Artificial Intelligence

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Contents:

Contents:

Objectives 教学目的

- Overview several approaches for AI.
  纵览AI的各种研究途径。
- Discuss the nature of intelligent agents, the diversity of environments, and the resulting menagerie of agent types.
  讨论智能体的性质、环境的多样性、以及由此产生的各种类型的智能体。

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2.1. Approaches for Artificial Intelligence

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Overview 概述

- In 1940s and 1950s, a number of researchers explored the connection between neurology, information theory, and cybernetics.
  1940年代至1950年代，许多研究者探索神经学、信息论和控制论之间的关系。
- Some of them built machines that used electronic networks to exhibit rudimentary intelligence.
  他们当中有些人采用电子网络打造机器来展现初步的智能。
- Many of these researchers gathered for meetings of the Teleological Society at Princeton University and the Ratio Club in England.
  许多研究者聚集在普林斯都大学和英国Ratio俱乐部，召开了目的论学会的会议。
- By 1960, this approach was largely abandoned, although elements of it would be revived in the 1980s.
  到了1960年，这种途径基本上被抛弃了，尽管有些要素于1980年代复活。

Overview 概述

- Herbert Simon and Allen Newell studied human problem-solving skills and attempted to formalize them.
  赫伯特·西蒙和艾伦·纽厄尔研究了人类问题求解技能，并且试图对其形式化。
- Their work laid the foundations of artificial intelligence, as well as cognitive science, operations research and management science.
  他们的工作奠定了人工智能、以及认知科学、运筹学和管理学的基础。
- Their research team used the results of psychological experiments to develop programs that simulated the techniques that people used to solve problems.
  他们的团队采用了心理学实验结果开发程序，仿真人们解决问题的技巧。
- Soar, a cognitive architecture, was originally created at CMU in the middle 1980s, now maintained at University of Michigan.
  Soar，一种认知架构，是以CMU为核心于1980年代中期开发，如今由密歇根大学维护。

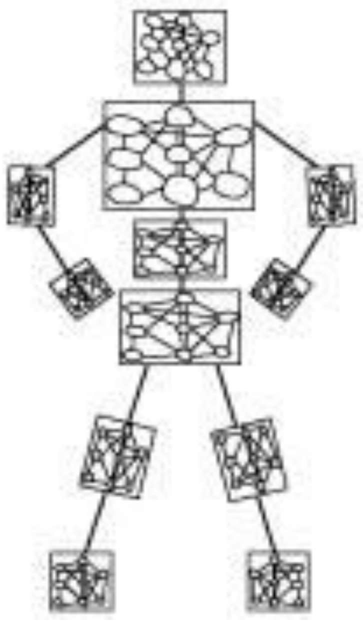
AI

2.1. Approaches for Artificial Intelligence

Contents:

Symbolic AI 符号AI

- Symbolic AI is based on high-level “symbolic” (human-readable) representations of problems, logic and search.
  符号AI是基于人类易懂的高级“符号”来表现问题、逻辑和搜索。
- The approach is based on the assumption that many aspects of intelligence can be achieved by the manipulation of symbols.
  该方式是基于这样一种假设：智能的许多方面能够通过符号操作来获得。
- The most successful form of symbolic AI is expert systems, it processes the rules to make deductions and to determine what additional information it needs, i.e. what questions to ask, using human-readable symbols.
  符号AI最成功的形式是专家系统，它对规则进行操作来进行推断和确定需要什么附加信息，即采用人类易懂的符号询问一些问题。



Symbolic

Sub-symbolic AI 亚符号AI

- By the 1980s, many researchers believed that symbolic systems would never be able to imitate all the processes of human cognition, especially perception, robotics, learning and pattern recognition.

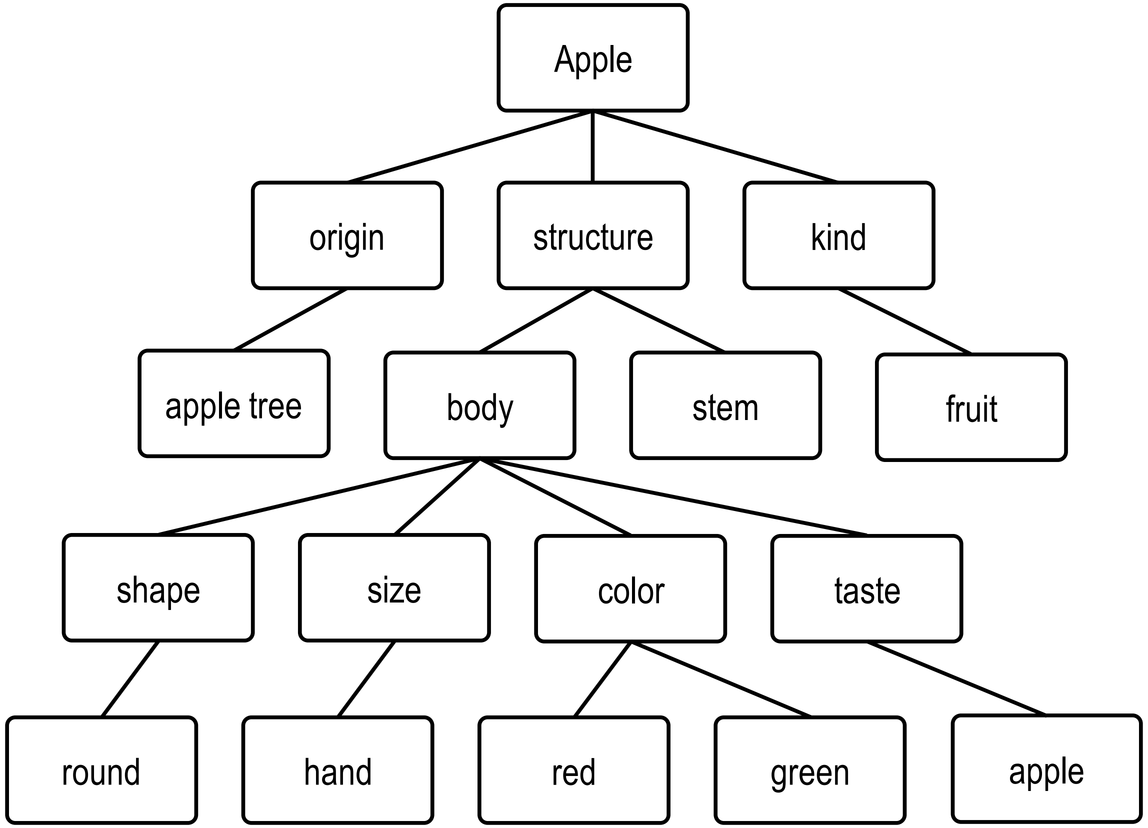
  到了1980年代，许多研究者已确信，符号系统将永远无法模仿人类认知的全部过程，尤其是感知、机器人技术、学习和模式识别。

- A number of researchers began to look into “sub-symbolic” approaches, based on neural networks, statistics, numerical optimization, etc.

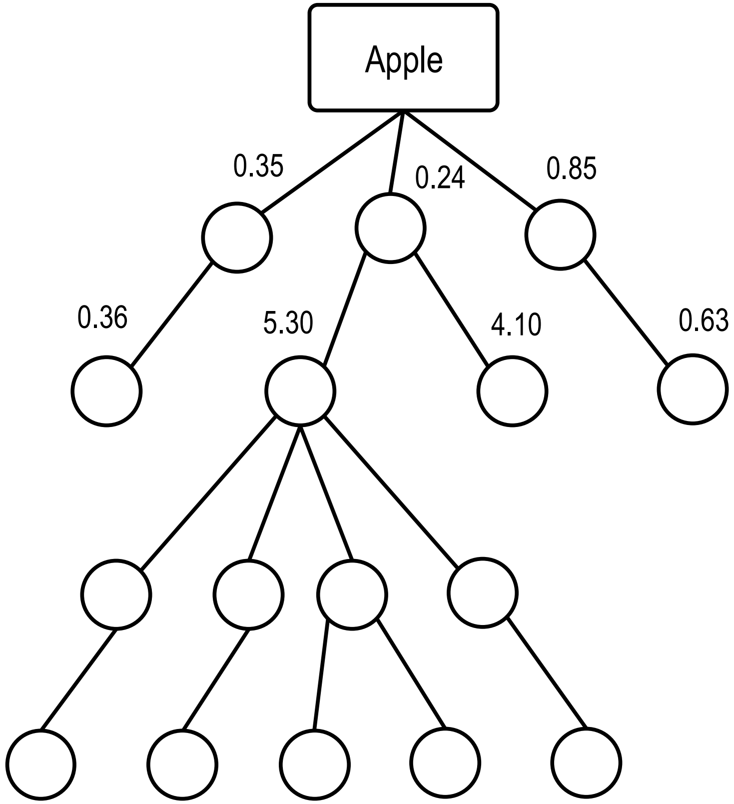
  一些研究者开始关注“亚符号”方式，以神经网络、统计学、数值优化等为基础。

sub-symbolic

Examples: Symbolic vs. Sub-symbolic AI 符号与亚符号AI



Symbolic Apple
符号化苹果



Sub-symbolic Apple
亚符号化苹果

2.1. Approaches for Artificial Intelligence

Contents:

Logic-based 基于逻辑

- Unlike Newell and Simon, John McCarthy felt that machines did not need to simulate human thought, but should instead try to find the essence of abstract reasoning and problem solving, regardless of whether people used the same algorithms.
  与纽厄尔和西蒙不同，麦卡锡觉得机器无需仿真人类的思考，反倒应该试图去发现抽象推理和问题求解的本质，不管人们是否使用同样的算法。
- His AI laboratory at Stanford (SAIL) focused on using formal logic to solve a wide variety of problems, including knowledge representation, planning and learning.
  他的斯坦福大学AI实验室（SAIL）专注于用使用形式逻辑来解决各种问题，包括知识表征、规划和学习。
- Logic was also the focus of the work in Europe, which led to the development of the programming language Prolog and the science of logic programming.
  逻辑也被欧洲的研究工作所专注，导致编程语言Prolog和逻辑编程科学的发展。

Anti-logic 反逻辑

- Researchers at MIT (such as Marvin Minsky) found that solving difficult problems in vision and natural language processing required ad-hoc solutions.

  MIT的研究者（比如明斯基）发现，解决视觉和自然语言处理的难题需要特别的解决办法。

- They argued, there was no simple and general principle (like logic) to capture all the aspects of AI.

  他们主张，没有简单和通用的原理（如logic）能涵盖AI的所有方面。

- Roger Schank described their “anti-logic” approaches as “scruffy”, as opposed to the “neat” paradigms at CMU and Stanford.

  罗杰·尚克描述他们的反逻辑方式属于“不整齐”，与CMU和斯坦福的“整齐”范式形成对照。

- Commonsense knowledge bases are an example of “scruffy” AI, since they must be built by hand, one complicated concept at a time.

  常识知识库就是“不整齐”AI的示例，因为它们必须用手工构建，每次一个复杂的概念。

Knowledge-based 基于知识

- Around 1970, researchers began to build knowledge into AI applications.
  1970年前后，研究者开始在AI应用中构建知识。
- This “knowledge revolution” led to the development and deployment of expert systems, the first truly successful form of AI software.
  这场“知识革命”导致专家系统的开发和部署，这是第一个真正成功的AI软件形式。
- Expert systems was introduced by Edward Feigenbaum at Stanford University, often called the “father of expert systems”.
  专家系统是由斯坦福大学的爱德华·费根鲍姆提出的，人们通常称他为“专家系统之父”。
- The knowledge revolution was also driven by the realization that enormous amounts of knowledge would be required by many simple AI applications.
  知识革命也是由这样的实现所驱动的，许多简单的AI应用需要庞大的知识。

2.1. Approaches for Artificial Intelligence

Contents:

Symbolism vs. Connectionism 符号主义与联结主义

Symbolist AI 符号主义AI

- It represents information through symbols and their relationships.
  符号AI凭借符号及他们之间的关系来表征信息。
- Specific algorithms are used to process these symbols to solve problems or deduce new knowledge.
  特定算法用于处理这些符号来解决问题和推导新的知识。

Connectionist AI 联结主义AI

- It represents information in a distributed form within a network.
  联结主义AI用网络内部的一种分布式形式来表征信息。
- It imitates biological processes underlying learning, task performance, and problem solving.
  模仿生物学过程的基础学习、任务功效和问题求解。

AI

2.1. Approaches for Artificial Intelligence

Contents:

Statistical Approach 统计方法

- In 1990s, AI researchers developed sophisticated mathematical tools to solve specific sub-problems. Stuart Russell and Peter Norvig describe this movement (statistical approach) as “the victory of the neats” 。

  1990年代，AI研究者开发了复杂的数学工具来解决特定的子问题。斯图尔特·罗素和彼得·诺维格描述这个运动（统计方法）为“整齐观点的胜利”。

- Critics argue that these techniques are too focused on particular problems and have failed to address the long term goal of general intelligence.

  批评者认为，这种技巧过于关注特定的问题、并且未能解决通用智能的长期目标。

- There is an ongoing debate about the validity of statistical approaches in AI, exemplified in part by exchanges between Peter Norvig and Noam Chomsky.

  关于AI统计学方式相关性和有效性的辩论一直在进行，部分体现在彼得·诺维格和诺姆·乔姆斯基之间的交锋。

2.1. Approaches for Artificial Intelligence

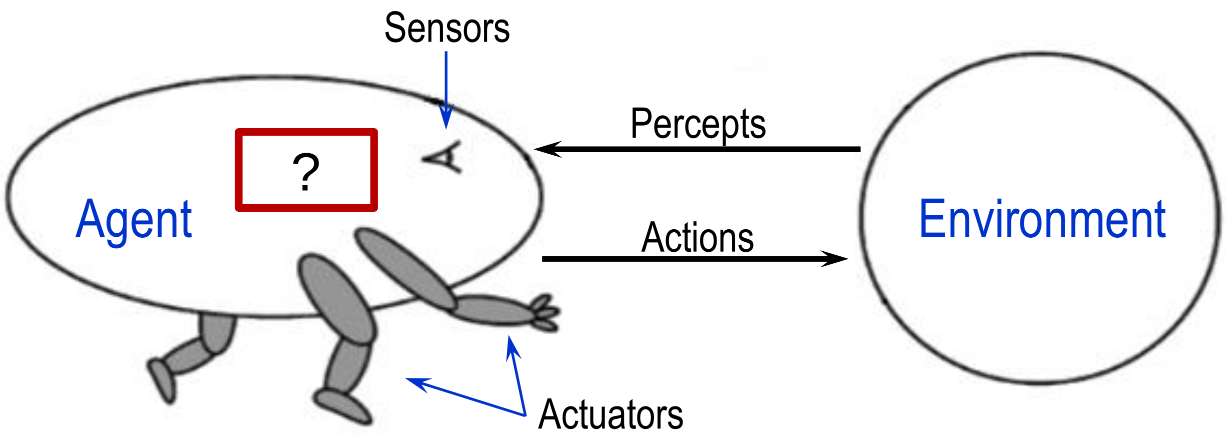
Contents:

What is an Intelligent Agent 什么是智能体

- Operate autonomously
  自主操作
- Perceive their environment
  感知环境
- Persist over a prolonged time period
  持续动作
- Adapt to change
  顺应变化
- Create and pursue goals
  实现目标
- The best outcome, or the best expected outcome (when there is uncertainty).
  最佳结果，或最佳预期结果（存在不确定性时）。

What is an Intelligent Agent 什么是智能体

- Broadly, an agent is anything that can be viewed as
  概括地说，一个智能体可以被看作具有如下功能的任何事物：
  - Perceiving its environment through sensors, and acting upon that environment through actuators.
    通过感受器感知外部环境，并且通过执行器作用于外部环境。
  - May also learn or use knowledge to achieve their goals.
    还可以通过学习或者应用知识来实现其目标。



Intelligent agents Include humans, robots, softbots, etc.
智能体包括人类、机器人、
软件机器人，等等。

Q: Which one could be better, Why? 哪种方法较好，为什么

- Cybernetics and brain simulation
  控制论和大脑仿真
- Symbolic vs. Sub-symbolic
  符号与亚符号
- Logic-based vs. Anti-logic
  基于逻辑与反逻辑
- Symbolism vs. Connectionism
  符号主义与联结主义
- Statistical approach
  统计方法
- Intelligent agent paradigm
  智能体范式

Contents:

Rational Agent Approach 理性智能体方法

Here we concentrate on general principles of rational agents and on components for constructing them.

我们在此专注于理性智能体的一般原理和构造智能体的组件。

Why rational agent 为何理性智能体

- More general than the “thinking/acting humanly” approaches, because correct inference is just one of several possible mechanisms for achieving rationality.
  与“人性思考/动作”方式相比更通用，因为正确推理只是为了获得理性的可行机制之一。
- More amenable to scientific development than the “thinking/acting humanly” approaches.
  与“人性思考/动作”方式相比更顺应科技的发展。

Examples: Intelligent Agents 智能体

- A human agent 人类智能体
  - sensors: eyes, ears, and other organs.
    感受器：眼、耳、和其它器官。
  - actuators: hands, legs, vocal tract, and so on.
    执行器：手、脚、声道、如此等等。
- A robotic agent (robot) 机器智能体（机器人）
  - sensors: cameras, infrared range finders.
    感受器：摄像头、红外测距仪。
  - actuators: various motors.
    执行器：各种马达。
- A software agent (softbot) 软件智能体（软件机器人）
  - sensors: keystrokes, file contents, and network packets.
    感受器：击键、文件内容、以及网络包。
  - actuators: display on screen, write files, and send network packets.
    执行器：屏幕显示、写文件、以及发送网络包。

Abstract Intelligent Agents 抽象智能体

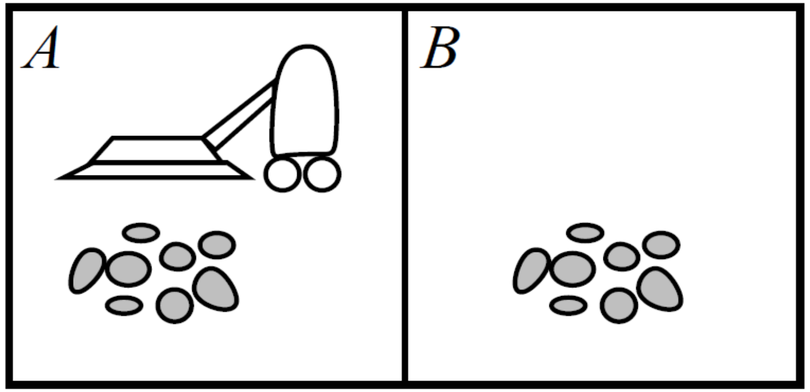
- Intelligent agents are often described schematically as an abstract functional system similar to a computer program.
  智能体经常被大致地描述成一个类似于计算机程序的抽象功能系统。
- They are sometimes called abstract intelligent agents to distinguish them from their real world ones as computer systems, biological systems, or organizations.
  它们有时被称为抽象智能体，将其与现实世界的计算机系统、生物系统、或组织机构加以区别。
- Some definitions of intelligent agents emphasize their autonomy, and so prefer the term autonomous intelligent agents.
  某些智能体的定义强调其自主性，因而喜欢自主智能体这个术语。
- Still others considered goal-directed behavior as the essence of intelligence, and so prefer a term borrowed from economics, rational agent.
  其他人仍然将目标导向行为作为智能的本质，故而喜欢从经济学借用的术语，理性智能体。

A Variety of Definitions 各种定义

- Accommodate new problem solving rules incrementally.
  逐渐顺应新的问题求解规则。
- Adapt online and in real time.
  适合在线与实时。
- Able to analyze itself in terms of behavior, error and success.
  能够从行为、错误与成功方面进行自我分析。
- Learn and improve through interaction with the environment.
  通过与环境交互进行学习与改善。
- Learn quickly from large amounts of data.
  迅速从大量的数据中学习。
- Have memory-based exemplar storage and retrieval capacities.
  具有基于内存的样本存储和检索能力。
- Have parameters to represent short and long term memory, forgetting, etc.
  具有表示短期和长期记忆、遗忘等参数。

Example: Vacuum-cleaner world 真空吸尘器世界

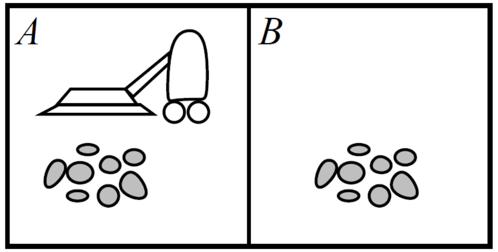
- A vacuum-cleaner world with just two locations: squares *A* and *B*.
  一个仅仅有两个地点的真空吸尘器世界：方形区域*A*和*B*。
- The vacuum agent perceives which square it is in and whether there is dirt in the square. It can choose to move left, move right, suck up the dirt, or do nothing. I.e.,
  该吸尘器智能体感知它在那个方形区域，以及该方形区域是否有灰尘。它可以选择左行、右行、吸尘、或者空操作。即：
  - Percepts:
    location and contents, e.g., [*A*, *Dirty*]
    感知：位置和内容
  - Actions:
    Left, *Right*, *Suck*, *NoOp*
    动作：左行、右行、吸尘、空操作



A vacuum-cleaner world with just two locations

Example: Vacuum-cleaner world 真空吸尘器世界

- What is the right function?
  正确的功能是什么?
- Can it be implemented in a small agent program?
  能用一个小智能体程序实现吗?



Partial tabulation of a simple agent function
一个简单智能体功能的部分列表

Percept	Action
[A, Clean]	*Right*
[A, Dirty]	*Suck*
[B, Clean]	*Left*
[B, Dirty]	*Suck*
…	…

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*

The agent program for a simple reflex agent in the two-state vacuum environment.
This program implements the agent function in upper right table.
两状态吸尘器环境下一个简单反射智能体的程序。该程序实现右上表的智能体功能。

What is a Rational Agent 什么是理性智能体

- It is one that does the right thing — every entry in the table for the agent function is filled out correctly.
  是一个有正确行为的智能体 —— 该功能表中的每个条目都正确填写。

What is the Right Thing 什么是正确的行为

- An agent in an environment generates a sequence of actions according to the percepts.
  一个智能体在一个环境中依据感知生成一系列动作。
- Those actions causes the environment to go through a sequence of states.
  这些动作经由一系列状态而引起环境发生变化。
- If the sequence is desirable, then the agent has performed well.
  如果该系列变化是所期望的，则该智能体表现良好。

Right Thing = Rational Action 正确的行为 = 理性的动作

- Rational 理性的

  exploration, learning, autonomy.

  探索、学习、自主

- Rational action 理性的动作

  Maximizes the expected value of performance measure given the percept sequence.

  对给定的感知序列，能使期待的性能指标最大化。

Rational = Best	理性 = 最佳
Rational = Optimal	理性 = 最优
Rational ≠ Omniscience	理性 ≠ 全知全能
Rational ≠ Clairvoyant	理性 ≠ 明察秋毫
Rational ≠ Successful	理性 ≠ 百战百胜

Concept of Rationality 理性的概念

- Rationality depends on four things:

  理性依赖于四件事：

  - The performance measure that defines the criterion of success.

    定义成功标准的性能指标。

  - The agent’s prior knowledge of the environment.

    智能体对环境的先验知识。

  - The actions that the agent can perform.

    智能体能够完成的动作。

  - The agent’s percept sequence to date.

    智能体最新的感知序列。

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What is PEAS 什么是PEAS

- PEAS is a task environment specification, stands for:

  PEAS是一种任务环境的规范，代表：

Performance	■	性能
Environment	■	环境
Actuators	■	动作器
Sensors	■	感受器

- In the simple vacuum-cleaner agent, we had to specify the performance measure, the environment, and the agent's actuators and sensors.

  在真空吸尘器智能体这个例子中，我们曾经详述了性能指标、环境、智能体的动作器和感受器。

- For building rational agents, we must think about task environments, which are the "problems" to which agents are the "solutions".

  为了构建理性智能体，我们必须思考关于任务环境，这是"问题"，而智能体是"解决方式"。

Example: PEAS description PEAS描述

☐ Agent Type: Taxi driver

智能体类型：的士司机

Performance	Environment	Actuators	Sensors
safe 安全 fast 快速 legal 守法 comfortable 舒适 profits 收益	roads 道路 traffic 交通 pedestrians 行人 customers 顾客	steering 方向盘 accelerator 油门 brake 刹车器 signal 信号 horn 喇叭 display 显示器	cameras 摄像头 sonar 声纳 speedometer 速度仪 GPS GPS odometer 里程表 accelerometer 加速度计 engine sensors 引擎传感器 keyboard 操作盘

Example: PEAS description PEAS描述

☐ Agent Type: Satellite image analysis system

智能体类型：卫星图像分析系统

Performance	Environment	Actuators	Sensors
correct image categorization. 正确的图像归类	downlink from orbiting satellite. 轨道卫星的下行信道	display of scene categorization. 场景归类的显示	color pixel arrays. 颜色像素阵列

Example: PEAS description PEAS描述

- Agent Type: Internet shopping

  智能体类型：网上购物

Performance	Environment	Actuators	Sensors
price 价格 quality 质量 appropriateness 合理性 efficiency 效率	Websites 网站 vendors 厂商 shippers 货主	display to user 商品展示 follow URL 跟随URL fill in form 填单	Webpages 网页 (text, （文本、 image, 图像、 scripts) 脚本）

2.3. Task Environments

Contents:

- ☐ 2.3.1. PEAS Description
- ☐ 2.3.2. Environment Types

Different Environment Types 不同的环境类型

- **Fully observable vs. partially observable** 完全可观测与部分可观测

  An agent’s sensors give it access to the complete state of the environment at each point in time, then the task environment is fully observable.

  一个智能体的传感器在每个时间点上可访问环境的完整状态，则该任务环境是完全可观测的。

- **Single agent vs. multi-agent** 单智能体与多智能体

  An agent operating by itself in an environment, then it is fully single agent.

  一个智能体在一个环境内自运行，则他就是一个单智能体。

- **Deterministic vs. stochastic** 确定性与随机性

  The next state of the environment is completely determined by the current state and the action executed by the agent, then the environment is deterministic.

  环境的下一个状态完全由当前的状态和由该智能体执行的动作所决定，则该环境是确定性的。

Different Environment Types 不同的环境类型

- **Episodic vs. sequential** 阵发性与连续性

  The agent's experience is divided into atomic episodes, and the choice of action in each episode depends only on the episode itself.

  智能体的动作过程被分为原子的片段，并且每个片段的动作选择仅仅依赖于片段本身。

- **Dynamic vs. static** 动态与静态

  If the environment can change while an agent is deliberating, then the environment is dynamic for that agent; otherwise it is static.

  如果环境随智能体的行为而改变，则该智能体的环境是动态的；否则是静态的。

  - **Semi-dynamic** 半动态

    If the environment itself does not change with the passage of time but the agent's performance score does.

    如果环境本身不随时间的推移而改变，但该智能体的性能发生变化。

Different Environment Types 不同的环境类型

- Discrete vs. continuous 离散与连续
  - The discrete/continuous distinction applies to the state of the environment, to the way time is handled, and to the percepts and actions of the agent.
    离散与连续的区别在于环境的状态、时间处理的方式、以及感知和智能体的动作。
- Known vs. unknown 已知与未知
  - In a known environment, the outcomes for all actions are given.
    在一个已知的环境下，所有动作的结果是给定的。
  - Obviously, if the environment is unknown, the agent will have to learn how it works in order to make good decisions.
    显然，如果环境是未知的，则该智能体将需要学习如何动作，以便做出正确的决策。

Example: Task environments and their characteristics 任务环境及其特性

Environment Types 环境类型	Example Agents 智能体举例		
	Taxi driving 的士司机	Image analysis 图像分析	Internet shopping 网上购物
Observable 可观测	Partially 部分	Fully 完全	Partially 部分
Agents 智能体	Multi 多个	Single 单个	Single 单个
Deterministic 确定性	Stochastic 随机	Deterministic 确定	Stochastic 随机
Episodic 阵发性	Sequential 顺序	Episodic 阵发	Sequential 顺序
Dynamic 动态	Dynamic 动态	Semi 半动态	Semi 半动态
Discrete 离散	Continuous 连续	Continuous 连续	Discrete 离散

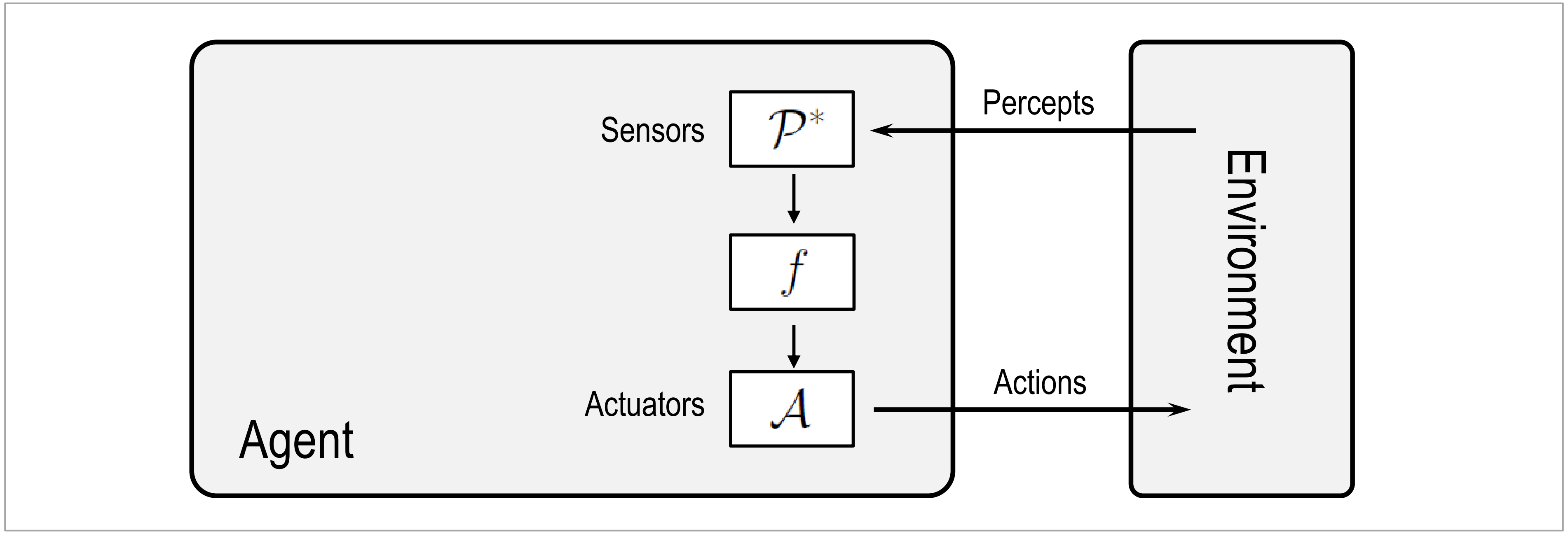
Contents:

The Structure of Agents 智能体的结构

- An agent's behavior can be described mathematically by an agent function which maps every percepts to a action.

  一个智能体的行为可以数学上被描述为一个智能体函数，将每个感知映射为动作。

$$f : \mathcal{P}^* \to \mathcal{A} \qquad \text{where} \quad \mathcal{P}^* = \sum_{t=1}^{T} |\mathcal{P}|^t$$



Agent Function 智能体函数

- The agent function is an abstract concept, it could incorporate various principles of decision making:
  智能体函数是一个抽象的概念，它可以包含将各种决策制定的原则：
  - calculation of utility of individual options,
    单个选项的效用计算
  - deduction over logic rules,
    贯穿逻辑规则的推论
  - fuzzy logic,
    模糊逻辑
  - lookup table,
    查找表
  - etc.

Agent Programs 智能体程序

- It implements an agent function. It take the current percept as input from the sensors, and return an action to the actuators.
  实现一个智能体功能。它将感受器的输入作为当前的感知，然后返回一个动作给执行器。

function TABLE-DRIVEN-AGENT(*percept*) **returns** an action
  persistent: *percepts*, a sequence, initially empty
    table, a table of actions, initially fully specified
    action, the most recent action, initially none
  append *percept* to the end of *percepts*
  action ← LOOKUP(*percepts*, *table*)
  return *action*

The agent program returns an action by lookup table each time.
该智能体程序通过查找表返回一个动作。

The Structure of Agents 智能体的结构

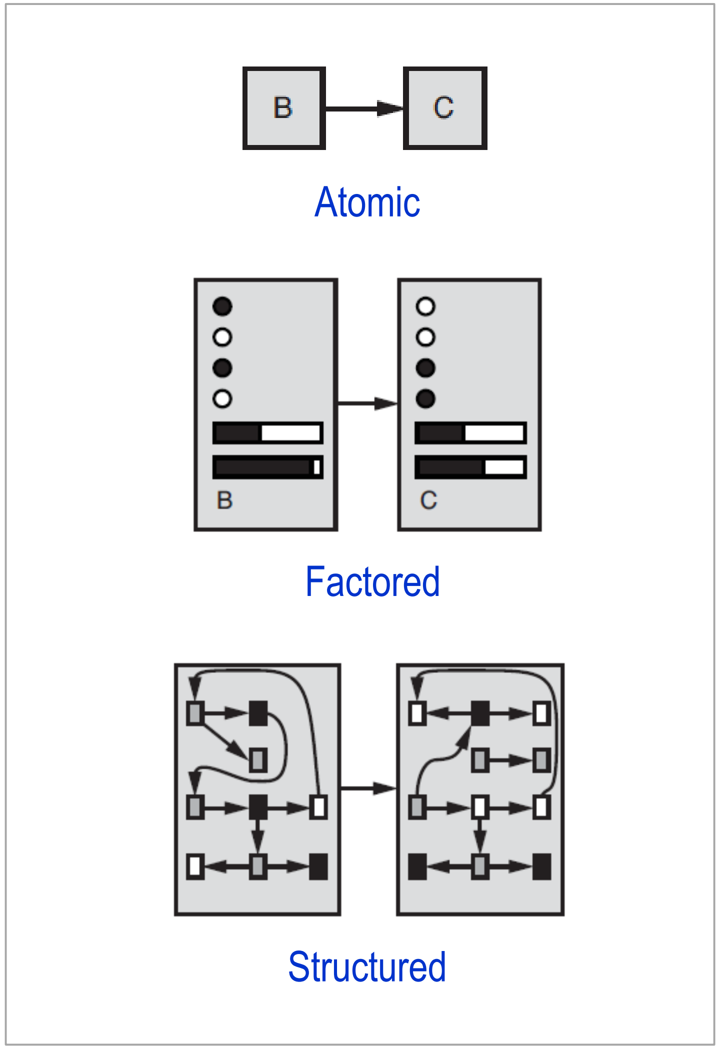
$$
\begin{aligned}
\textit{Agent} &= \textit{platform} + \textit{agent program} \\
\textit{platform} &= \textit{computing device} + \textit{sensors} + \textit{actuators} \\
\textit{agent program} &\supset \textit{agent function}
\end{aligned}
$$

Hierarchies of agents 智能体的层次

- Intelligent agents today are normally gathered in a hierarchical structure containing many “sub-agents”.
  智能体通常表现为一个分层的结构，它包含许多“子智能体”。
- Intelligent sub-agents process and perform lower level functions.
  子智能体处理和执行较低级的功能。
- Intelligent agent and sub-agents create a complete system that can accomplish difficult tasks with behaviors and responses.
  智能体和子智能体构建一个完整的系统，它可以通过行为和反应来完成艰巨的任务。

Three ways to represent states for an agent 表征智能体状态的三种方式

- **Atomic** 原子式
  each state is a black box with no internal structure.
  每个状态是个黑盒子，没有内部结构。
- **Factored** 因子式
  each state consists of a fixed set of attributes and values.
  每个状态由一组固定的属性和值组成。
- **Structured** 结构式
  each state includes objects, each has attributes and relationships to other objects.
  每个状态包含对象，每个具有属性以及与其它对象的关系。



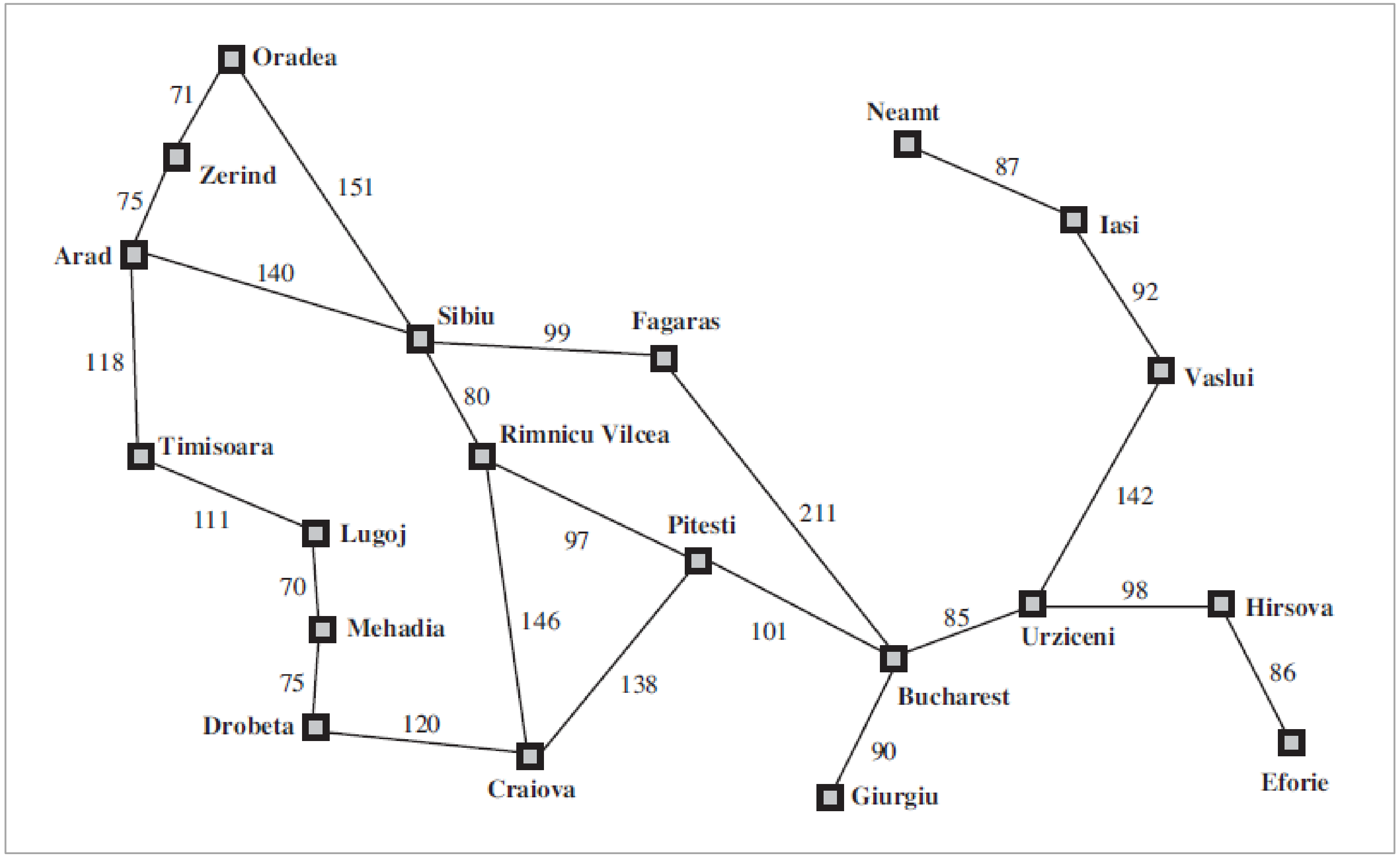
a) Atomic representation 原子式表征

- Each state is a black box with no internal structure.

  每个状态是个黑盒子，没有内部结构。

- E.g. the problem of finding a driving route from one end of a country to the other via some sequence of cities.

  例如，寻找驾驶路径问题，从某个国家的一端到另一端，经过一系列城市。

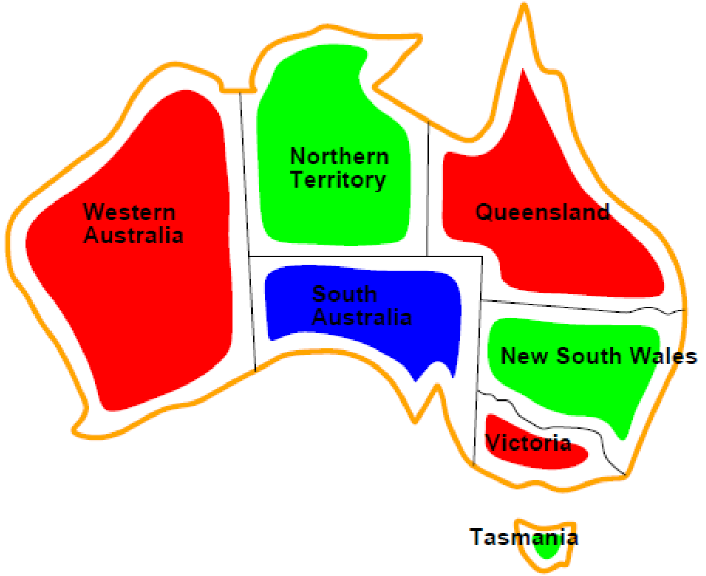


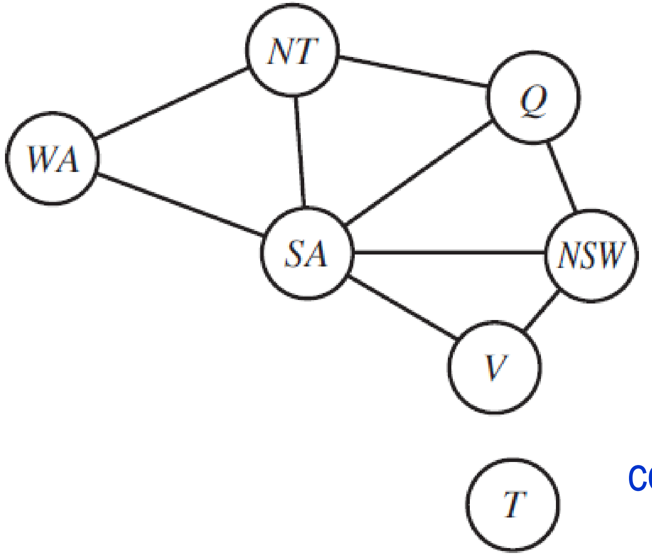
A simplified road map of part of Romania.

一个简化的罗马尼亚部分公路交通图

b) Factored representation 因子式表征

- Each state consists of a fixed set of attributes and values.
  每个状态由一组固定的属性和值组成。





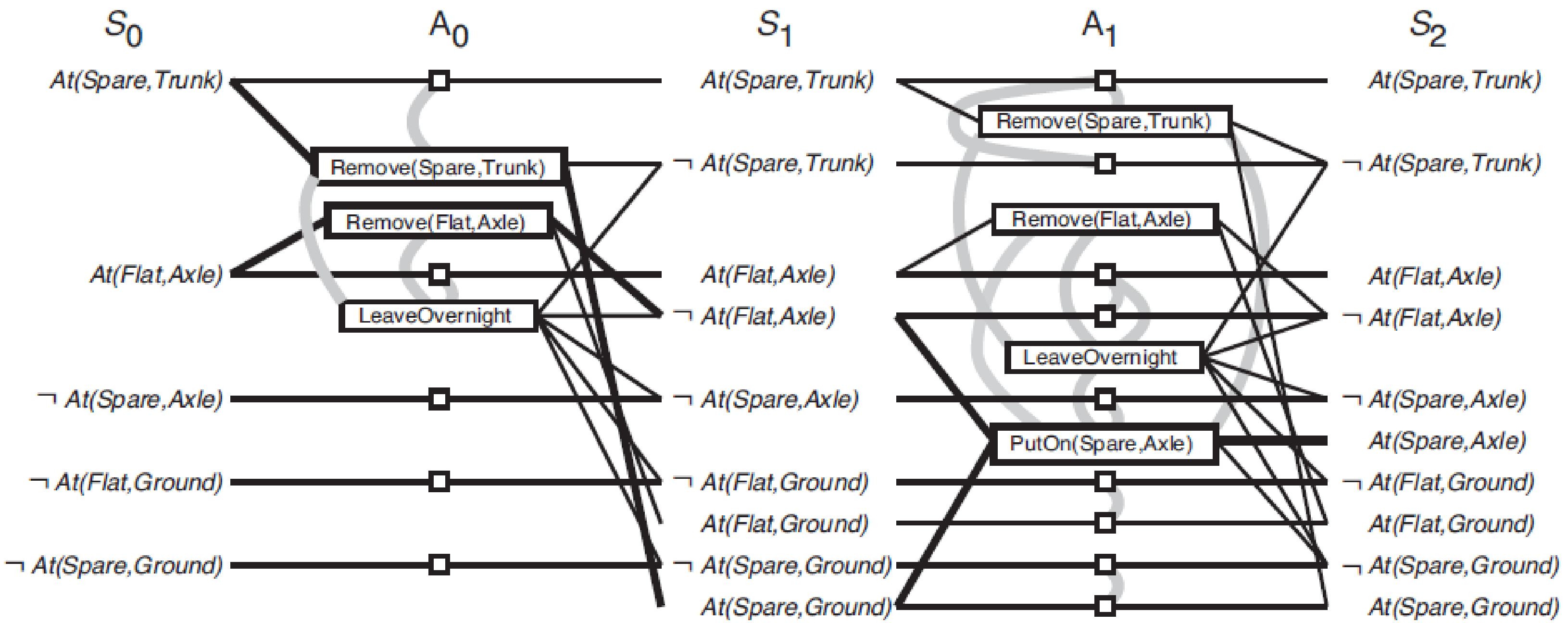
constraint graph
约束图

Many possible solutions to this problem, e.g.,
该问题可能的解决方案，例如：

$$\{WA = red, NT = green, Q = red, NSW = green, V = red, SA = blue, T = red\}.$$

c) Structured representation 结构式表征

- Each state includes objects, each object has attributes and relationships to other objects.
  每个状态包含对象，每个对象具有属性和与其它对象的关系。



A sample of structured representation of states
一个状态结构化表示的示例

Contents:

Typical Classes of Agents 智能体的主要类别

- The classification is based on their degree of perceived intelligence and capability.
  该分类是基于他们感知的智能和能力的程度。
- Here we will introduce five kinds of agents that embody the principles underlying almost all intelligent systems.
  这里我们将介绍5种类型的智能体，体现几乎所有智能系统的基本原理。

Simple reflex agents	■	简单反射智能体
Model-based reflex agents	■	基于模型的反射智能体
Goal-based agents	■	基于目标的智能体
Utility-based agents	■	基于效用的智能体
Learning agents	■	学习智能体

AI

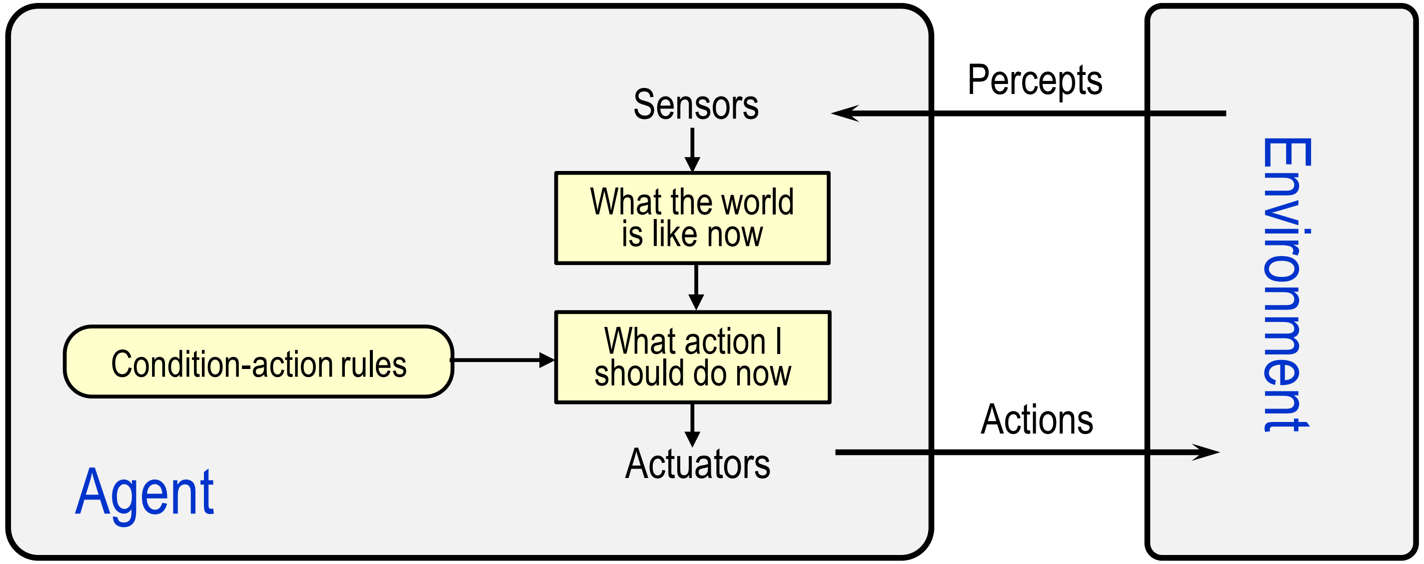
2.5. Category of Intelligent Agents

Contents:

- 2.5.1. Simple Reflex Agents
- 2.5.2. Model-based Reflex Agents
- 2.5.3. Goal-based Agents
- 2.5.4. Utility-based Agents
- 2.5.5. Learning Agents
- 2.5.6. Other Agents

Structure of Simple Reflex Agents 简单智能体的结构

- Simple reflex agents act only on the basis of the current percept, ignoring the rest of the percept history.
  简单反射智能体仅仅在当前感知的基础上动作，忽略其余的感知历史。
- Agent function is based on condition-action rule: *if* condition *then* action.
  智能体功能是基于条件动作规则：*if* 条件 *then* 动作。



About Simple Reflex Agents 关于简单智能体

- This agent function only succeeds when the environment is fully observable.
  仅当外部环境为完全可观测时，该智能体的功能才能发挥。
- Some reflex agents can also contain information on their current state which allows them to disregard conditions whose actuators are already triggered.
  某些反射智能体也可以包含关于其当前状态的信息，允许它们忽视执行器已被触发的条件。
- Infinite loops are often unavoidable for agents operating in partially observable environments.
  智能体在部分可观测环境下运行时，无限循环往往是无法避免的。
- Note: If the agent can randomize its actions, it may be possible to escape from infinite loops.
  注意：如果智能体可以随机产生其动作，有可能从无限循环中摆脱出来。

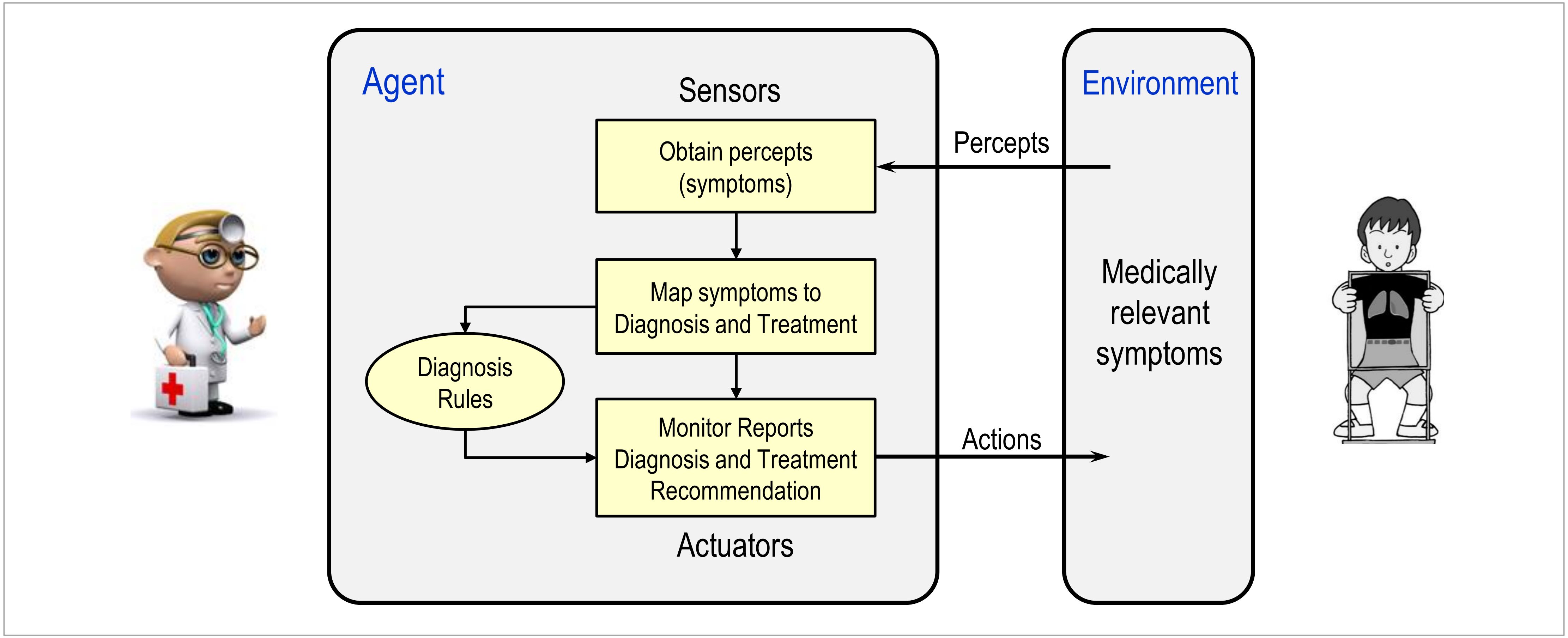
Algorithm of Simple Reflex Agents 简单智能体的算法

function SIMPLE-REFLEX-AGENT(*percept*) **returns** an action
  persistent: *state*, the agent's current conception of the world state
    rules, a set of condition–action rules
    action, the most recent action, initially none
  state ← INTERPRET-INPUT(*percept*)
  rule ← RULE-MATCH(*state*, *rules*)
  action ← *rule*.ACTION
  return *action*

A simple reflex agent. It acts according to a rule
whose condition matches the current state, as defined by the percept.

一个简单反射智能体。它按照规则动作，其条件匹配由感知所定义的当前状态。

Example: A Simple Reflex Agent 一个简单智能体



Structure of a simple reflex agent for medical diagnosis and treatment recommendation

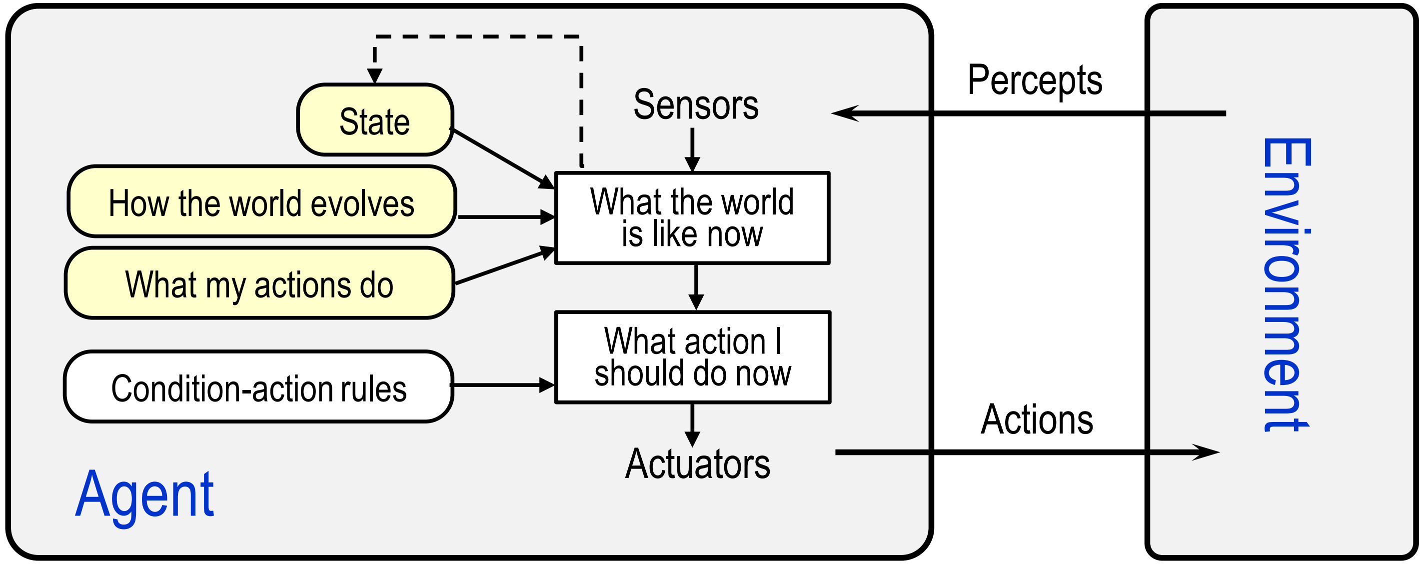
一个用于医学诊断和治疗建议的简单反射智能体结构

2.5. Category of Intelligent Agents

Contents:

Structure of Model-based Reflex Agents 基于模型反射智能体的结构

- A model-based reflex agent can handle partially observable environment.
  一个基于模型的反射智能体可以处理部分可观测环境。
- Its current state is stored inside the agent maintaining some kind of structure which describes the part of the world which cannot be seen.
  其当前状态存储在智能体中，维护某种结构，它描述不可见外部环境的一部分。



About Model-based Reflex Agents 关于基于模型反射智能体

- This knowledge about "how the world works" is called a model of the world, hence the name "model-based agent".
  关于“外部环境如何运作”的知识被称为一个外部环境模型，由此得名“基于模型的智能体”。
- A model-based reflex agent should maintain some sort of internal model.
  基于模型的反射智能体将保持某种内部模型。
- The internal model depends on the percept history and thereby reflects at least some of the unobserved aspects of the current state.
  内部模型依赖于感知的历史，因此至少反射某些当前状态无法观测的方面。
- It then chooses an action in the same way as the reflex agent.
  然后它作为反射智能体以某种方式选择动作。

Algorithm of Model-based Reflex Agents 基于模型反射智能体的算法

function MODEL-BASED-REFLEX-AGENT(*percept*) **returns** an action
  persistent: *state*, the agent's current conception of the world state
    model, a description of how the next state depends on current state and action
    rules, a set of condition–action rules
    action, the most recent action, initially none

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

The algorithm of a model-based reflex agent. It keeps track of the current state of the world, using an internal model. It then chooses an action in the same way as simple reflex agent.

一个基于模型的反射智能体算法。它采用一个内部模型来保持当前外部环境状态的轨迹。
然后用等同于简单反射智能体的方式选择一个动作。

AI

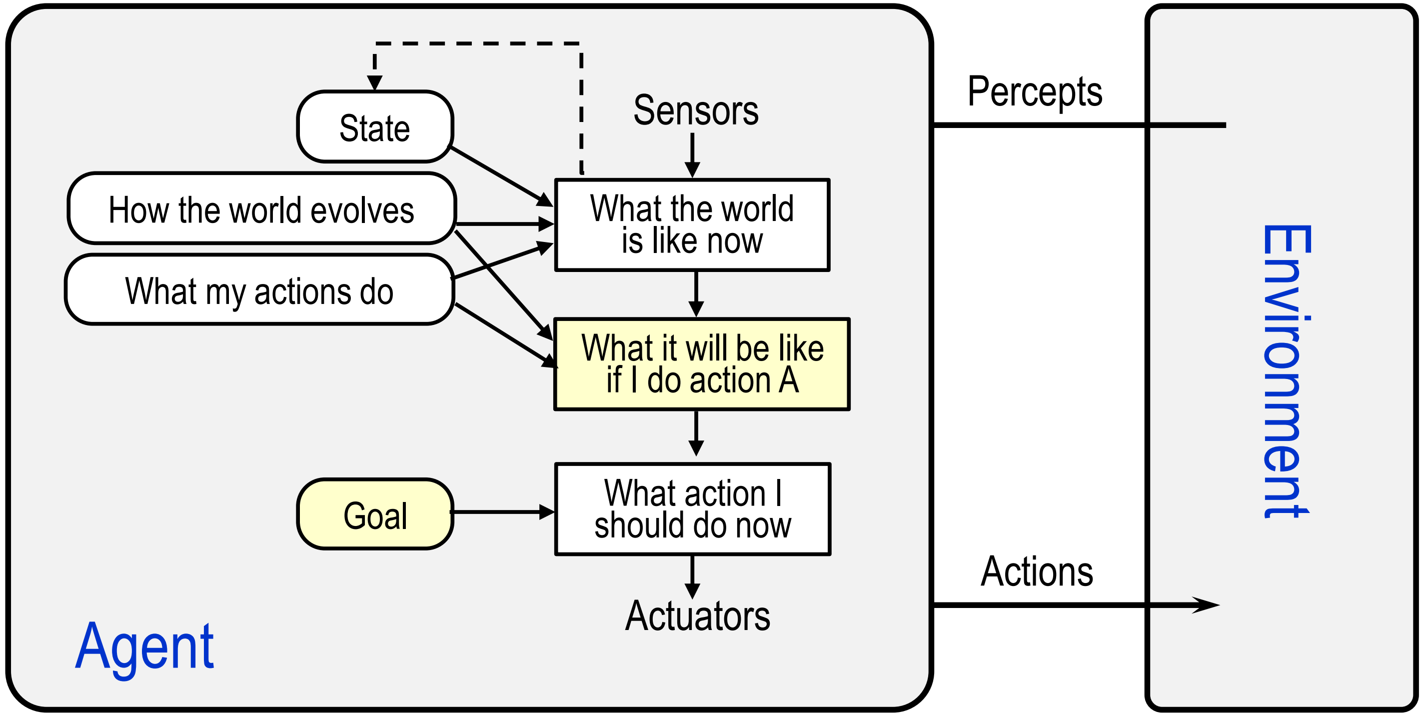
2.5. Category of Intelligent Agents

Contents:

Structure of Goal-based Agents 基于目标智能体的结构

- Goal-based agents further expand on the capabilities of the model-based agents, by using “goal” information.

  通过利用“目标”信息，基于目标的智能体进一步扩展了基于模型的智能体的功能。



About Goal-based Agents 关于基于目标智能体

- Goal information describes situations that are desirable.
  目标信息描述所希望的情形。
- This allows the agent a way to choose among multiple possibilities, selecting the one which reaches a goal state.
  它允许智能体在多个可能性之间选择一种方式，挑选出达到目标状态的那一个。
- Search and planning are the subfields of artificial intelligence devoted to finding action sequences that achieve the agent's goals.
  搜索和规划是人工智能的子领域，致力于发现达到智能体目标的动作序列。
- In some instances the goal-based agent appears to be less efficient.
  在某些情况下，基于目标的智能体似乎不太有效。
- But it is more flexible because the knowledge that supports its decisions is represented explicitly and can be modified.
  但它更灵活，因为这种支持其决策的知识明显地展示出来，并且可以被修改。

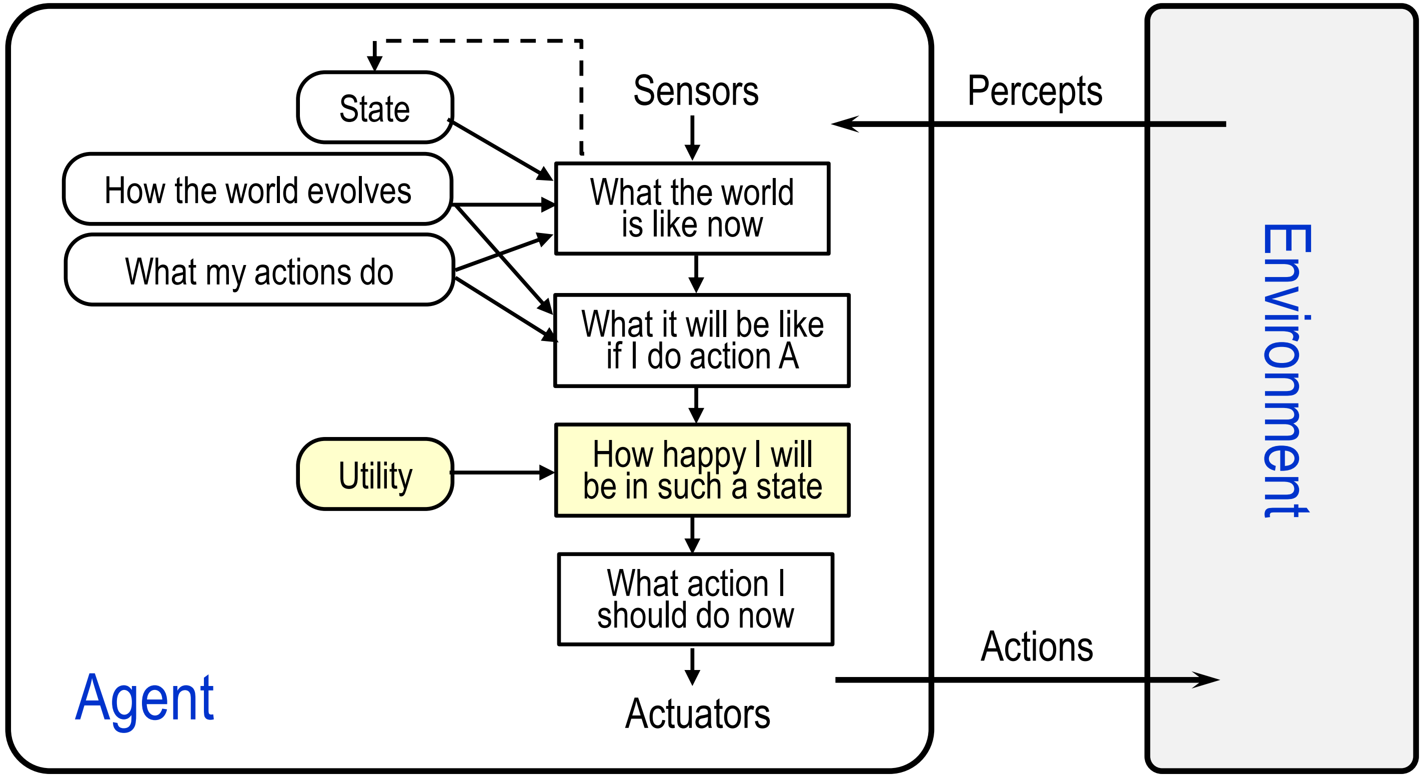
2.5. Category of Intelligent Agents

Contents:

Structure of Utility-based Agents 基于效用智能体的结构

- A particular state can be obtained by a *utility function* which maps a state to a measure of the utility of the state.

  一个特殊的状态可通过一个效用函数得到，该函数将一个状态映射到一个该状态效用的度量。



About Utility-based Agents 关于基于效用智能体

- A more general performance measure should allow a comparison of different world states according to exactly how “happy” they would make the agent.

  一种更通用的性能度量，应该根据他们使得智能体多么“高兴”的程度，允许对不同的外部环境状态进行比较。

- The term utility, can be used to describe how happy the agent is.

  效用这个术语，可用于描述智能体是多么高兴。

- A rational utility-based agent chooses the action that maximizes the expected utility of the action outcomes.

  一个理性的基于效用的智能体选择动作，将动作结果的期待效应最大化。

- 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.

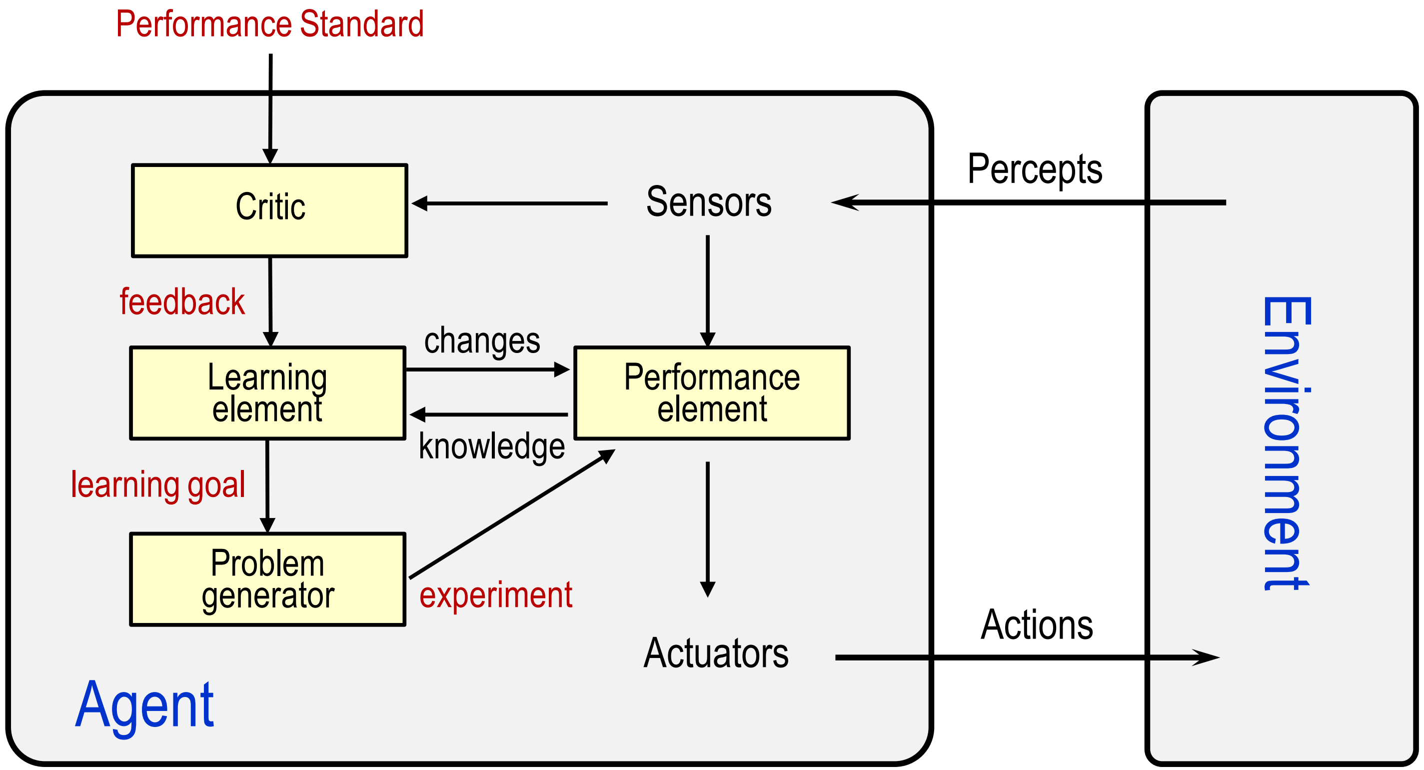
  一个基于效用的智能体需要建模并记录环境、任务的轨迹，这涉及大量的感知、表征、推理、和学习的研究。

2.5. Category of Intelligent Agents

Contents:

Structure of Learning Agents 学习智能体的结构

- Learning allows the agents to initially operate in unknown environments and to become more competent than its initial knowledge.
  学习允许智能体最初在未知的环境中运行，并且与其最初的知识相比，会变得越来越胜任。



About Learning Agents 关于学习智能体

- **Learning element** 学习要素

  It uses feedback from the “Critic” on how the agent is doing, and determines how the performance element should be modified to do better in the future.

  它利用评论者对智能体如何动作的反馈，然后决定应该如何修改性能要素以便未来做得更好。

- **Performance element** 性能要素

  It is what we have previously considered to be the entire agent: it takes in percepts and decides on actions.

  它是我们曾考虑过的什么是完整的智能体：它获得感知并且决定动作。

- **Problem generator** 问题发生器

  It is responsible for suggesting actions that will lead to new experiences.

  它对推荐的动作负责，这将形成新的经验。

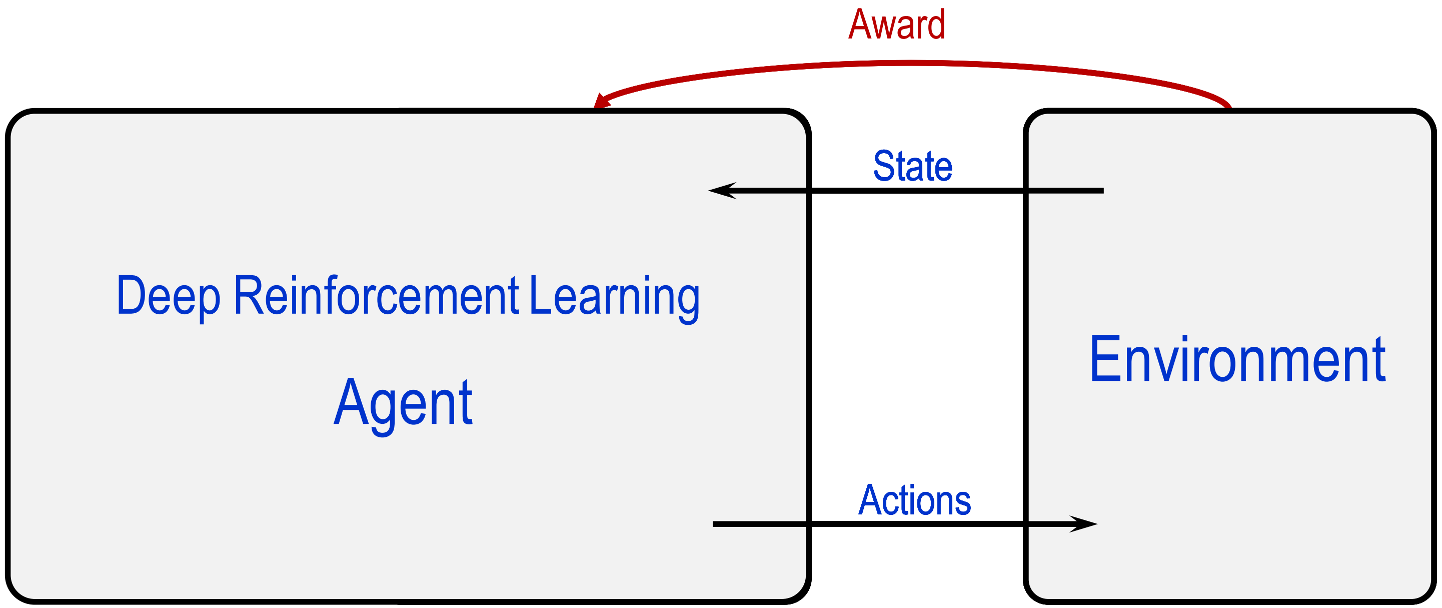
Example: Deep Reinforcement Learning 深度强化学习

- DeepMind has been getting superhuman performance on certain Atari games, by deep reinforcement learning.

  DeepMind采用深度强化学习的方法，在某些Atari游戏上，已超过人类玩家的水平。

- Their new agent architecture outperforms all previous approaches.

  他们新的智能体架构的性能超过了以往的所有方法。



AI

2.5. Category of Intelligent Agents

Contents:

Other Intelligent Agents 其它智能体

Some of the sub-agents not already mentioned above may be a part of an intelligent agent or a complete intelligent agent:

前面尚未介绍的某些子智能体也许是智能体的一部分，或者是一个完整的智能体：

- **Decision Agents** 决策智能体

  geared to decision making.

  与决策制定相关。

- **Input Agents** 输入智能体

  process and make sense of sensor inputs.

  处理和理解感受器的输入。

- **Processing Agents** 处理智能体

  solve a problem like speech recognition.

  解决诸如语音识别的问题。

Other Intelligent Agents 其它智能体

- **Spatial Agents 空间智能体**

  relate to the physical real-world.

  与物理现实世界相关联。

- **Temporal Agents 时间智能体**

  may use time based stored information to offer instructions (or data acts) to a computer program (or human being), and takes program inputs percepts to adjust its next behaviors.

  可以使用基于时间的信息来提供指令（或数据动作）给计算机程序（或人类），然后接收程序输入感知来调整下一步行为。

- **World Agents 世界智能体**

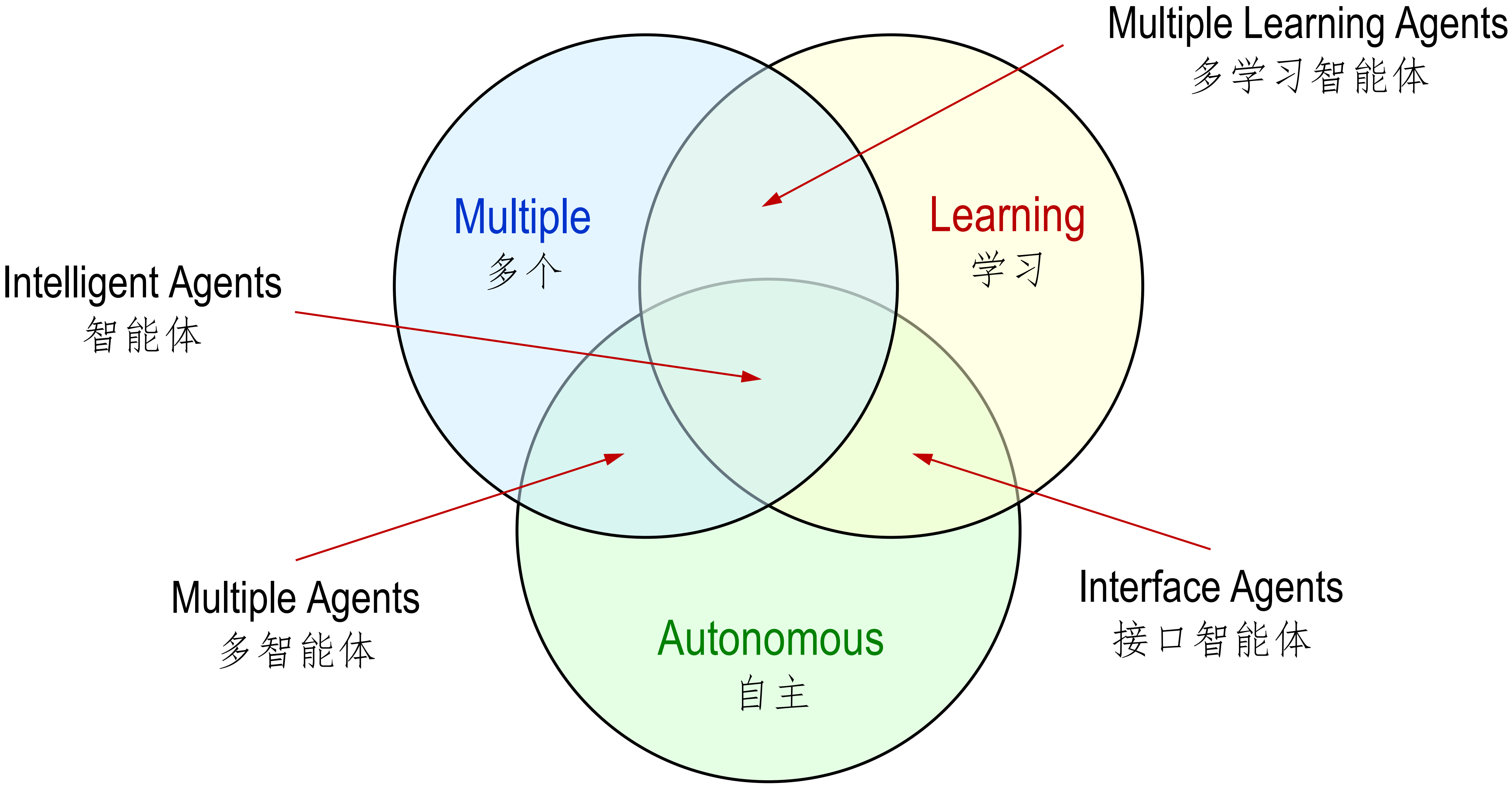
  incorporate a combination of all the other agents to allow autonomous behaviors.

  并入所有其它智能体的组合以便允许自主行为。

Other Intelligent Agents 其它智能体

- Believable agents 可信智能体
  exhibiting a personality via the use of an artificial character (the agent is embedded) for the interaction.
  可信智能体：通过利用交互的（智能体所嵌入的）人工特性展示个性。
- Shopping Agent 购物智能体
- Customer Help Desk 客户服务台
- Personal Agent 个人智能体
- Data-mining Agent 数据挖掘智能体

A Perspective for Agents 智能体的视角



A Taxonomy of Agents 智能体的分类法