Real-World Planning

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Contents

Classical planning vs. Hierarchical planning 经典规划和分层规划

Classical planning 经典规划

- feature: a fixed set of actions.

  特征：一组固定的动作

- problem: a state-of-the-art algorithms can generate solutions containing thousands of actions.

  问题：最新式的算法可以生成包含数千个动作的解。

Hierarchical planning 分层规划

- feature: decompose high-level, abstract tasks into low-level, concrete tasks.

  特征：将高层、抽象的任务分解为低层、具象的任务

- benefit: at each level of the hierarchy, a computational task is reduced to a small number of activities, so the computational cost is small.

  益处：在层次结构的每一级，计算任务被缩减为少量活动，因此计算成本也减少。

Primitive action and High-level action 基本动作和高层动作

Primitive action 基本动作

- Means the actions in classical planning, with standard precondition - effect schemas.
  指的是经典规划中的动作，具有经典的前提-效用模式。
- Has no refinements.
  没有提炼过程。

High-level action (HLA) 高级动作 (HLA)

- Key additional concept for hierarchical task networks (HTN) planning.
  层次任务网络 (HTN) 规划中的重要概念。
- Each HLA has one or more possible refinements, each of which may be an HLA, or a primitive action.
  每个HLA有一个或多个可能的提炼，每个动作可以是一个HLA、或一个基本动作。

Example: Refinement 提炼

- The action is “Go to San Francisco airport”, represented formally as:
  该动作是“去旧金山机场”，形式化表示为：

$$Go(Home, SFO).$$

- May have two possible refinements: 1) drive a car to get to the airport, or 2) take a taxi to get to the airport.
  可以有两种可能的提炼：1）开车去机场，或 2）打车去机场。

Refinement(*Go*(*Home*, *SFO*),
STEPS: [*Drive*(*Home*, *SFOLongTermParking*), *Shuttle*(*SFOLongTermParking*, *SFO*)])

Refinement(*Go*(*Home*, *SFO*),
STEPS: [*Taxi*(*Home*, *SFO*)])

What is multi-agent planning 什么是多智能体规划

- So far, we have assumed that only one agent is doing the planning.
  迄今为止，我们假设仅有一个智能体在做计划。
- When there are multiple agents in the environment, each agent faces a multi-agent planning problem in which it tries to achieve its own goals with the help or hindrance of others.
  当环境中有多个智能体时，每个面临多智能体规划问题，试图通过其他智能体的帮助或阻碍达到自己的目标。
- This planning involves coordinating resources and activities of multiple agents.
  这种多智能体规划涉及多个智能体之间协调资源和活动。
- The topic also involves how agents can do this in real time while executing plans (distributed continual planning).
  该主题也涉及到多个智能体在执行计划（分布式连续规划）时如何能够实时动作。

Single-agent vs. Multi-agent problem 单智能体与多智能体问题

Single-agent problem 单智能体问题

- Multi-effector 多效用器

  an agent with multiple effectors that can operate concurrently,

  e.g., a human who can type and speak at the same time.

  一个智能体有多个可以并发运行的效用器。例如，一个人可以同时一边打字一边说话。

- Multi-body 多躯体

  effectors are physically decoupled into detached units, but act as a single body,

  e.g., a fleet of delivery robots in a factory.

  效应器物理分解为独立的单元，但是作为一个躯体动作。例如，工厂里的传送机器人机群。

Multi-agent problem 多智能体问题

- multiple agents coordinate the resources and actions.

  多智能体之间协调资源与动作。

Characteristics of multi-agent 多智能体的特性

- Autonomy: 自主性

  the agents are at least partially independent, self-aware, autonomous.

  这些智能体至少是部分独立、自我意识的、自主的。

- Local views: 局部视野

  no agent has a full global view of the system, or the system is too complex for an agent to make practical use of such knowledge.

  没有智能体对系统具有全局视野，或者系统太复杂，一个智能体无法实际使用这些知识。

- Decentralization: 分散化

  no designated controlling agent, for each agent may need to include communicative actions with other bodies.

  不指定控制智能体，每个智能体可能需要包含与其它躯体进行沟通的动作。

  - e.g., multiple reconnaissance robots. 例如：多机器人侦查。

Issues in Multi-agent Planning 多机器人规划中的问题

- The clearest case of a multi-agent problem is when the agents have different goals.
  多智能体问题最明显的案例是这些智能体具有不同目标时。
- The issues in multi-agent planning can be divided roughly into two sets:
  多智能体规划中的问题可以大致分为两类：
  - 1) involving issues of representing and planning for multiple simultaneous actions.
    多同步动作的表示与规划所涉及的问题。
    - these occur in all settings from multi-effector to multi-agent planning.
      这些问题从多效应器到多智能体规划的所有状况下都会发生。
  - 2) involving issues of cooperation, coordination, and competition arising in true multi-agent settings.
    真正的多智能体环境中所发生的合作、协调和竞争的问题。

1) Planning with multiple simultaneous actions 具有多同步动作的规划

- **Actor** 行动者

  a generic term to cover effectors, bodies, and agents.

  一个涵盖效用器、躯体和智能体的通用术语。

- **Multi-actor** 多行动者

  a generic term to treat multi-effector, multi-body, and multi-agent.

  一个涉猎多效用器、多躯体、以及多智能体的通用术语。

- **Multiple simultaneous actions** 多同步动作

  for multi-actor, to work out how to define:

  对于多行动者，要解决如何定义：

  - transition models, correct plans, and efficient planning algorithms.

    迁移模型、正确的规划、以及有效的规划算法。

Example: Doubles tennis problem 双打网球问题

$$
\begin{aligned}
&\mathit{Actors}(A, B)\\
&\mathit{Init}(\mathit{At}(A, \mathit{LeftBaseline}) \land \mathit{At}(B, \mathit{RightNet}) \land\\
&\qquad \mathit{Approaching}(\mathit{Ball}, \mathit{RightBaseline})) \land \mathit{Partner}(A, B) \land \mathit{Partner}(B, A)\\
&\mathit{Goal}(\mathit{Returned}(\mathit{Ball}) \land (\mathit{At}(a, \mathit{RightNet}) \lor \mathit{At}(a, \mathit{LeftNet}))\\
&\mathit{Action}(\mathit{Hit}(\mathit{actor}, \mathit{Ball}),\\
&\qquad \text{PRECOND}: \mathit{Approaching}(\mathit{Ball}, \mathit{loc}) \land \mathit{At}(\mathit{actor}, \mathit{loc})\\
&\qquad \text{EFFECT}: \mathit{Returned}(\mathit{Ball}))\\
&\mathit{Action}(\mathit{Go}(\mathit{actor}, \mathit{to}),\\
&\qquad \text{PRECOND}: \mathit{At}(\mathit{actor}, \mathit{loc}) \land \mathit{to} \neq \mathit{loc},\\
&\qquad \text{EFFECT}: \mathit{At}(\mathit{actor}, \mathit{to}) \land \neg \mathit{At}(\mathit{actor}, \mathit{loc}))
\end{aligned}
$$

- Two actors A and B are playing together. 两个行动者A和B一起打球。
- They can be in one of four locations: 他们可以位于四个位置中的一个：
  LeftBaseline, *RightBaseline*, *LeftNet*, and *RightNet*.
- The ball can be returned only if a player is in the right place. 只有当球手位于正确的地方时才可以回球。
- Each action must include the actor as an argument. 每个动作必须包含该行动者作为参数。

2) Planning with multiple agents 具有多智能体的规划

Cooperation and coordination are the feature of multiple agents planning.

合作与协调是多智能体规划的特征。

- **Convention** 协定

  A convention is any constraint on the selection of joint plans.

  It is an option to adopt a convention before engaging in joint activity.

  协定是选择联合计划时的约束。在参与联合行动之前，通过一项协定是一个选项。

- **Communication** 通信

  Agents use it to achieve common knowledge of a feasible joint plan.

  智能体用它来获得可行的联合计划的共同知识。

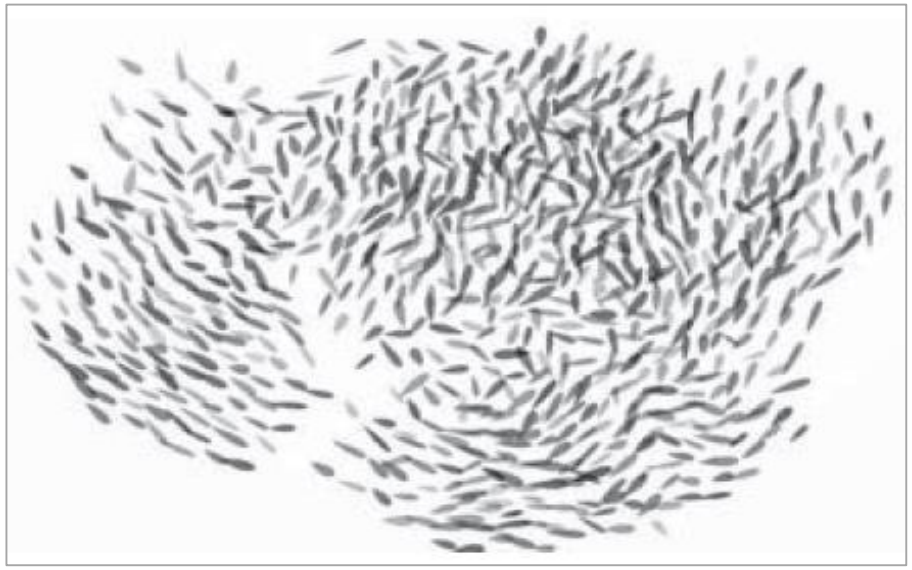
- **Plan recognition** 规划认可

  It is the approach to coordination works to determine a joint plan unambiguously.

  是进行协调工作的方法，用来明确地决定一个联合计划。

Example: Cooperative behavior in flock of birds 鸟群中的合作行为

(a)



(b)

(a) An actual flock of birds. 一个实际的鸟群。

(b) A simulated flock of birds using Reynold's boids model. 用Reynold的boids模型模拟的鸟群。

Particle Swarm Optimization 粒子群优化

Reynold's Boids Model 雷诺的Boids模型

- Boids is an program, developed by Craig Reynolds in 1986.
  Boids是一个程序，由克雷格·雷诺于1986年研发。
- Boids simulates the flocking behavior of birds. The rules in Boids are as follows:
  Boids仿真鸟群的群体行为。Boids中的规则如下：

Rule 规则	Score 成绩	Behavior 行为
Cohesion 聚集	a positive one 正值	getting closer to the average position of the neighbors 接近相邻鸟的平均位置
Separation 分离	a negative one 负值	getting too close to any one neighbor 过于接近任一个相邻的鸟
Alignment 对齐	a positive one 正值	getting closer to the average heading of the neighbors 接近相邻鸟的平均航向

Thank you for your attention!

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