CSE 591 - FALL 04. HANDOUT 2. VERSION 0.4

Chitta Baral

Department of Computer Science and Engineering
Arizona State University
Tempe, AZ 85287-5406 USA
chitta@asu.edu

http://www.public.asu.edu/∼cbaral/

September 30, 2004

RECAP

Current status

- Autonomous agents have three main parts:
  - representing and reasoning with actions and environment assuming simple goals and plans;
  - representing and understanding complex directives/goals;
  - synthesizing and/or verifying complex plan of actions given in some action execution language.
- We are in the first part and discussed representing and reasoning about actions in the simple language $\mathcal{A}$.
- Next Step: Extend $\mathcal{A}$ to allow expression of relationship between objects in an environment.

REPRESENTING THE ENVIRONMENT

Motivation

- What if fluents in the environment are related?
- Do we need to express it explicitly?
- Example 1: dead *iff* $\neg$ alive
  - Approach 1:
    - In our observations, whenever we say something about *alive* we must say the opposite about *dead*.
    - In addition we need to add:
      shoot **causes** *dead* **if** *loaded*.
  - Approach 2: We just add 'dead *iff* $\neg$ alive' to the agents knowledge and let the agent think through it.

    i.e., need to extend $\mathcal{A}$ (both syntax and semantics).

The language $\mathcal{AR}$ (Kartha and Lifschitz)

- Syntax: In addition to $\mathcal{A}$ we have classical domain constraints of the form:

  always ϕ

  where ϕ is a propositional formula.

- Illustration:

  – *load* **causes** *loaded*

  – *shoot* **causes** $\neg$*alive* **if** *loaded*

  – **initially** $\neg$*loaded*

  – **initially** *alive*

  – **always** *dead* $\Leftrightarrow \neg$*alive*

  We would like to conclude *dead* **after** *load*, *shoot*

- Semantics: Need to define the initial state and the transition function.

  We may have non-deterministic transition.

Semantics of $\mathcal{AR}$

- Valid state: a state that satisfies all the classical constraints.
- Only valid states are candidate for initial states.
- Transition function Φ
  - With constraints transition could be non-deterministic.
    - $toss$ **causes** $tossed$
    - **always** $tossed \Leftrightarrow heads \oplus tails$
    - If you do the action $toss$ in the state $\emptyset$ then intuitively the resulting states may be $\{tossed, heads\}$ or $\{tossed, tails\}$.
    - Note: $\{tossed\}$ is not a valid state. Transitions are from one valid state to one among a set of valid states.
  - How to define the transition:
    - Let $\sigma' \in \Phi(a, \sigma)$. Then σ' must satisfy the following.
      - σ' must be a valid state. (Note: $\sigma \cup E^+(a, \sigma) \setminus E^-(a, \sigma)$ may not be valid state.)
      - $E^+(a, \sigma) \subseteq \sigma'$ must be true.

  - $E^-(a,\sigma) \cap \sigma' = \emptyset$ must be true.
  - σ' must be as close to σ as possible.

- Closeness: Which one between σ_1 and σ_2 is closer to σ.
  $\sigma_1 \leq_\sigma \sigma_2$ iff $((\sigma_1 \setminus \sigma) \cup (\sigma \setminus \sigma_1)) \subseteq ((\sigma_2 \setminus \sigma) \cup (\sigma \setminus \sigma_2))$
- $\Phi(a,\sigma) = \{\sigma' : E^+(a,\sigma) \subseteq \sigma', E^-(a,\sigma) \cap \sigma' = \emptyset$, σ' is valid and there does not exist a valid σ'', which satisfies $\sigma'' <_\sigma \sigma'$ and $E^+(a,\sigma) \subseteq \sigma'', E^-(a,\sigma) \cap \sigma'' = \emptyset$
- Consider the action *shoot* and the state $\sigma = \{alive, loaded\}$
  * $E^+(shoot,\sigma) = \emptyset$; $E^-(shoot,\sigma) = \{alive\}$
  * $(\sigma \cup E^+) \setminus E^- = \{loaded\}$. $\{loaded\}$ is not a valid state.
  * Let $\sigma' = \{dead, loaded\}$. σ' is a valid state.
  * $E^+ \subseteq \sigma'$ and $E^- \cap \sigma' = \emptyset$
  * $\Phi(shoot,\sigma) = \{\sigma'\}$