulloch & Pitts: Boolean circuit model of brain

1950 Turing's "Computing Machinery and Intelligence"

1956 Dartmouth meeting: "Artificial Intelligence" adopted

1952–69 Look, Ma, no hands!

1950s Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine

1965 Robinson's complete algorithm for logical reasoning

Neural network research almost disappears

1969–79 Early development of knowledge-based systems

1980– AI becomes an industry

1986– Neural networks return to popularity

1987– AI becomes a science

1995– The emergence of intelligent agents

2001– The availability of very large data sets

State of the art

- Robotic vehicles can drive autonomously in most situations (95%). CMU's BOSS can drive through an urban environment, following traffic rules and avoiding pedestrians.
- Customers can call United Airlines to book flights, or use Google Voice to translate their native speech into other languages
- Deep Blue beat the world-reigning chessmaster Gary Kasparov in 1997, and computers have continued to convincingly beat humans in recent years.
- Learning algorithms help to classify spam mail, helping all email users save time, sorting out over 80-90% of mail as spam traffic.
- Both military and commercial sectors employ AI to handle logistics.Aircraft routing and convoy logistics A.I. are used to coordinate the movement of massive numbers of supplies and units according to constraints

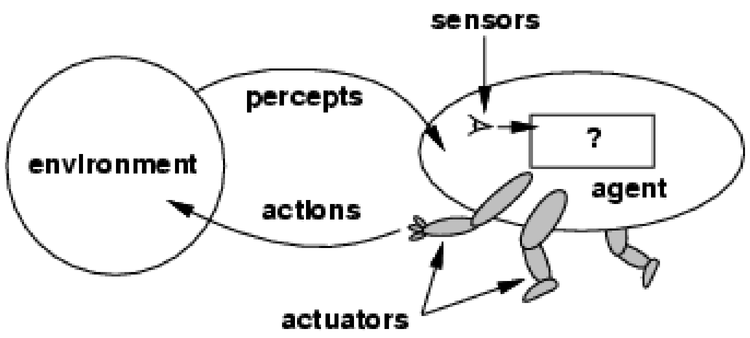
Agents

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

- Human agent: eyes, ears, and other organs for sensors; hands, legs, mouth, and other body parts for actuators

- Robotic agent: cameras and infrared range finders for sensors; various motors for actuators

Agents and environments



- The agent function maps from percept histories to actions:

[f: P* -> A]

- The agent program runs on the physical architecture to produce f

Agent = architechture + program

Vacuum-learner word

- Percepts: location and contents, e.g.,

[A,Dirty]

- Actions: *Left*, *Right*, *Suck*, *NoOp*

A vacuum-learner agent

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

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
- E.g., performance measure of a vacuum-cleaner agent could be amount of dirt cleaned up, amount of time taken, amount of electricity consumed, amount of noise generated, etc.

Rational agents

Rational Agent: 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 agents

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

PEAS

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

PEAS

- Must first specify the setting for intelligent agent design
- Consider, e.g., the task of designing an automated taxi driver:
  - Performance measure: Safe, fast, legal, comfortable trip, maximize profits
  - Environment: Roads, other traffic, pedestrians, customers
  - Actuators: Steering wheel, accelerator, brake, signal, horn
  - Sensors: Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard

PEAS

- Agent: Medical diagnosis system
  - Performance measure: Healthy patient, minimize costs, lawsuits
  - Environment: Patient, hospital, staff
  - Actuators: Screen display (questions, tests, diagnoses, treatments, referrals)
  - Sensors: Keyboard (entry of symptoms, findings, patient's answers)

PEAS

- Agent: Part-picking robot
  - Performance measure: Percentage of parts in correct bins
  - Environment: Conveyor belt with parts, bins
  - Actuators: Jointed arm and hand
  - Sensors: Camera, joint angle sensors

PEAS

- Agent: Interactive English tutor
  - Performance measure: Maximize student's score on test
  - Environment: Set of students
  - Actuators: Screen display (exercises, suggestions, corrections)
  - Sensors: Keyboard

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. (If the environment is deterministic except for the actions of other agents, then the environment is strategic)
- **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 **semidynamic** if the environment itself does not change with the passage of time but the agent's performance score does)
- **Discrete** (vs. continuous): A limited number of distinct, clearly defined percepts and actions.
- **Single agent** (vs. multiagent): An agent operating by itself in an environment.

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
- The real world is (of course) partially observable, stochastic, sequential, dynamic, continuous, multi-agent

Agent functions and programs

- An agent is completely specified by the agent function mapping percept sequences to actions
- One agent function (or a small equivalence class) is rational
- Aim: find a way to implement the rational agent function concisely

Table-lookup agent

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

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

Drawbacks:

- Huge table
- Take a long time to build the table
- No autonomy
- Even with learning, need a long time to learn the table entries

Agent program for a vacuum-cleaner agent

function REFLEX-VACUUM-AGENT([*location*, *status*]) **returns** an action

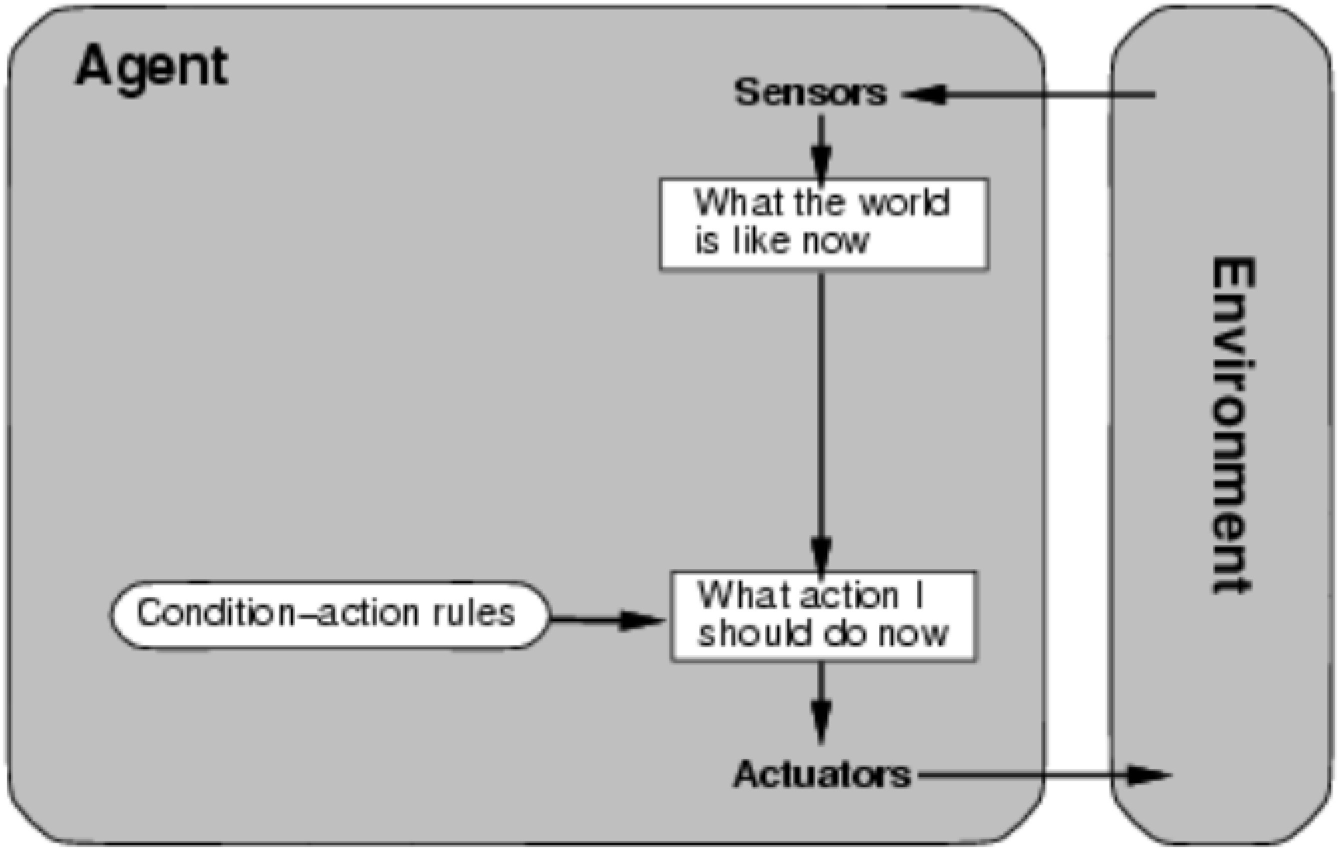
  if $status = Dirty$ **then return** *Suck*
  else if $location = A$ **then return** *Right*
  else if $location = B$ **then return** *Left*

Agent types

Four basic types in order of increasing generality:

- Simple reflex agents
- Model-based reflex agents
- Goal-based agents
- Utility-based agents

Simple reflex agents

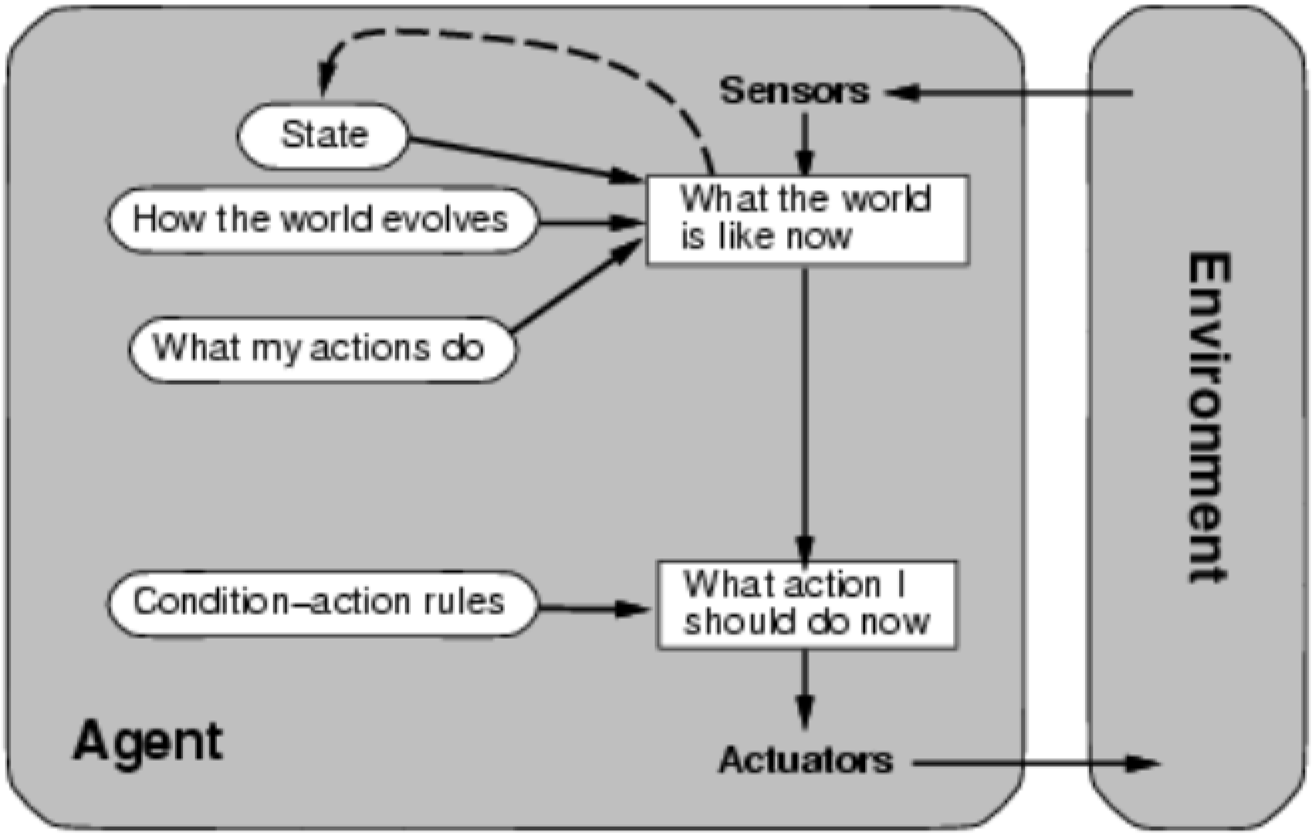


Simple reflex agents

```
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
```

Model-based reflex agents

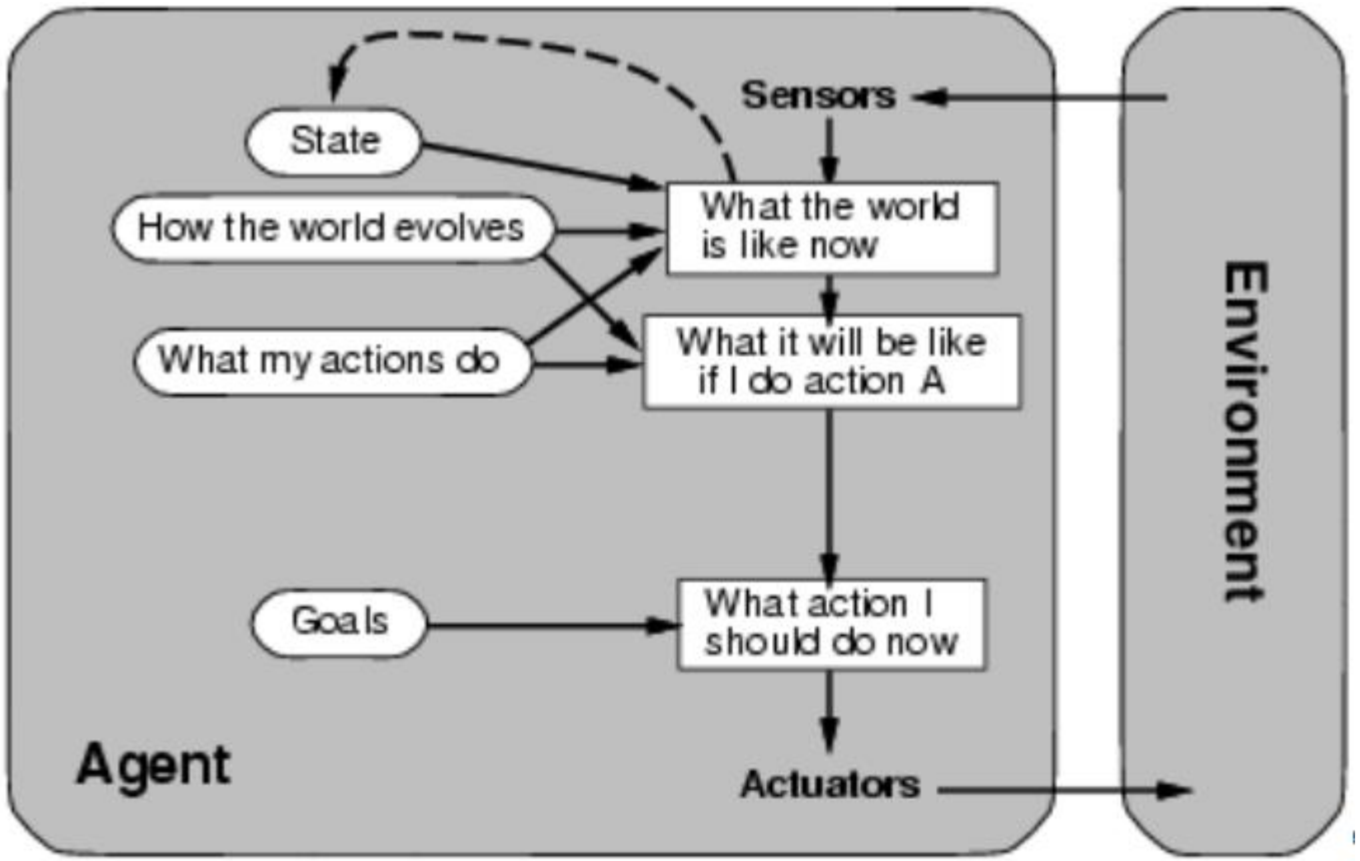


Model-based reflex agents

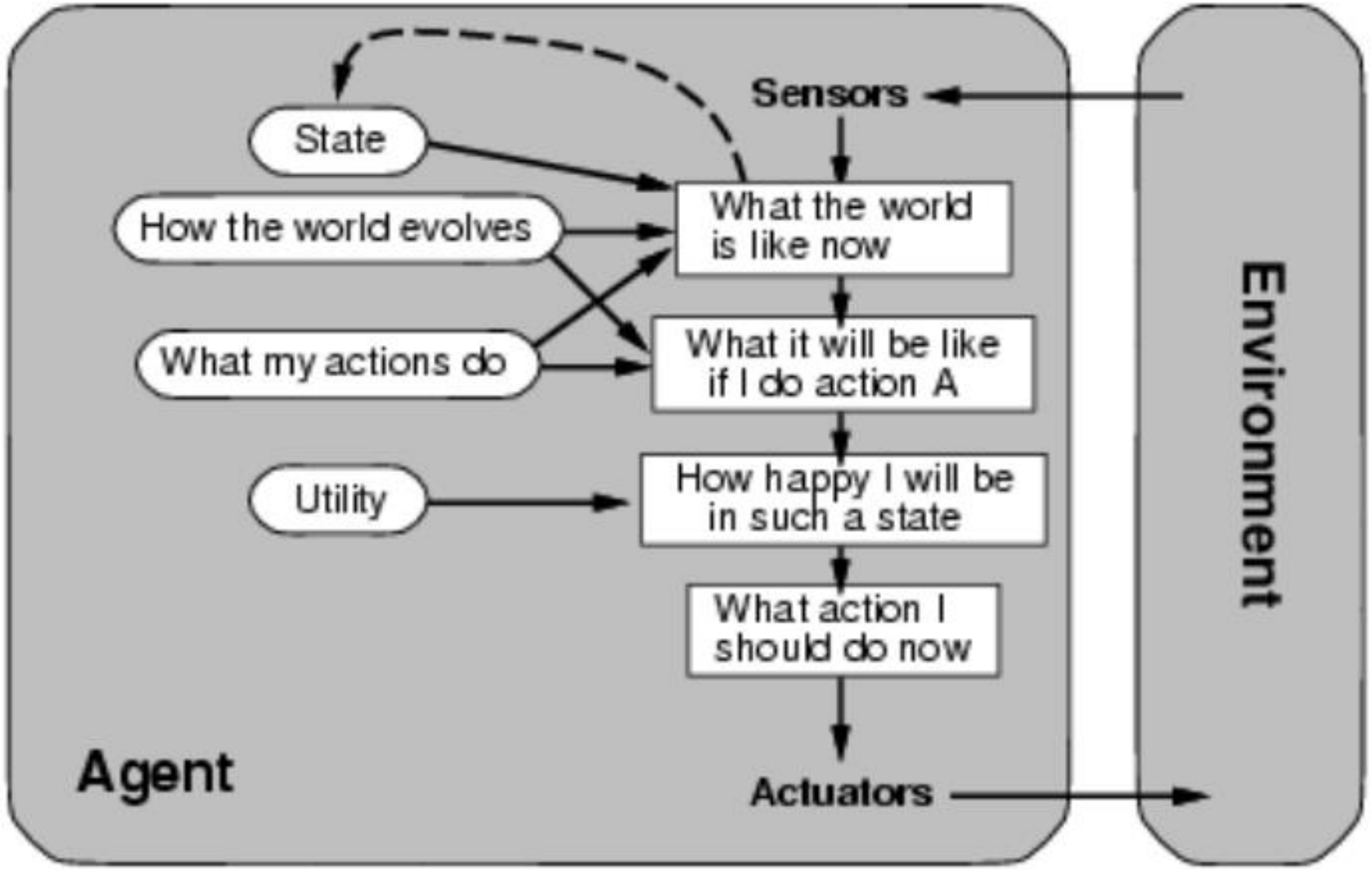
```
function REFLEX-AGENT-WITH-STATE(percept) returns action
    static: state, a description of the current world state
            rules, a set of condition-action rules
            action, the most recent action, initially none

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

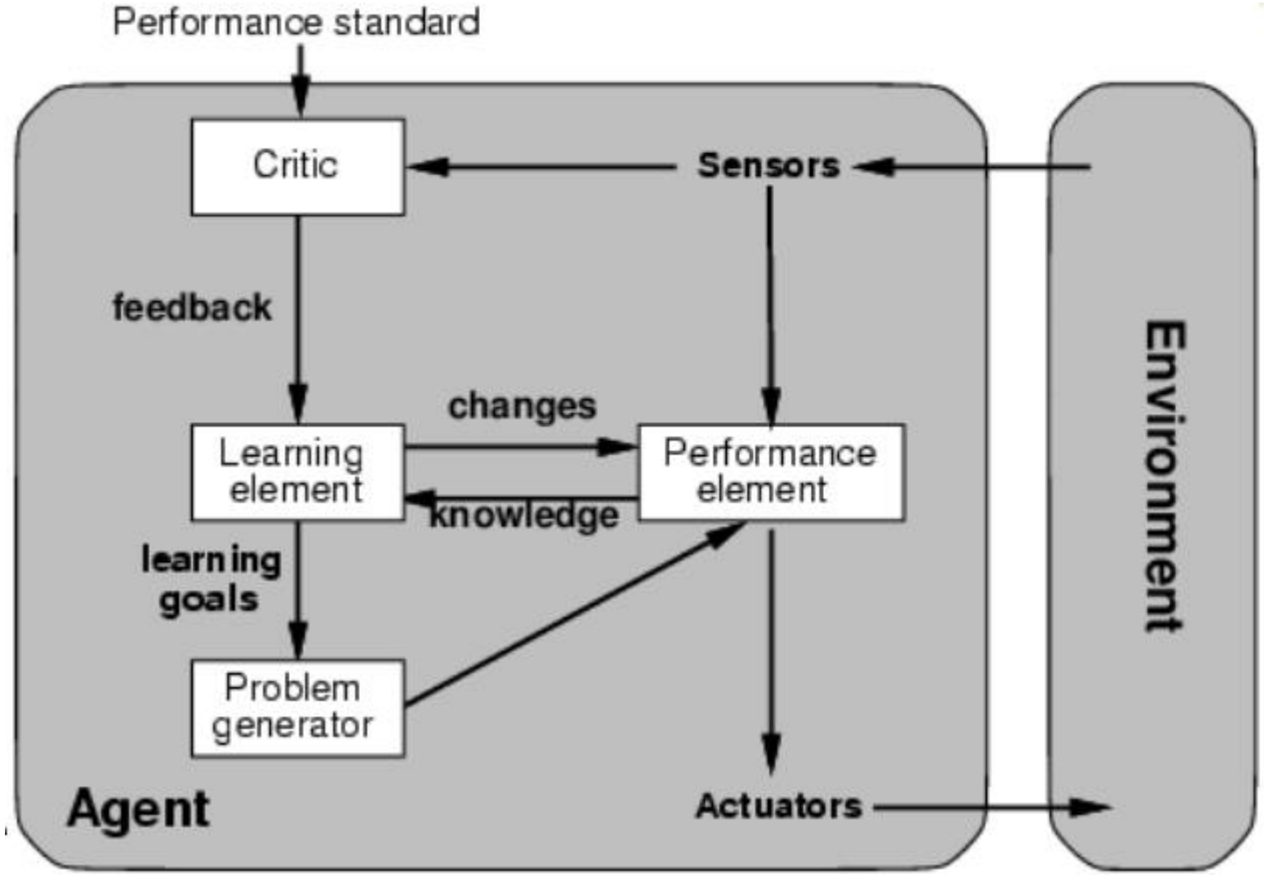
Goal-based agents



Utility-based agents



Learning agents



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