Planning Problems

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Contents

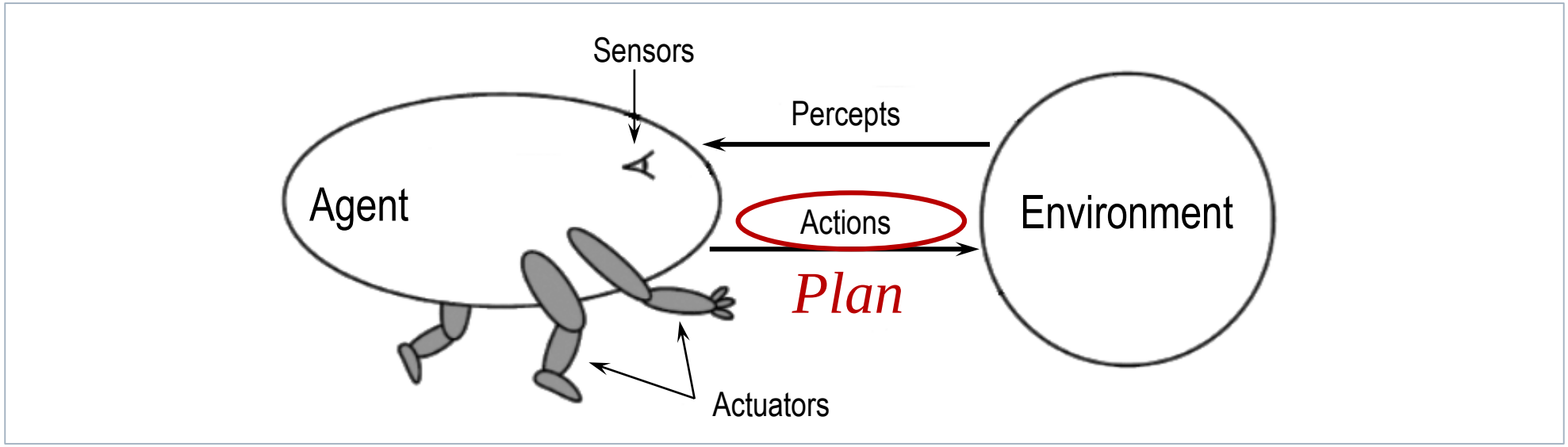
What is Planning 什么是规划

- We have defined AI as the study of rational action. Action is a critical part for an intelligent agent.

  我们已经把人工智能定义为理性动作的研究。动作是智能体的一个关键部分。

- Planning means devising a plan of action to achieve one's goals.

  规划意味着制定一套行动计划来达到既定的目标。



What are Planning Problems 什么是规划问题

- A longer definition 较长的定义

  given the descriptions for a problem in the real world:

  给定现实世界中一个问题的描述：

  - the initial states, the desired goals, and the possible actions,

    初始状态、预期目标、和可能的动作，

  planning is to find a plan that is generating a sequence of actions that leads from any of the initial states to one of the goal states.

  规划是找到一个计划：它产生从任何初始状态到达一个目标状态的一系列动作。

- A shorter definition 较短的定义

  devising a plan of action to achieve one's goals.

  制定一个达到既定目标的行动计划。

What is Classical Planning 什么是经典规划

Classical planning has following features:

经典规划具有如下特征：

- fully observable 完全可观测
- a unique known initial state 唯一已知初始状态
- static environments 静态环境
- deterministic actions 确定性的动作
- can be taken only one at a time 每次仅一个动作
- a single agent 单一智能体

Simplest planning known as Classical Planning

简单规划被称为经典规划

Planning Difficulties 规划的难度

Properties 特性	Questions 问题
actions 动作	• deterministic or nondeterministic? 确定性还是不确定性 • have a duration? 有一段持续时间 • can take concurrently or only one at a time? 可并发执行还是串行
state variables 状态变量	• discrete or continuous? 离散还是连续
initial states 初始状态	• finite or arbitrarily many? 有限还是任意多
objective 目标	• to reach a designated goal state? 要达到指定的目标状态 • to maximize a reward function? 要最大化回报函数
agents 智能体	• only one or several? 仅一个还是多个 • cooperative or selfish? 合作还是单干

Problem-solving Agent vs. Planning Agent 问题求解智能体与规划智能体

	Problem-solving agent 问题求解智能体	Planning agent 规划智能体
State (Initial / Goal) 状态（初始/目标）	Atomic representation 原子表示	Factored representation 因子表示 -- collection of variables 变量的集合
Action 动作	Instantiated actions 实例化动作	Actions schemas 动作模式 -- use Planning Domain Definition Language (PDDL) 使用规划领域定义语言PDDL
Heuristic 启发法	Domain-specific heuristics 领域特定启发法	Domain-independent heuristics 领域无关启发法

About PDDL 关于PDDL

- PDDL (Planning Domain Definition Language) is an attempt to standardize AI planning languages. First developed in 1998.

  PDDL（规划领域定义语言）是对AI规划语言标准化的一种尝试。于1998年首次开发。

- The latest version is PDDL 3.1 (2011), its BNF syntax definition can be found from the IPC-2014 homepage:

  最新版是PDDL 3.1 (2011)，其BNF语法定义可以从IPC-2014主页找到：

  https://helios.hud.ac.uk/scommv/IPC-14/software.html

The PDDL used in this course 本课程使用的PDDL

- It select a simple version, and alter its syntax to be consistent with the rest of the course.

  选择了最简单的版本，并且修改了其语法，以便与课程的其它部分保持一致。

Three Components to Define a Planning Task 定义规划任务的三个要素

State 状态

- represented as a conjunction of fluents (fluents: a relation that varies from one to next).
  表示为变数的合取（fluents：从一个到另一个变化的关系）。
  e.g., $At(Truck_1, Melbourne) \wedge At(Truck_2, Sydney)$.

Actions 动作

- described by a set of action schemas, implicitly define the functions.
  用一组动作模式描述，隐式定义函数。
  e.g., $\text{ACTION}(s)$, $\text{RESULT}(s, a)$.

Goal 目标

- represented as a conjunction of literals (literals: an elementary proposition).
  表示为文字的合取（literals：一个基本的命题）。
  e.g., $At(p, SFO) \wedge Plane(p)$.

Example 1: Air cargo transport 航空货物运输

- Problem: 问题

  To load cargo, then fly, and unload it. 装货、然后飞行、再卸货。

  - from SFO (San Francisco Airport) to JFK (New York John Fitzgerald Kennedy Airport).
    从SFO（旧金山机场）到JFK（纽约约翰·菲茨杰拉德·肯尼迪机场）。
- Actions: 动作
  - $Load(.)$
  - $Unload(.)$
  - $Fly(.)$
- Predicates: 谓词
  - $In(c, p)$ -- cargo c is inside plane p, 货物c在飞机p内,
  - $At(x, a)$ -- object x (either plane or cargo) is at airport a. 物体x（飞机或货物）在机场a。

Example 1: Air cargo transport 航空货物运输

$Init(At(C_1, SFO) \land At(C_2, JFK) \land At(P_1, SFO) \land At(P_2, JFK) \land Cargo(C_1) \land Cargo(C_2) \land Plane(P_1) \land Plane(P_2) \land Airport(JFK) \land Airport(SFO))$

$Goal(At(C_1, JFK) \land At(C_2, SFO))$

$Action(Load(c, p, a),$
PRECOND: $At(c, a) \land At(p, a) \land Cargo(c) \land Plane(p) \land Airport(a)$
EFFECT: $\neg At(c, a) \land In(c, p))$

$Action(Unload(c, p, a),$
PRECOND: $In(c, p) \land At(p, a) \land Cargo(c) \land Plane(p) \land Airport(a)$
EFFECT: $At(c, a) \land \neg In(c, p))$

$Action(Fly(p, from, to),$
PRECOND: $At(p, from) \land Plane(p) \land Airport(from) \land Airport(to)$
EFFECT: $\neg At(p, from) \land At(p, to))$

A PDDL description for the air cargo transportation planning problem
针对航空货物运输规划问题的PDDL描述

Example 1: Air cargo transport 航空货物运输

Solution 解答

$$[Load(C_1, P_1, SFO), Fly(P_1, SFO, JFK), Unload(C_1, P_1, JFK),$$
$$Load(C_2, P_2, JFK), Fly(P_2, JFK , SFO), Unload(C_2, P_2, SFO)]$$

Spurious action 谬误动作

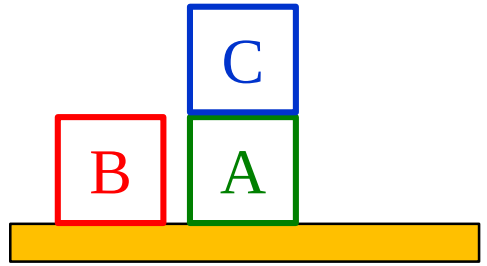
$$Fly(P_1, JFK, JFK)$$

Contradictory effect 矛盾作用

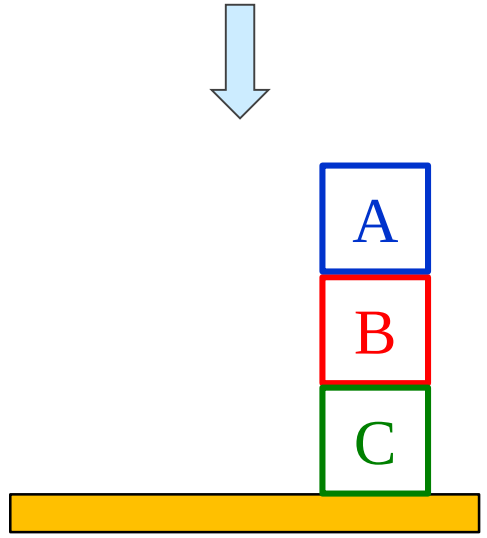
$$At(P_1, JFK) \wedge \neg At(P_1, JFK)$$

Example 2: The blocks world 积木世界

- Problem: 问题
  - three blocks sitting on a table, the goal is to get block A on B, and block B on C.
    桌子上放着三块儿积木，目标是使积木A放在B、并且B放在C上。
- Actions: 动作
  - *Move*(.), *MoveToTable*(.)
- Predicates: 谓词
  - *On*(b, x) -- block b is on x (either another block or table)
    积木b在x上（其它积木或桌子）
  - *Clear*(x) -- true when nothing is on x.
    当x上空无一物时为真。



Start State



Goal State

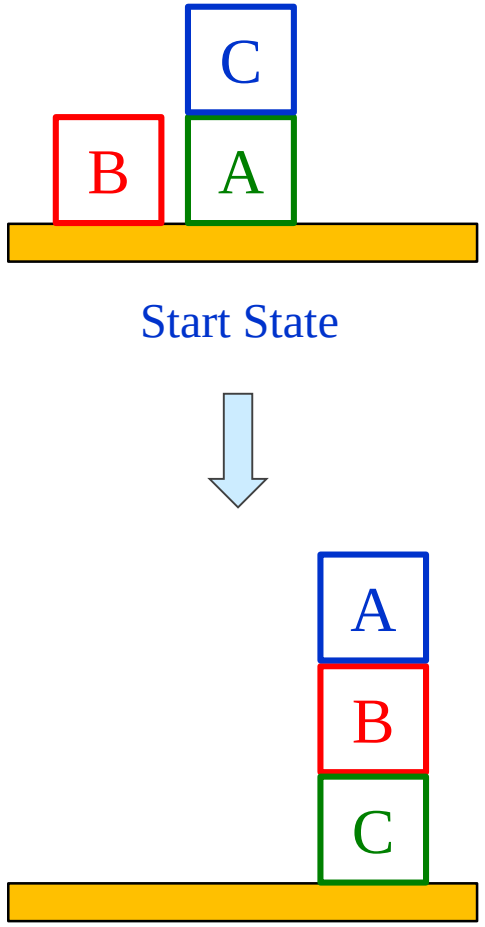
Example 2: The blocks world 积木世界

$Init(On(A, \text{Table}) \land On(B, Table) \land On(C, A)$
$\land Block(A) \land Block(B) \land Block(C) \land Clear(B) \land Clear(C))$

$Goal(On(A, B) \land On(B, C))$

$Action(Move(b, x, y),$
PRECOND: $On(b, x) \land Clear(b) \land Clear(y) \land$
$Block(b) \land Block(y) \land$
$(b \neq x) \land (b \neq y) \land (x \neq y),$
EFFECT: $On(b, y) \land Clear(x) \land \neg On(b, x) \land \neg Clear(y))$

$Action(MoveToTable(b, x),$
PRECOND: $On(b, x) \land Clear(b) \land Block(b) \land (b \neq x),$
EFFECT: $On(b, Table) \land Clear(x) \land \neg On(b, x))$



A PDDL description for the blocks world problem
针对积木世界问题的PDDL描述

Thank you for your attention!

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