Logic and Symbolic Robotics
Exercise Week 10

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1. Given are the following facts.

   (a) Every barber shaves all persons who do not shave themselves

   (b) No barber shaves any person who shaves himself.

   (c) There are no barbers.

   Formalize 1a and 1b in predicate logic. Use $B(x)$ for "x is a barder", and $S(x, y)$ for "x shaves y". Show by resolution that 1c is a consequence of 1a and 1b.[US]

2. One solution of the frame problem makes use of successor-states axioms. When employing these, they will constitute the effect axioms. Will the KB become inconsistent if both effect and successor-state axioms are added to the KB? Motivate your answer.

3. Reason to the effect that the deciding problem for applicability of an action to a situation is NP-hard. (Hint: consider the 3-colorability as in Figure 9.5.)

4. What are non-monotonic logics?

5. In STRIPS we are discouraged, if not to say disallowed, to use function symbols in our language. There exists a standard way to avoid the use of function symbols according to which a $n+1$-ary predicate symbol $F(\vec{x}, y)$ is used to represent an n-ary function symbol. The idea is, that in the real world holds: $F(\vec{x}, y) \Leftrightarrow f(\vec{x}) = y$.

   (a) Following this approach, an axiom should be included in the KB stating that F is a functional relation. Give this axiom.

   (b) Let $F(x, y)$ represent the unary function symbol $f(x)$. How should we write an equivalent of $P(f(f(f(x))))$.

   (c) We continue on the previous item and now also consider a binary function $g(u, v)$ which is to be represented by a ternary predicate $G(u, v, w)$. How should we write an equivalent of $P(g(f(a), g(f(a), f(b))))$?

6. Consider the Fly action specified in the STRIPS language on Page 377.
   (a) On the third line of the formal specification, is there a closing bracket too many?
   (b) Does the axiom really say that a plane can not fly from one airport to the same airport?
   (c) Can Fly be a transitive relation/action (concerning the last two elements)?
   (d) Chose a KB formulated with situation calculus and successor state axioms that model the Fly action.
7. Does the closed world assumption also apply to the specification of preconditions and effects in the STRIPS language? Motivate your answer.
8. Make Exercise 11.1
9. The ramification problem is hard to solve in a natural way using STRIPS. Consider the problem of dust motes on the airplane whose location you want to keep track of. Show how this can be easily dealt with using the conditional in ADL.
10. Make Exercise 11.2
11. Consider the STRIPS cargo problem from Figure 11.2.
    (a) Translate the problem into situation calculus using possibility and effect axioms
    (b) Translate the problem into situation calculus using possibility and successor state axioms
12. Consider the running example of the introduction of the situation calculus of Section 10.3. Thus, we have a wumpus world (say, 4×4) with only an agent in $[1, 1]$ and the gold in $[1, 2]$. The goal is to get the gold in $[1, 1]$. Describe the problem using STRIPS. Point out where differences and where similarities are with the description in situation calculus.
13. Make Exercise 11.3
14. Consider the ADL specification problem of the spare tire problem from Figure 11.3. Reformulate the problem in STRIPS employing a predicate $Clear(Axle)$ in analogy with the blocks world.
15. From the book we learn that Set of Support resolution is complete whenever the complement of the set of support is satisfiable. Consider the Curiosity proof from Figure 9.12.
    (a) Is this proof a set of support proof?

(b) We now consider the set of support S just being the negation of the goal $Killed(Curiosity, Tuna)$. Is the proof a set of support proof w.r.t. S? Motivate your answer.

(c) If your above answer was no, give proof of $Killed(Curiosity, Tuna)$ using S as your set of support.

(d) Give the definition of an input resolution proof.

(e) Is your proof an input resolution proof.

(f) Is input resolution refutation complete?

(g) Give the definition of linear resolution.

(h) Is linear resolution refutation complete?

(i) Give a linear proof of $Killed(Curiosity, Tuna)$.