Assignment Six: Reasoning Under Uncertainty

Due: 11:59pm, Monday 2 November 2020.

Solving following problems requires using the `https://aispace.org` belief and decision networks applet (you may need to download the jar file) and/or the Python code at `https://aipython.org/aipython_322.zip` (which now includes reasoning with uncertainty and planning with uncertainty).

This can be done in groups of size 1, 2 or 3. Working alone is not recommended. All members of the group need to be able to explain the group's answer.

Submit your answers in individual files using Canvas. Use proper sentences in your answers.

Ask questions on Canvas discussion board. Feel free to answer them too.

Question One

Consider the domain of house plumbing represented in the diagram of Figure 1.

In this figure, $p1$, $p2$ and $p3$ denote cold water pipes. $p1$ is the pipe coming in from the main water supply. $t1$, $t2$ and $t3$ are taps and $d1$, $d2$ and $d3$ are drainage pipes. The constants *shower* denotes a shower, *bath* denotes a bath, *sink* denotes a sink, and *floor* denotes the floor. There can also be plugs in the sink or in the bath. You can assume that you are in a static situation (i.e., you don't have to worry about time); imagine that you have stumbled in this situation and must reason about it.

Suppose you can observe or query the tap positions, flow out of drain d1, and whether there is water in the sink and bath, and whether there is water on the floor.

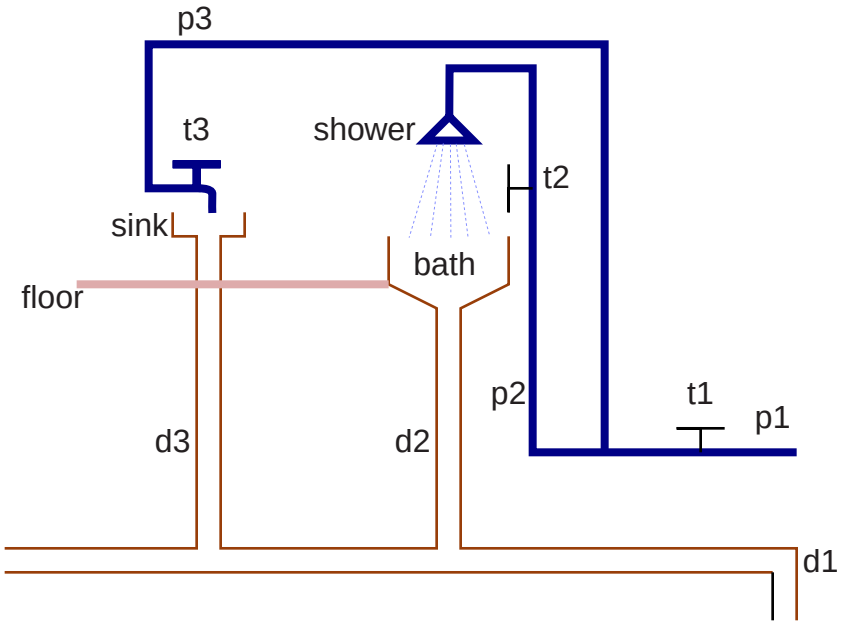

Figure 1: The Plumbing Domain

(a) What are the random variables? In particular, you need random variables to represent the observations you may want to make, the queries you may be interested and other (hidden) variables to keep the model simple. For each variable, give its domain and intended interpretation. Hint: some of the Boolean variables in my solution are $T2\_on$, $P2\_pressurized$, $Shower\_on$, $plug\_in\_bath$, $D2\_flow$, $Bath\_overflowing$, $Floor\_wet$.

(b) Give a belief network for these variables, assuming a causal ordering of the variables. Give reasonable conditional probability tables. You can use the AISpace.org applet, AIPython or any other belief network tool.

(c) Suppose you had to demonstrate to a skeptic that belief networks are appropriate for this domain. Argue that this is a reasonable representation, and as part of your explanation, you need to give some test cases that show what your model is capable of. Use proper English. Be brief and concise (as this skeptic doesn't have much time).

(d) What would your belief network look like if you had chosen the opposite ordering of variables? (Explain, with examples. You don't need to draw the network.)

Question Two

D. Kahneman [Thinking Fast and Slow, 2011, p. 166] gives the following example:

"A cab was involved in a hit-and-run accident at night. Two cab companies, the Green and the Blue, operate in the city. You are given the following data:

- 85% of the cabs in the city are Green and 15% are Blue.
- A witness identified the cab as Blue. The court tested the reliability of the witness in the circumstances that existed on the night of the accident and concluded that the witness correctly identifies each one of the two colours 80% of the time and failed 20% of the time.

What is the probability that the cab involved in the accident was Blue?"

(a) Represent this story as a belief network. Explain all variables and conditional probabilities. What is observed, what is the answer?

(b) Suppose there were three independent witnesses, two of which claimed the cab was Blue and one of whom claimed the cab was Green. Show the corresponding belief network. What is the probability the cab was Blue? (What if all three claimed the cab was Blue?)

(c) Suppose it was found that the two witnesses who claimed the cab was Blue were not independent, but there was a 60% chance they colluded. (What might this mean?) Show the corresponding belief network, and the relevant probabilities. What is the probability that the cab is Blue, (both for the case where all three witnesses claim that cab was Blue and the case where the other witness claimed the cab was Green)?

(d) In a variant of this scenario, Kahneman [p 167] replaced the first condition with: "The two companies operate the same number of cabs, but Green cabs are involved in 85% of the accidents." How can this new scenario be represented as a belief network? Show how it works. Be explicit about any assumptions you make.

Question Three

For each question, specify how long you spend on it, and what you learned. How was the work in the team allocated? Was the question reasonable? (This questions is worth marks, so please do it!)