Plan Recognition for Behavior Estimation in a Robotic Soccer Player

Douglas Tesch

PUCRS

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RoboCup

Figure: RoboCup

RoboCup

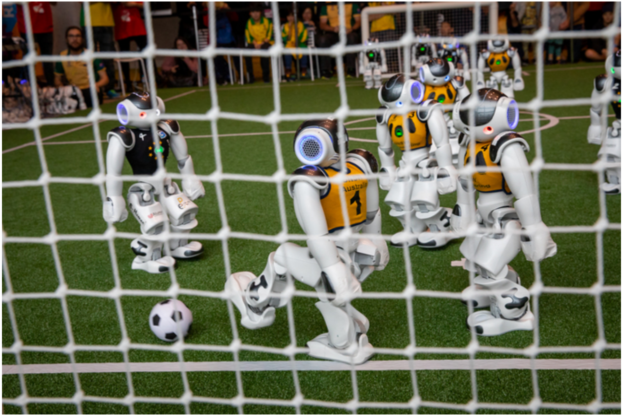

Figure: RoboCup

Plan recognition

Plan recognition is the task of recognizing goals and plans based on often incomplete observations executed by agents and properties of agent behavior in an environment [Sukthankar et al., 2014]

Plan Recognition

Some applications of plan recognition

- traffic monitoring [Pynadath and Wellman, 2013]
- dialog system [Carberry, 1990]
- crime detection and prevention
- military [Agmon et al., 2008]

Plan Recognition

- The plan recognition itself have your formulation in discrete world.
- But in robotic we deal with continuous states (angle, position, velocity)
  - The main method to deal with continuous states is discretization.
  - However, a wrong discretization lead a loss of information [Nash and Koenig, 2013]

Plan Recognition

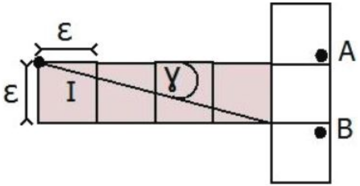

Figure: Example of Discretized Plan Recognition [Kaminka et al., 2018]

The Conclusion

- The planner could define the ϵ discretization ad-hoc.
  - Mirroring

Plan Recognition

- In real robot applications a path is a soft trajectories between states points.
- In a robotic competition, is easy to consider that any team has you own path generation with your own desirable dynamic.
  - Propose: Identify the path generation function.

Plan Recognition

- The cubicle function can generate any trajectory for this problem.

$$
\begin{aligned}
T_x =& A_3^x t^3 + A_2^x t^2 + A_1^x t + A_0^x && (1)\\
T_y =& A_3^y t^3 + A_2^y t^2 + A_1^y t + A_0^y && (2)\\
T_\theta =& A_3^\theta t^3 + A_2^\theta t^2 + A_1^\theta t + A_0^\theta && (3)
\end{aligned}
$$

where t is the real time and A_i^η, $i \in \{0, 1, 2, 3\}$, $\eta \in \{x, y, \theta\}$ are the unknown coefficients.

Plan Recognition

Domain Formulation
A domain theory is a tuple where

$$W = \langle T, V, A, cost_i \rangle \tag{4}$$

- T is a finite set of fluents ex: $T = \{x(r), y(r), \theta(r)\}$.
- V is the set of values.
- A is a set of actions.
- cost is a measure between transformations.
- fluents literal ex: $s = \{x(r) = 10.14,\ y(r) = 7.13,\ \theta(r) = 45^\circ\}$.

Plan Recognition

Problem Formulation
A recognition problem is tuple where

$$R := \langle W, O, I, G \rangle \tag{5}$$

- W is the domain
- O is a sequence of observations
- I is the initial states
- G is a set of goals

Plan Recognition

The main objective is

$$\alpha_R = \underset{\alpha \in W}{\text{argmax}}\, P(\alpha|O) \tag{6}$$

- α is vector $\alpha = \otimes[A_0^\eta, \ldots, A_n^\eta]^T \;\; \eta \in \{x, y, \theta\}$

With Bayes Rules we can compute the $P(\alpha|O)$

$$\begin{aligned} P(\alpha|O) =& \beta P(O|\alpha)P(\alpha) \\ =& \beta P(O|\alpha)P(\alpha|g)P(g), \end{aligned} \tag{7}$$

- where $P(g)$ is a uniform distribution probability that robot is pursuing the goal g

Plan Recognition

The main question in Bayes rule is compute the terms $P(O|\alpha)$ and $P(\alpha|g)$

- $P(O|\alpha)$ - Synthetized a trajectory that passes through the observations and continues until reach g.
- $P(\alpha|g)$ - We can use following approximation

$$\forall g \in G, P(\alpha|g) := \frac{cost_i(\hat{\alpha}_g)}{cost_i(\alpha)}. \tag{8}$$

Plan Recognition

$$\forall g \in G, P(\alpha|g) := \frac{cost_i(\hat{\alpha}_g)}{cost_i(\alpha)}. \tag{9}$$

Possible Cost Function

- Shortest path
- Less time.
- Less battery use.
- A linear combinations of latter options.

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