

# Logic and Symbolic Robotics

## Exercise Week 9

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1. Express the following facts in predicate logic.

- (a) Every dragon is happy if all its children can fly.
- (b) Green dragons can fly.
- (c) A dragon is green if it is the child of at least one green dragon.

Prove by resolution that the conjunction of 1a 1b and 1c implies: all green dragons are happy. [US]

2. Use resolution to show that the following formula is a tautology.

$$(\forall x P(x) \wedge ((\forall y P(y)) \Rightarrow Q(x))) \Rightarrow \forall x Q(x)$$

Next, use resolution to show that the following formula is a tautology.

$$\exists x P(x) \wedge ((\forall y P(y)) \Rightarrow Q(x)) \Rightarrow \forall x Q(x)$$

Compare the two resolution proofs.

3. Consider Line 7 on Page 330. In what order do we execute actions in a list? From left to right or from right to left?
4. Prove that

- (a)  $Result([a], s) = Result(a, s)$ ,
- (b)  $Result([a_1, a_2, a_3], s) = Result(a_3, Result(a_2, Result(a_1, s)))$ .

5. Consider the possibility and effect axioms involving *Grabbing* and *Holding* on Page 331. Can an agent *Grab* and *Hold* itself?
6. Is the following successor-state axiom adequate for describing the location of the gold  $G_1$  in our simplified wumpus world?

$$Poss(a, s) \Rightarrow (At(G_1, x, Result(a, b)) \Leftrightarrow a = Go(y, x) \vee \neg Holding(g, s))$$

7. Consider the successor-state axiom on Line 3 of Page 333. Are there sufficiently many brackets?

8. This exercise is based on Exercise 10.1 from the Book. We consider the wumpus world again. In this exercise we wish to describe, using situation calculus, the action of shooting an arrow.
  - (a) Develop a consistent vocabulary that is adequate for formulating the possibility axiom and effect axiom involving the shooting. You should take into account the orientation of the agent (or make the *Shoot* action also dependent on an orientation (e.g., *N, S, W, E*)), the status quo of the wumpus (alive, dead or in agony), the location of the arrow (where does it stay after *Shooting*?, and is it re-usable?), the *Haveing* (or *Holding*, it's your choice) of the arrow and maybe other things too. Motivate your choice.
  - (b) Point out in your vocabulary, which are actions, which are situations, which are fluents and which are eternal.
  - (c) Write down the possibility axiom for the *Shooting*.
  - (d) Write down the effect axiom for the *Shooting*.
  - (e) Write down all successor-state axioms involved in the above model.
9. Redo the previous exercise, but now in a slightly different wumpus world. In this new wumpus world, the wind above a pit is that strong, so that an arrow can not be shot over a pit. The wind will just break the velocity and the arrow will fall into the pit.
10. Make Exercise 10.2 from the book.
11. Why do we write actions in such a strange way. E.g., we write *Holding* instead of *Hold*ing.
12. Make Exercise 10.3 from the book.
13. Situation calculus uses *perfect information*, that is, everything is known and modeled. How can it still be used in combination with the *imperfect information* of the agent?