Exam for IN4010TU Artificial Intelligence Techniques

23 January 2009

This exam will test your knowledge and understanding of Russell and Norvig, *Artificial Intelligence: A Modern Approach*. Using the book during the examination is *not* allowed. You will have 3 hours (from 9 till 12) to complete the exam. It has 5 questions, for a total of 58 points. Please don't include irrelevant information: you will be marked down for this. Before you hand in your answers, please check that you have put your name and student number on top of every sheet you hand in.

Questions

Question 1 *25 points*

This question is about agent programs, Prolog, and GOAL.

```
main:deliveryAgent
{
   knowledge{
     ordered(C,P) :- order(C,Y), member(P,Y).
     loaded_order(C) :- order(C,O), loaded(O).
     delivered_order(C) :- order(C,O), loc(C,X), loc(O,X), loc(truck,a).
     packed :- setOf(P,in(P,truck),L), size(L,2).
     empty :- setOf(P,in(P,truck),[]).
   }
   beliefs{ home(a).
     loc(p1,a). loc(p2,a). loc(p3,a). loc(p4,a). loc(truck,a).
     loc(c1,b). loc(c2,c). order(c1,[p1,p2]). order(c2,[p3,p4]).
   }
   goals{ delivered_order(c1). delivered_order(c2). ... }
   program{
     if goal(delivered_order(C)),bel(ordered(C,P)),not(bel(in(P,truck)))
       then load(P).
     if goal(delivered_order(C)),
        bel(loc(truck,X), loaded_order(C), loc(C,Y)) then goto(Y).
     if goal(delivered_order(C)), bel(loc(truck,X), loc(C,X),
        in(P,truck), ordered(C,P)) then unload(P).
     if bel(loc(C, X), empty, home(Y)) then goto(Y).
         }
   action-spec{
     load(P){
       pre{not(packed), loc(truck,X), loc(P,X)}
       post{in(P,truck), not(loc(P,X))} }
     goto(Y){
       pre{loc(truck,X), not(X=Y)}
       post{loc(truck,Y), not(loc(truck,X))} }
   ...
   }
}
```

Figure 1: GOAL Agent Program

(a) (3 points) Consider the agent program listed in Figure 1. This program uses a predicate `loc(O,X)` in the belief base to compute the location `X` of an order `O` in the definition of `delivered_order(C)`. Orders are lists of packages, for example, `[p1,p2]` as specified by the fact `order(c1,[p1,p2])`. However, the program does not define a rule to evaluate the location of an order. *Provide a Prolog definition for the predicate* `loc(O,X)` *that can be used to compute the location of an order, if the packages are located at a single location, and that fails otherwise.*[1]

(b) (3 points) Similarly, provide a definition for the predicate `loaded(O)` where `O` is a list of packages, and `loaded(O)` is true when all of the packages in the list are in the truck. In this case, however, make sure that your definition does *not* evaluate `loaded([])` to true.

(c) (6 points) Assuming the definitions of `loc(O,X)` and `loaded(O)` are given, list the actions that can be executed by the GOAL agent given the agent's belief and goal base listed in Figure 1.[2]

[1] You may assume that the basic facts about the location of single packages are given by the facts of the form `loc(p1,b)`. Also, the location of an empty order should return true for arbitrary locations.

[2] The Prolog predicate `member(Elem, List)` succeeds when `Elem` can be unified with one of the members of `List`; the predicate

(d) (8 points) Provide an action specification for the action `unload` that can be added to the action specification section of the GOAL agent.

(e) (5 points) Explain why the GOAL agent may *not* be successful in reaching its goals, i.e. delivering packages to clients. Also, explain why the agent nevertheless may be successful *sometimes*.

Question 2 *8 points*

Consider information type `cards_info` in Figure 2.

```
information type cards_info
  sorts
        CARD, MARK, SUIT;
  objects
        a, k, q, j, 10, 9, 8, 7, 6, 5, 4, 3, 2        : MARK;
        spade, heart, diamond, club                   : SUIT;
  functions
        c                                             : MARK * SUIT → CARD;
  relations
        trump, called_for                             : SUIT;
        >                                             : MARK * MARK;
        outranks                                      : CARD * CARD;
end information type
```

Figure 2: Information type `cards_info`

(a) (2 points) Which of the strings in Table 1 are terms, which are atoms? Which of the terms are well-formed terms? Which of the atoms are well-formed atoms? Motivate your answers briefly.

	term	atom	well-formed
trump(c(a,spade))			
outranks(X: MARK, Y: SUIT)			
outranks(c(2,spade), c(k, spade))			
trump(called_for(diamond))			
called_for(X)			
c(X: MARK, club)			

Table 1: Which are terms, atoms, well-formed?

(b) (6 points) Assume that a ranking of marks has already been given. Provide a representation of the following knowledge: *Given two cards of the same suit, the card with the highest mark outranks the other. Suppose there are two cards c1 and c2 and c1 is of the suit called for, and the suit of c2 differs of that of c1. Then c1 outranks c2 unless c2 is of the trump suit. If c2 is of the trump suit, then c2 outranks c1.*

Question 3 *5 points*

(a) (5 points) What is the added value of a three-valued logic in knowledge representation?

Question 4 *10 points*

This question is about applying Bayes' rule.

(a) (4 points) John flies frequently and likes to upgrade his seat to first class. He has determined that, if he checks in for his flight at least two hours early, the probability that he will get the upgrade

`size(List, Nr)` succeeds when the length of `List` equals `Nr`; finally, the predicate `setOf(P,in(P,truck),List)` succeeds when `List` consists of an alphabetically sorted list of terms that make `in(P,truck)` true and that that does not contain duplicates.

is .75; otherwise, the probability that he will get the upgrade is .35. With his busy schedule, he checks in at least two hours before his flight only 40% of the time. What is the probability that, for a randomly selected trip, John will be able to upgrade to first class?

(b) (6 points) Suppose Susan is like John in the sense that the probability that she will get an upgrade is .75 if she checks in for her flight at least two hours early, and, otherwise, the probability that she will get the upgrade is .35. Now also suppose she did not receive an upgrade on her most recent attempt, and chances she did not are $P(\text{no upgrade}) = .55$ (which means she is not like John in this regard, i.e. she differs in the percentage of checking in at least two hours before a flight, which she only does 25% of the time). What, then, is the probability that she arrived late?

Question 5 *10 points*

This question is about decision theory, more in particular about representing preferences.

(a) (4 points) Provide an argument why it is not rational for an agent to have intransitive preferences, such as $A > B > C > A$ where A is preferred over B, B over C, and C over A.

(b) (6 points) Suppose someone uses a computer system to help clarify her preferences with regards to going on a holiday. Suppose the user has indicated that, generally speaking, she prefers having an active holiday over a cultural holiday. Specifically, she prefers skying over sightseeing. Moreover, again speaking generally, she prefers going to a warm holiday location over going to a cold location. More specifically, she prefers Egypt over Austria. However, she also prefers skying in Austria over skying in Egypt. Can the user's preferences be represented by a function of the following form, where x_1 ranges over holiday types such as a skying holiday and x_2 ranges over locations such as Egypt?

$$V(x_1, x_2) = \sum_i V_i(x_i)$$

Explain why such a function exists, or why there is no such function.

End of exam