

Informatics 2D. Tutorial 7

Planning and Acting in the Real World

Week 8

The problem description

This week's tutorial builds on last week's tea making domain. Your personal robotic assistant who helps you make tea has the following information:

- a set of predicates:
 $cup(c)$, $kettle(k)$, $containsWater(x)$ where x is either a cup or a kettle, $containsTeabag(x)$ where x is usually a cup, $waterIsHot()$ which takes no arguments.

- a set of actions: $Action(FillWithWaterFromTap(k))$
 $PRECONDITION : kettle(k) \wedge \neg containsWater(k)$
 $EFFECT : containsWater(k)$

$Action(AddTeabagToCup(c))$
 $PRECONDITION : cup(c) \wedge \neg containsTeabag(c)$
 $EFFECT : containsTeabag(c)$

$Action(PourWaterToCupFromKettle(c, k))$
 $PRECONDITION : kettle(k) \wedge cup(c) \wedge waterIsHot \wedge containsWater(k) \wedge \neg containsWater(c)$
 $EFFECT : containsWater(c)$

$Action(BoilWaterInKettle(k))$
 $PRECONDITION : kettle(k) \wedge \neg waterIsHot() \wedge containsWater(k)$
 $EFFECT : waterIsHot()$

You ask the robot to make you two cups of tea $C1$ and $C2$. This goal state can be represented as follows:

$containsWater(C1) \wedge containsWater(C2) \wedge containsTeabag(C1)$
 $\wedge containsTeabag(C2) \wedge waterIsHot()$

Part 1: Planning with certainty

With an initial state of:

$$kettle(K) \wedge cup(C1) \wedge cup(C2)$$

and everything else being false, since we are operating under a closed world assumption, produce a plan that takes you from the initial state to the goal state described above.

Part 2: Conformant Planning

Assume that your robot does not have complete information about the state of the world at the start of the problem, and has no sensing abilities either. Let's assume that in the initial state the robot knows that K is a kettle, C1 and C2 are cups, but does not know whether any of the containers contain water or tea, or whether or not the water is hot.

1. Represent the agent's *belief state* as a compact logical representation, which expresses the agent's ignorance about predicates by not mentioning them, and by explicitly mentioning everything else in the world whether true or false.
2. Modify the description of your world by introducing new actions or by making changes to existing actions to enable your robot to produce a *conformant* plan, i.e. a plan that works regardless of what the true state of the world is at the start of the problem.
3. Give an example of a conformant plan to make two cups of tea for your updated domain.

Part 3: Contingent Planning

Assume that your robot has incomplete information about the state of the world at the start of the problem, but is equipped with sensing abilities that allow it to detect the true value of the unknown predicates.

1. Add sensing actions to the original domain (which excludes changes you've made in step 2) to allow your agent to produce *contingent* plans that examine the different possibilities for the predicates *containsWater(x)*, *containsTeabag(x)*, and *waterIsHot()*.
2. Let's say that the agent's initial belief state is as follows:

$$kettle(K) \wedge cup(C) \wedge containsTeabag(C) \\ \wedge \neg containsWater(C) \wedge containsWater(K)$$

this means that the agent does not know whether or not the water is hot. Write an example of a contingent plan that should result in a cup of tea in cup C.