COMP-424: Artificial intelligence

Homework 3

Due on *myCourses* on March 14, 2022 at 9:00pm.

General instructions.

- This is an individual assignment. You can discuss solutions with your classmates, but should only exchange information orally, or else if in writing through the discussion board on *myCourses*. All other forms of written exchange are prohibited.
- Unless otherwise mentioned, the only sources you should need to answer these questions are your course notes, the textbook, and the links provided. Any other source used should be acknowledged with proper referencing style in your submitted solution.
- Submit a single pdf document containing all your pages of your written solution on your McGill's *myCourses* account. You can scan-in hand-written pages. If necessary, learn how to combine many pdf files into one.
- You may solve the questions by hand or by writing a program, but if you write a program, you must not rely on existing implementations, and must do it from scratch (and must submit your code along with the pdf).

Question 1: Planning in STRIPS [30]

Adapted from R&N 3rd edition.

The monkey-and-bananas problem is faced by a monkey in a laboratory with some bananas hanging out of reach from the ceiling. A box is available that will enable the monkey to reach the bananas if he climbs on it. Initially, the monkey is at *A*, the bananas at *B*, and the box at *C*. The monkey and box have height *Low*, but if the monkey climbs onto the box he will have height *High*, the same as the bananas. The actions available to the monkey include *Go* from one place to another, *Push* an object from one place to another, *ClimbUp* onto or *ClimbDown* from an object, and *Grasp* or *Ungrasp* an object. The result of a *Grasp* is that the monkey holds the object if the monkey and object are in the same place at the same height.

a. Write down the initial state description.
b. Write the six action schemas.
c. The monkey wants to fool the scientists, who are off to tea, by grabbing the bananas, but leaving the box in its original location. Write down this goal.

Question 2: Designing a Bayesian Network [30]

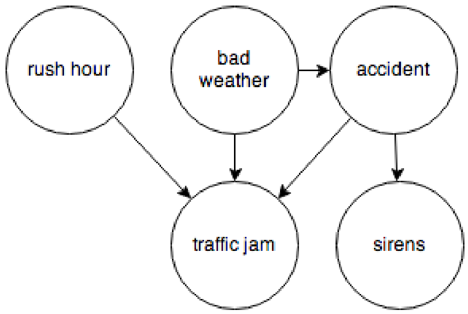
Marv the cat is having a bad day. His brother Harry ate all the food set out by their owner, Shannon, so Marv has to find a way to feed himself. He can try to catch a bird outside, and if he succeeds, he'll eat it. But sometimes, Shannon makes Marv wear a collar with a bell, so that he's less likely to catch a bird. Marv can also try to steal Shannon's sandwich, which does not depend on whether he's wearing a bell. However, even if he succeeds in stealing the sandwich, he might not get to eat it (for example, Shannon may notice and snatch it back). Finally, if Marv manages to eat at least something, he might feel content, in spite of everything. Though if he's wearing the collar, he is less likely to feel content in general (it's rather itchy and uncomfortable).

Consider the Boolean variables: B (Marv wears a bell), C (Marv is content), E (Marv eats at least one item), R (Marv catches a bird), S (Marv steals the sandwich).

a. Draw a Bayesian network for this domain. Only include the Boolean variables listed above, so your network should have 5 nodes.
b. Suppose the probability that Marv catches the bird is x when he wears a bell, and y when it is not. Give the conditional probability table associated with R.
c. Suppose that if Marv catches a bird, he will eat it with probability 1, and if he successfully steals the sandwich, he will eat it with probability 0.5. If he fails at both hunting and stealing, then he will not eat anything. Give the conditional probability table associated with E.
d. Suppose Marv is content. Write down the expression for the probability he caught a bird, in terms of the various conditional probabilities in the network.

Question 3: Inference in Bayesian Networks [40]

Consider the following Bayesian Network



R: rush hour
B: bad weather
A: accident
T: traffic jam
S: sirens

We denote random variables with capital letters (e.g., R for “rush hour”), and the binary outcomes with lowercase letters (e.g., r and ¬r for “it is rush hour” and “it is not rush hour,” respectively).

The network has the following parameters:

$P(b)=0.5$
$P(r)=0.1$

$P(t|r, b,a) = 0.95$
$P(t|r, \neg b,a) = 0.9$
$P(t|r,b,\neg a) = 0.8$
$P(t|r,\neg b,\neg a) = 0.7$
$P(t|\neg r,b,a) = 0.6$
$P(t|\neg r,b,\neg a) = 0.3$
$P(t|\neg r,\neg b,a) = 0.65$
$P(t|\neg r,\neg b,\neg a) = 0.05$

$P(s|a) = 0.75$
$P(s|\neg a) = 0.05$

$P(a|b) = 0.15$
$P(a|\neg b) = 0.05$

Compute the following terms using basic axioms of probability and the conditional independence properties encoded in the above graph.

a. $P(a, \neg r)$
b. $P(b, a)$
c. $P(t \mid b)$
d. $P(r \mid \neg t, \neg s)$