CPSC 322 **Artificial Intelligence I** **November 2020**

Practice Midterm #2

The exam will be worth 60 marks and take 75 minutes. This means that we expect you should spend one minute per mark (and have 15 minutes at the end to check it over). Each question below has an associated mark, so you can calibrate your timing. Short answer questions require at most two sentences to explain each point, unless they specify otherwise.

You can expect to have questions that arise from the assignments, so look at all of the questions and solutions.

Some important points (that students often forget):

- **Read the question and answer what is asked**. You will not get marks for writing things (whether they are true or not) that are not relevant to the question. Writing extra stuff that is not relevant can only hurt your mark. You can only write what there is space for.
- Use proper English in full sentences. You will not get marks if we cannot work out what you are saying.
- If a question asks about a particular instance of a problem, make sure your answer refers to that instance. Writing a general formula that you may have copied from the Internet is not worth any marks. (The questions are usually asking to apply a formula to a particular case, to make sure you understand it).
- If the question asks for a definition, give the definition in your own words. Don't plagiarize from the textbook. (We are not testing your ability to copy from your notes.) If it doesn't ask for a definition, don't give one. Answer the question specifically to the case at hand, not a generic case. (If someone says "what is on the table?" you don't define what on the table means, nor do you tell them "all of the things in the room that are not on the floor except for the chair and the table", you tell them "there is a cup and two books").

Question 1

Suppose we must solve planning problems for cleaning a house. Various rooms can be dusted (making the room dust-free) or swept (making the room have a clean floor), but the robot can only sweep or dust a room if it is in that room. Sweeping causes a room to become dusty (i.e., not dust-free). The robot can only dust a room if the dustcloth is clean; but dusting rooms that are extra-dusty, like the garage, cause the dustcloth to become dirty. The robot can move directly from any room to any other room.

Assume there are only two rooms, the garage – which, if it is dusty, it is extra-dusty – and the living room – which is not extra-dusty. Assume the following features:

- *Lr_dusty* is true when the living room is dusty.
- *Gar_dusty* is true when the garage is dusty.
- *Lr_dirty_floor* is true when the living room floor is dirty.
- *Gar_dirty_floor* is true when the garage floor is dirty.
- *Dustcloth_clean* is true when the dust cloth is clean.
- *Rob_loc* is the location of the robot.

Suppose the robot can do one of the following actions at any time:

- *move*: move to the other room,
- *dust_lr*: dust the living room (if the robot is in the living room and the living room is dusty),
- *dust_gar*: dust the garage (if the robot is in the garage and the garage is dusty),
- *sweep_lr*: sweep the living room floor (if the robot is in the living room), or
- *sweep_gar*: sweep the garage floor (if the robot is in the garage).

(a) [3 marks] Give the STRIPS representation for *dust_gar*.

(b) [5 marks] Suppose that the initial state is that the robot is in garage, both rooms are dusty but have clean floors and the goal is to have both rooms not dusty. Draw the first two levels (so each path has two actions, so the root has children and grandchildren) of a forward planner showing the actions (but you don't have to show the states).

(c) [4 marks] Pick two of the states at the second level (after 2 actions) and show what is true in those states

(d) [5 marks] Suppose that the initial state is that the robot is in garage, both rooms are dusty but have clean floors and the goal is to have both rooms not dusty. Draw the first two level (with two actions, so the root has children and grandchildren) of a regression planner showing the actions (but you do not have to show what the nodes represent).

(e) [4 marks] Pick two of the nodes at the second level (after 2 actions) and show what the subgoal is at those nodes.

Question 2

Suppose you have a Bayesian network that has the probabilities: $P(A)$, $P(B \mid A)$, $P(C \mid B)$, $P(D \mid A, C)$, $P(E \mid B)$, $P(F \mid E)$.

(a) [5 marks] Draw the belief network that has these conditional probabilities.

(b) [3 marks] Suppose you want to compute $P(d)$. What variables can be pruned?

(c) [7 marks] In the belief network, each variable is Boolean (that is, has domain $\{true, false\}$). $A = true$ is written as a and $A = false$ is written as $\neg a$, and similarly for the other variables. You have the following conditional probabilities:

$$\begin{array}{rclrclrcl}
P(a) & = & 0.8 & P(d \mid a \wedge c) & = & 0.5 & P(e \mid b) & = & 0.9 \\
P(b \mid a) & = & 0.9 & P(d \mid a \wedge \neg c) & = & 0.6 & P(e \mid \neg b) & = & 0.4 \\
P(b \mid \neg a) & = & 0.3 & P(d \mid \neg a \wedge c) & = & 0.7 & P(f \mid e) & = & 0.3 \\
P(c \mid b) & = & 0.9 & P(d \mid \neg a \wedge \neg c) & = & 0.2 & P(f \mid \neg e) & = & 0.8 \\
P(c \mid \neg b) & = & 0.3 & & & & & &
\end{array}$$

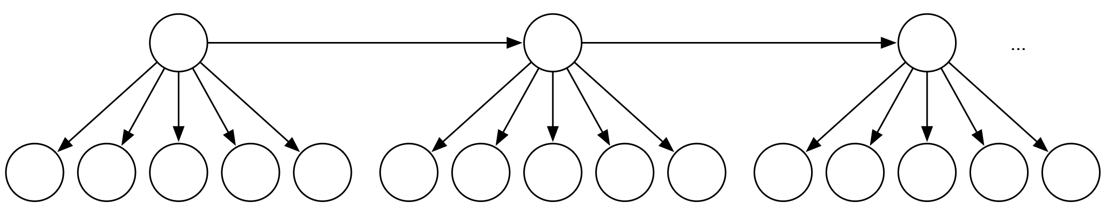
You want to compute $P(d)$ and are going to eliminate A first. What is the resulting factor after eliminating A? You need to show the variables that this is a factor on and you must show the first *three* elements of the factor numerically, but don't simplify them (e.g., you should write them as $0.1 * 0.2 + 0.3 * 0.4 + 0.5$).

(d) [6 marks] Show the remaining factors that are created in computing $P(d)$. For each variable eliminated you need to show what variable was eliminated, show which factors were removed to create the factor, and show the new factor (including which variables the new factor depends on). You do not need to give the numerical values of the factors created, just what variables they depend on.

Variable Eliminated	Factors Removed	Factor Added

Question 3

Suppose Sam built a robot with 5 sensors and wanted to keep track of the location of the robot, and built a hidden Markov model with the following structure (which repeats to the right):



(a) [3 marks] What probabilities does Sam need to provide? (You can label the diagram, if that helps explain your answer.)

(b) [3 marks] What independence assumptions are made in this model?

(c) [3 marks] Sam discovered that the HMM with 5 sensors did not work as well as a version that only used 2 sensors. Explain why this may have occurred.

(d) [4 marks] Suggest a way that this problem could be overcome, so that all 5 sensors could be used effectively.

(e) [3 marks] Use this diagram to explain how intervening is different from observing. Label the diagram as necessary. Your explanation needs to refer to the world (not just the diagram). Hint: explain what intervening would actually do.