① internet definition

★ ② my notes

③ other notes by Niccolò Brandizzi

Agents in Artificial Intelligence

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In this tutorial, we are going to discuss agents in Artificial Intelligence. An AI system contains an agent and its environment. An intelligent agent is a **software entity** that enables artificial intelligence to take action. Intelligent agent senses the environment and uses actuators to initiate action and conducts operations in the place of users. Or simply an **Intelligent Agent (IA) is an entity that makes decisions**.

What is an agent?

Anything that recognizes the environment through **sensors** and acts upon the environment initiated through **actuators** is called **AGENTS**. An agent performs the tasks of recognition, thinking, and acting cyclically. An agent can be:

- **Human-Agent**: eyes, ears, and other organs as sensors and hand, legs, vocal track as actuators.
- **Robotic Agent**: cameras, infrared range finder, sensors, and various motors
- **Software Agent**: Set of programs designed for particular tasks like checking the contents of received emails and grouping them as junk, important, very important.

What is an intelligent agent?

An intelligent agent is an agent that can perform specific, predictable, and repetitive tasks for applications with some level of individualism. These agents can learn while performing tasks. These agents are with some human mental properties like knowledge, belief, intention, etc. A thermostat, Alexa, and Siri are examples of intelligent agents.

The main functions of intelligent agents are

- Perception: Done through sensors
- Actions: Initiated through actuators.

Four rules for an AI agent:

Rule 1: Must have the ability to recognize the environment.
Rule 2: Decisions are made from observations.
Rule 3: Decision should result in actions.
Rule 4: The action must be rational.

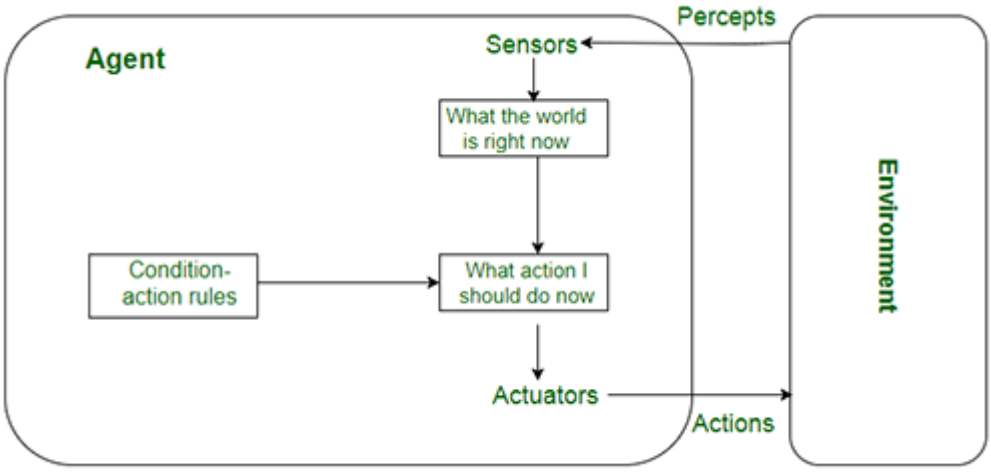
How do intelligent agents work?

Sensors, **actuators**, and **effectors** are the three main components the intelligent agents work through. Before moving into a detailed discussion, we should first know about sensors, effectors, and actuators.

Sensor: A device that detects environmental changes and sends the information to other devices. An agent observes the environment through sensors. E.g.: Camera, GPS, radar.

Actuators: Machine components that convert energy into motion. Actuators are responsible for moving and controlling a system. E.g.: electric motor, gears, rails, etc.

Percepts or inputs from the environment are received through sensors by the intelligent agent. Using this acquired information or observations this agent uses artificial intelligence to make decisions. Actuators will then trigger actions. Percept history and past actions will influence future decisions.



Characteristics of intelligent agents

- Intelligent agents have some level of individualism that allows them to perform certain tasks on their own.
- IA can learn even as tasks are carried out.
- They can make interactions with other entities like agents, humans, and systems.
- New rules can be accommodated.
- Goal-oriented habits

Structure of AI agent

The structure of an intelligent agent can be viewed as the combination of architecture and agent program

IA structure consists of three main parts:

1. **Architecture**: The machinery that the agent executes on or the devices that consist of actuators and sensors. PC, camera, etc are examples.
2. **Agent function**: It is used to map a percept to an action. Percept Sequence refers to the history of the recognized information of the intelligent agent.
3. **Agent program**: It is an implementation of the agent function. The execution of the agent program on the physical architecture produces the agent function.

F: P* → A = the agent program runs on the physical architecture to produce function f
simple agent program can be defined as an agent function that maps every possible percept to a possible action that an agent can perform.
Now we got a clear picture of what an intelligent agent is. For artificial intelligence, the actions based on logic(rational) are much important because the agent gets a positive reward for each best possible action and a negative reward for each wrong action. Now take a look at rationality and rational agents.

Rational Agent

An ideal rational agent is an agent that can perform in the best possible action and maximize the performance measure. The actions from the alternatives are selected based on:

- Percept sequence
- Built-in knowledge base

The actions of the rational agent make the agent most successful in the percept sequence given. The highest performing agents are rational agents.

RATIONALITY

Rationality defines the level of being reasonable, sensible, and having good judgment sense. It is concerned with actions and results depending on what the agent has recognized. Rationality is measured based on the following:

- Performance measure
- Prior knowledge about the environment
- Best possible actions that can be performed by an agent
- Percepts sequence

PEAS representation in AI

It is a type of model on which an AI agent works on. It is used to group similar agents. Environment, actuators, and sensors of the respective agent are considered to make performance measure by PEAS.

PEAS stands for Performance Measure, Environment, Actuator, and Sensor.

1. **Performance Measure**: The performance of each agent varies based on their percepts and the success of agents is described using the performance measure unit.
2. **Environment**: The surrounding of the agent for every instant. The environment will change with time if the respective agent is set in motion. Environments are of 5 major types:
    - Fully observable & Partially observable
    - Episodic & Sequential
    - Static & Dynamic
    - Discrete & Continuous
    - Deterministic & Stochastic
3. **Actuator**: Part of the agent which initiates the action and delivers the output of action to the environment.
4. **Sensors**: Part of the agent which takes inputs for the agent.

Example of Agents with their PEAS representation

Agent	Performance Measure	Environment	Actuators	Sensors
Vacuum Cleaner	Cleanness Efficiency Battery Life Security	Room Table Wood floor Carpet Various Obstacles	Wheels Brushes Vacuum Extractor	Camera Dirt detection sensor Cliff sensor Bump sensor Infrared wall sensor
Automated Car Drive	Comfortable trip Safety Maximum Distance	Roads Traffic Vehicles	Steering wheel Accelerator Brake Mirror	Camera GPS Odometer

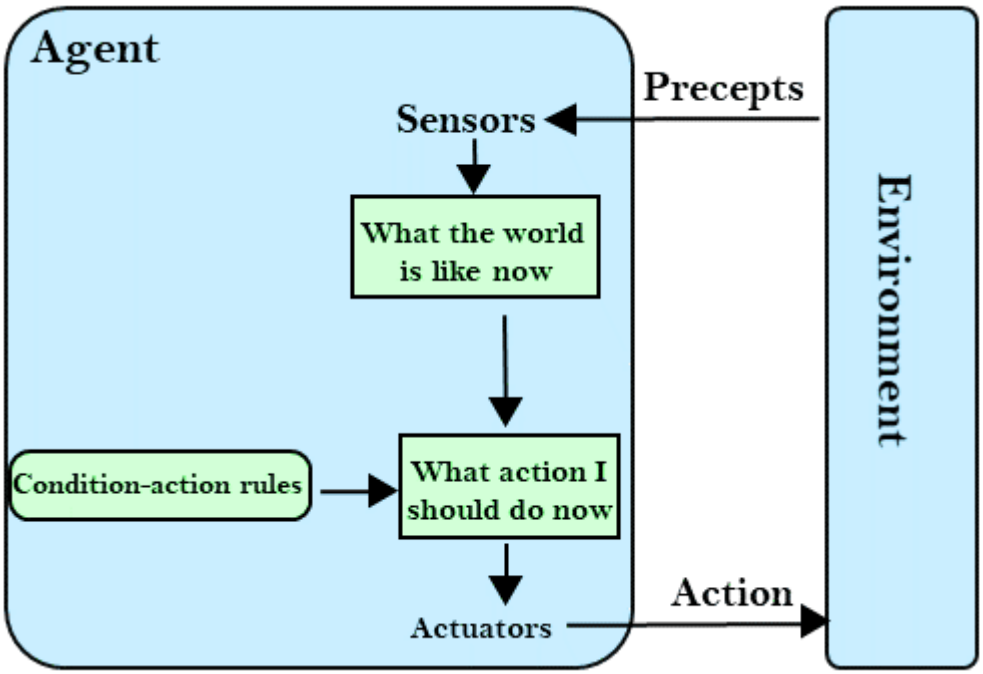
Hospital Management System	Patient's health Admission process Payment	Hospital Doctors Patients	Prescription Diagnosis Scan report	Symptoms Patient's response

Types of AI Agents

Based on the capabilities and level of perceived intelligence, intelligent agents can be grouped into five main categories.

1. Simple Reflex Agents
2. Model-Based Reflex Agents
3. Goal-Based Agents
4. Utility-Based Agents
5. Learning Agent

1. SIMPLE REFLEX AGENTS

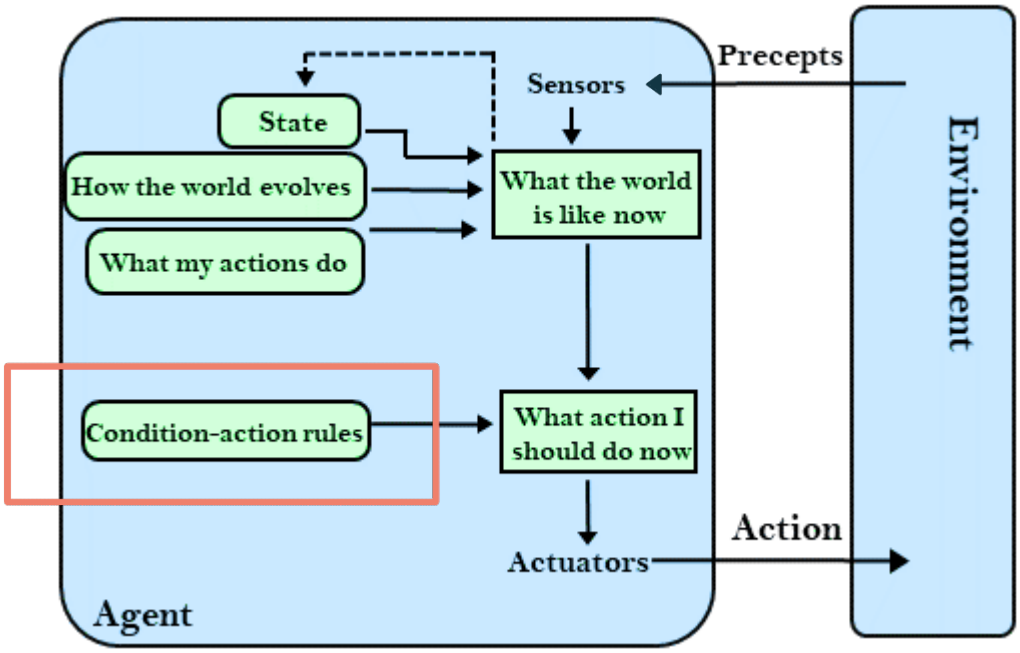


The current percept is used rather than the percept history to act by these agents. The basis for the agent function is the condition-action rule. The Condition-action rule is a rule that maps a condition to an action. (e.g.: a room cleaner agent works only if there is dirt in the room). The environment is fully observable and a fully observable environment is ideal for the success of the agent function. The challenges to the design approach of the simple reflex agent are:

- Very limited intelligence

- No knowledge of Unrecognized parts of the current state.
- Size is difficult to store.
- Environmental changes are not adaptable.

2. MODEL-BASED REFLEX AGENT



The percept history is considered by Model-based reflex agents in their actions.
These agents can still work well in an environment that is not fully observable.
They use a model of the world to choose respective actions and they maintain an internal state.

Model – understand How things are happening in the world, so it is called a model-based agent.

Internal State – The unnoticed features of the current state is represented with the percept history.

Updating the agent state requires the information about

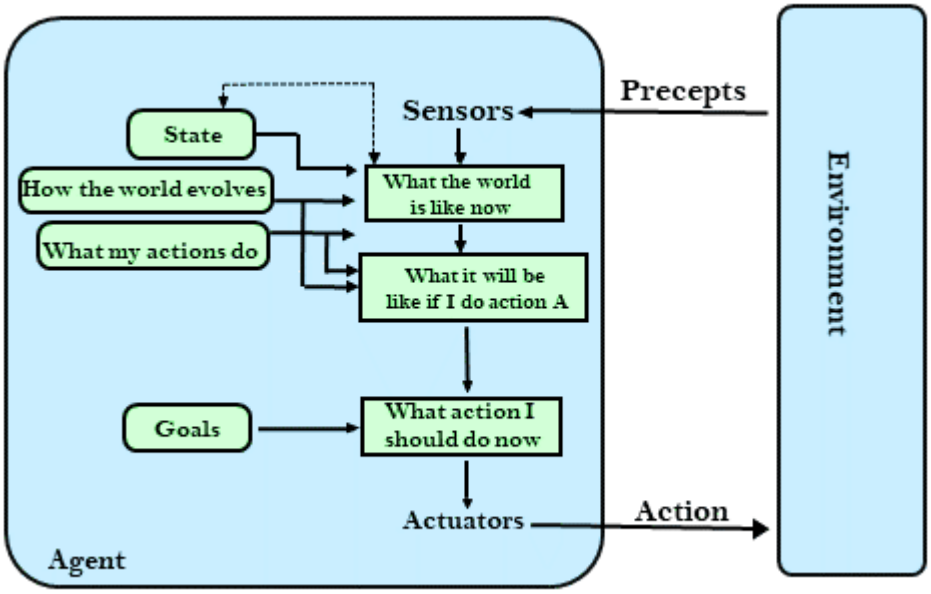
- How the world evolves.
- How the world is affected by the agent's action.

simple-reflex agents	model-based agents
• look at the environment and act accordingly	• look at the environment; • ask yourself which effects will each action have • update the model • consult the same condition-action

they still have that sort of condition-action rule set and they don't have a goal: they have a model of the world; each time they take an action they know the effects of that action on the world; the action is still taken on the basis of the condition-action rule set.

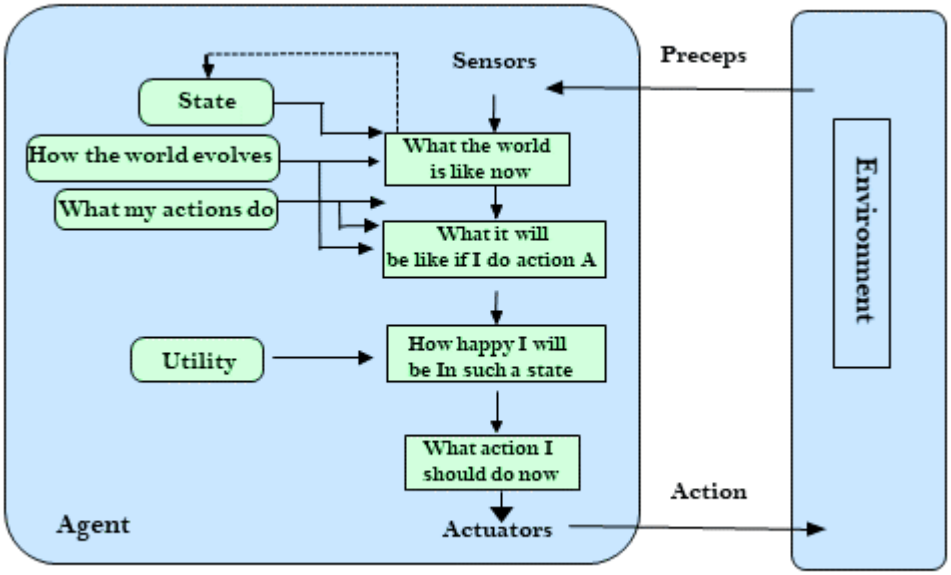
Basically we add a model of the world

3. GOAL-BASED AGENTS



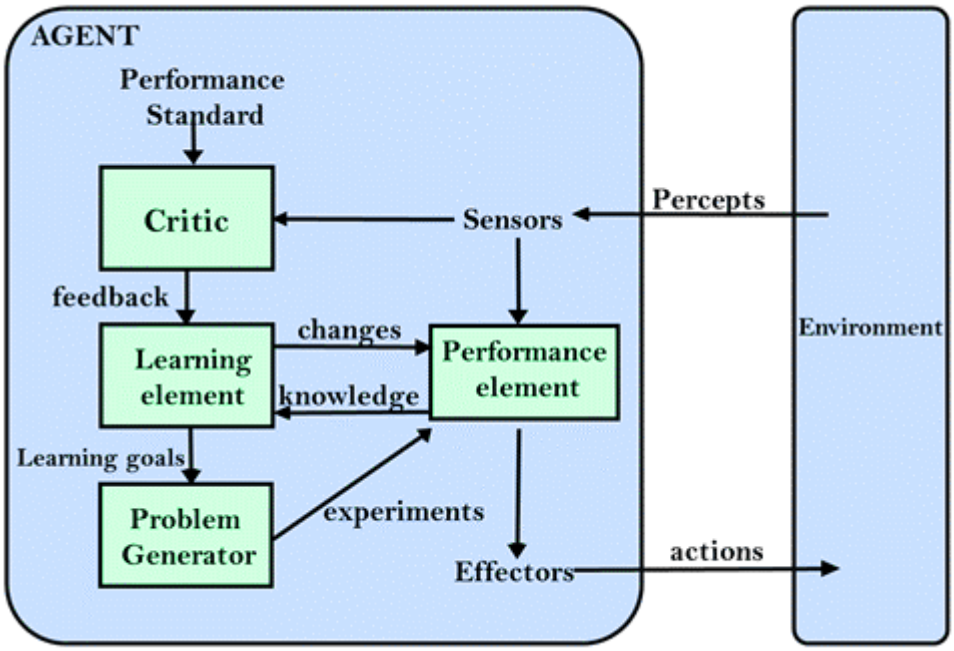
For describing capabilities, goal-based agents use goal information. These agents have higher capabilities than model-based reflex agents since the knowledge supporting a decision is explicitly modeled and thereby modifications are allowed. For these agents, the knowledge about the current state environment is not sufficient to decide what to do. The goal must describe the desirable situations. The agent needs to know about this goal. The agents choose actions to achieve the goal. Before deciding whether the goal is achieved or not these agents may have to consider a long sequence of possible actions. Goal – description of desirable situations

4. UTILITY-BASED AGENTS



Choices made by these agents are based on utility. Extra components of utility measurement made them more advanced than goal-based agents. They act based not only on goals but also on the best way to achieve the goal. The utility-based agents are useful when the agent has to perform the best action from multiple alternatives. The efficiency of each action to achieve the goal is checked by mapping each state to a real number.

5. LEARNING AGENTS



Agents with the capability of learning from their previous experience are learning agents. They start to act with their basic knowledge and then through learning they can act and adapt automatically. Learning agents can learn, analyze the performance, and improve the performance. Learning agents have the following conceptual components:

- **Learning element**: Element enables learning from previous experience.
- **Critic**: Provides feedback on how well the agent is doing concerning a fixed performance standard.
- **Performance element**: The actions to be performed are selected.
- **Problem generator**: Acts as a feedback agent that performs certain tasks such as making suggestions that will lead to new and informative experiences.

Applications of intelligent agents

In many real-life situations, intelligent agents in artificial intelligence have been applied.

Information search, retrieval, and navigation

Through the search of information using search engines, intelligent agents enhance the access and navigation of information. Intelligent agents perform the task of searching for a specific data object on behalf of users within a short time.

Repetitive office activities

Some of the functional areas of some companies have automated to reduce operating costs include customer support and sales.

Medical diagnosis

The patient is considered as the environment computer keyboard is used as the sensor that receives data on the symptoms of the patient and the intelligent agent uses this information to decide the best course of action. Tests and treatments are given through actuators.

Vacuum cleaning

For a vacuum cleaner, the surface to be cleaned is the environment (e.g. Room, table, carpet).Using sensors employed in vacuum cleaning (cameras, dirt detection sensors, etc.)Senses the environment condition. Actuators such as brushes, wheels, and vacuum extractors are used to perform actions.

Autonomous driving

In autonomous driving cameras, GPS, and radar are employed as sensors to collect information. Pedestrians, other vehicles, roads, or road signs are the environment. Various actuators like brakes are used to initiate actions.

Rational agents

An agent is an entity that perceives and acts; a rational agent, on the other hand, is a person or entity that always aims to perform optimal actions based on given premises and information.

Agent and environment

An AI system can be defined as the study of a rational agent and its environment.
A rational agent can be anything that makes decisions, typically a person, robot or software.
An agent can be seen as a black box interacting with the environment in two ways:

- takes input from it (perceives)
- produces an output (acts)

The agents sense the environment through sensors and act on their environment through actuators.

How can we implement this box?
How do the system will convert perceptions into actions?

Agent architecture

Abstractly, an agent can be seen as a function that maps from percept history to actions:

$$f : \mathcal{P}^* \longrightarrow A$$

A percept is a sequence of perceptions: maybe previous perceptions could help us in the future.
For a given task we seek the agent (or agent class) with the best performance: whichever maximises the expected value of the performance measure used.
Computational limitations make perfect rationality unachievable.

Simple reflex agents: they look at what the world is now and then they decide which action to take based on this data; they are a direct connection between perception and action; they can't make predictions since the model doesn't know how the world will change in response to the action.

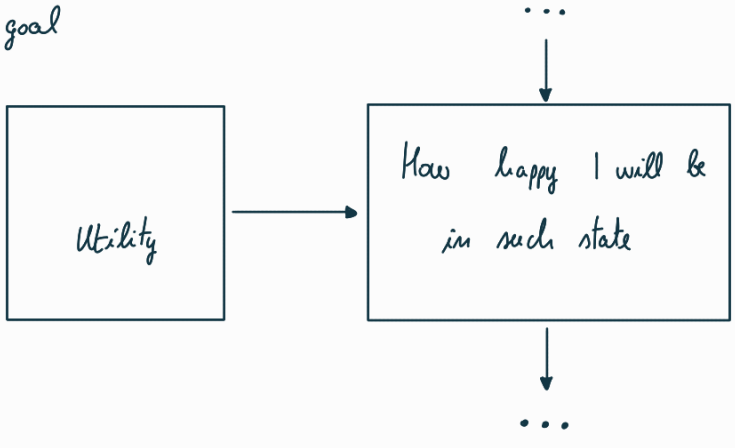
Model-based reflex agents / Reflex agents with state: they keep track of the percepts (perception history) and in addition to this they have a model on how the world changes based on the agent actions.

Goal-based agents: the agent, knowing how the world evolve, can also project himself towards the future; knowing how the world evolve the agent can say if a sequence of actions will eventually let him reach the goal.

This is an ex ante model → take the sequence of actions that will lead to the goal; this is guessed using a model of the world.

In short: they try to reach a goal (thus the name)

Utility-based agents: still a goal based agent but with an additional element: the agent can know how much a transition state will be useful to reach the goal

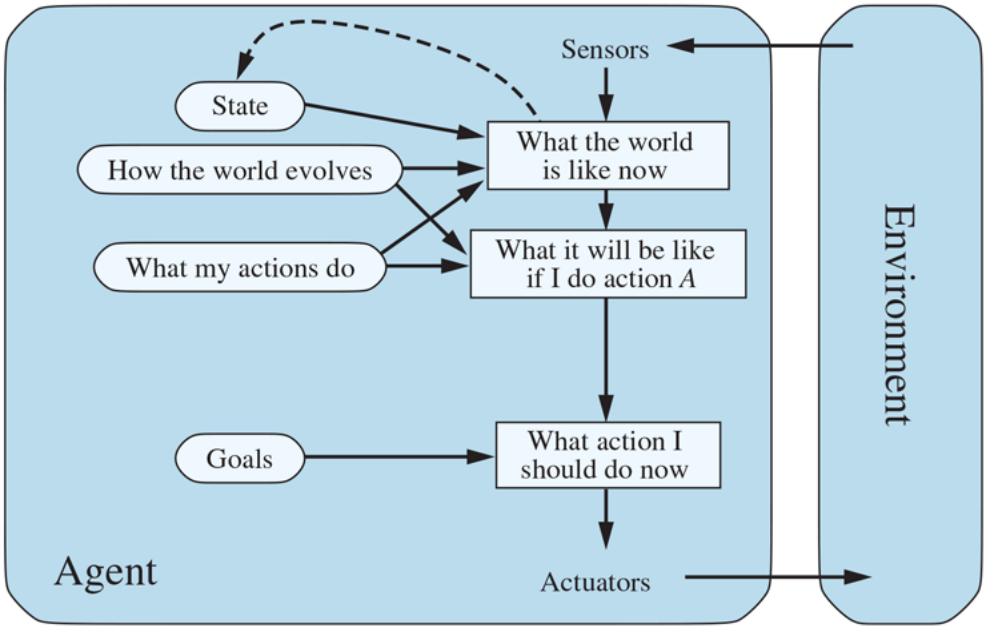


Learning agents: the learning mechanism (new element) tries to improve the performance of the agent; the critic block provides feedback on how well the agent is performing and this info is used by the learning element.

AI FIRST MID-TERM

Goal-Based Agent

The agent needs some sort of **goal** information that describes situations that are desirable. The agent program can combine this with the model to choose actions that achieve the goal.



Sometimes it will be tricky when the agent has to consider long sequences of twists and turns in order to find a way to achieve the goal.
Notice that decision making of this kind is fundamentally different from the condition, action depends on the consideration of the future.
Although the goal-based agent appears less efficient, it is more flexible because the knowledge that supports its decisions is represented explicitly and can be modified. For example, a goal-based agent's behaviour can easily be changed to go to a different destination, simply by specifying that destination as the goal. The reflex agent's rules for when to turn and when to go straight will work only for a single destination; they must all be replaced to go somewhere new.

Utility-Based Agent

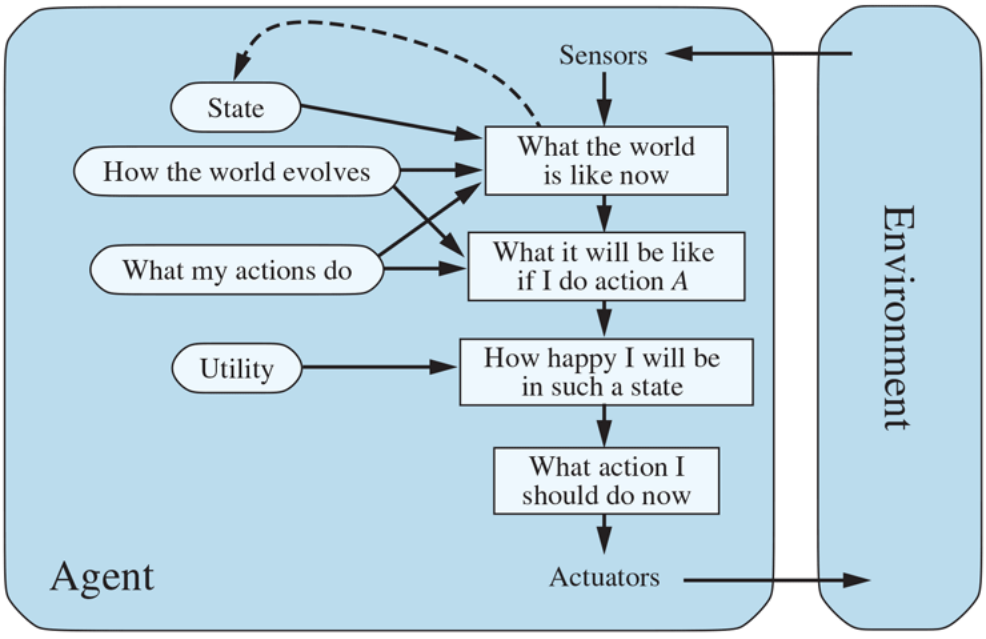
Goals alone are not enough to generate high-quality behaviour in most environments. For example, many action sequences will get the taxi to its destination (thereby achieving the goal), but some are quicker, safer, more reliable, or cheaper than others. Goals just provide a crude binary distinction between "happy" and "unhappy" states.

We have already seen that a performance measure assigns a score to any given sequence of environment states, so it can easily distinguish between more and less desirable ways of getting to the taxi's destination. An agent's utility function is essentially an internalization of the performance measure. Provided that the internal utility function and the external performance measures are in agreement, an agent that chooses actions to maximize its utility will be rational according to the external performance measure.

First, when there are conflicting goals, only some of which can be achieved (for example, speed and safety), the utility function specifies the appropriate trade-off. Second, when there are several goals that the agent can aim for, none of which can be achieved with certainty, utility provides a way in which the likelihood of success can be weighed against the importance of the goals.

Technically speaking, a rational utility-based agent chooses the action that maximizes the expected utility of the action outcomes.

An agent that possesses an explicit utility function can make rational decisions with a general-purpose algorithm that does not depend on the specific utility function being maximized.



It’s true that such agents would be intelligent, but it’s not simple. A utility-based agent has to model and keep track of its environment, tasks that have involved a great deal of research on perception, representation, reasoning, and learning.