COMP4200 / COMP 5430: Artificial Intelligence
Exam 2 (HOME EXAM)
Fall 2019

UMASS - LOWELL

Name: PHONG VO

Student ID: 01790283

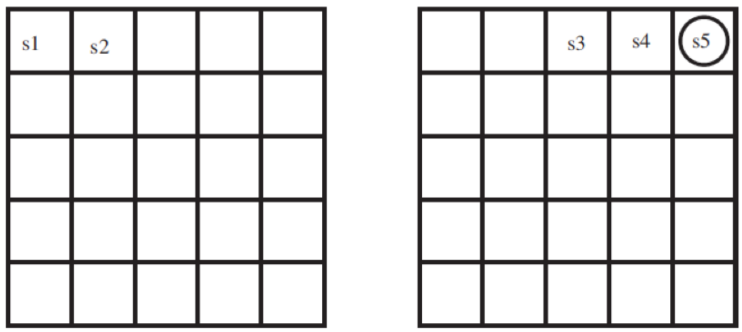
No.	Topic	Points	Scores
1	Reinforcement Learning	15	
2	Bayesian Networks P1	25	
3	Bayesian Networks P2	15	
Total		55	

Instructions:

1. This is a one hour exam.
2. This examination contains 7 pages, including this page.
3. All questions are compulsory;
4. Write your answers in this booklet. If you must write on the back page, please indicate **very** clearly on the front of the page that you have written on the back of the page.
5. This is a take home exam. You may refer to your textbooks but work alone. Detected cheating will be penalised
6. In order to get an points on any question, actual calculations will with the formulas need to be shown.

Question 1: Agent RL

[15 pts] Consider a grid world shown below. The agent can move up, right, down or left. A prize could appear at one of the corners. Monsters (stochastically) attack at certain locations. Suppose that the agent steps through the state space in the order of steps given in the diagram below, (i.e., going from s1 to s2 to s3 to s4 to s5), each time doing a "right" action. In this diagram the right grid represents those states where there is a treasure in the top-right position and the states on the left represent states where there is no treasure.



You should assume that this is the first time the robot has visited any of these states. All Q-values are initialized to zero. Assume that the discount is 0.9.

(a) (2 points) Suppose the agent received a reward of -10 entering state s3 and received a reward of +10 on entering the state s5, and no other rewards. What Q-values are updated during Q-learning based on this experience? Explain what values they get assigned. You should assume that $\alpha_k = 1/k$.

$S1 \xrightarrow{\text{RIGHT}} S2 \Rightarrow Q_{S_1} = \emptyset$

$S2 \xrightarrow{\text{RIGHT}} S3 \Rightarrow Q_{S_2} = -10$

$S3 \xrightarrow{\text{RIGHT}} S4 \Rightarrow Q_{S_3} = \emptyset$

$S4 \xrightarrow{\text{RIGHT}} S5 \Rightarrow Q_{S4} = 10$

$S5 \xrightarrow{\text{RIGHT}} \text{NOWHERE} \Rightarrow Q_{S5} = \emptyset$

$S_{\text{OTHERS}} = \emptyset$

(b) (8 points) Suppose that, at some later time in the same run of Q-learning, the robot revisits the same states: s1 to s2 to s3 to s4 to s5, and has not visited any of these states in between (i.e, this is the second time visiting any of these states). Suppose this time, the agent only receives a reward of +10 on entering the state s5. You should assume that $\alpha_k = 1/k$. What Q-values have their values changed? What are their new values? Do not evaluate arithmetic expressions. Explain the answers.

$S1 \xrightarrow{\text{RIGHT}} S2 \Rightarrow Q_{S_1} = \emptyset + (.9) \times 1 \times \emptyset = \boxed{\emptyset}$

$S2 \xrightarrow{\text{RIGHT}} S3 \Rightarrow Q_{S2} =$

$S3 \xrightarrow{\text{RIGHT}} S4 \Rightarrow Q_{S3} = \emptyset + (.9)(.5)(10) = \boxed{4.5}$

$S4 \xrightarrow{\text{RIGHT}} S5 \Rightarrow Q_{S4} = \boxed{+10}$ (Due to entering S5)

$S5 \xrightarrow{\text{RIGHT}} \text{NOWHERE} \Rightarrow Q_{S5} = \boxed{\emptyset}$

(c) (5 points) Explain what happens in reinforcement learning if the agent always chooses the action that maximizes the Q-value. Suggest two methods to force the agent to explore.

Question 2: Bayesian Networks:Mumps Outbreak

[25 pts] There has been a mumps outbreak in Lowell. You feel fine, but you're worried that you might already be infected and therefore won't be able to enjoy the holidays. You decide to use Bayes nets to analyze the probability that you've contracted mumps.

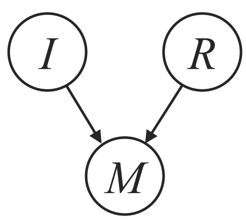
You first think about the following two factors:

- You think you have immunity from mumps ($+i$) due to being vaccinated recently, but the vaccine is not completely effective, so you might not be immune ($-i$).
- Your roommate didn't feel well yesterday, and though you aren't sure yet, you suspect they might have mumps ($+r$).

Denote these random variables by I and R. Let the random variable M take the value $+m$ if you have mumps, and $-m$ if you do not. You write down the following Bayes net to describe your chances of being sick:

I	P(I)
+i	0.8
-i	0.2

R	P(R)
+r	0.4
-r	0.6



I	R	M	P(M|I,R)
+i	+r	+m	0
+i	+r	-m	1.0
+i	-r	+m	0
+i	-r	-m	1.0
-i	+r	+m	0.7
-i	+r	-m	0.3
-i	-r	+m	0.2
-i	-r	-m	0.8

(a) (4 points) Fill in the following table with the joint distribution over I, M, and R, $P(I, M, R)$.

I	R	M	$P(I, R, M)$	
$+i$	$+r$	$+m$	0	
$+i$	$+r$	$-m$	$=(.8)(.4)(1) = .32$	$= P(I)_{+i} * P(R)_{+r} * P(M\|I,R)$
$+i$	$-r$	$+m$	0	
$+i$	$-r$	$-m$	$=(.8)(.6)(1) = .48$	$= P(I)_{+i} * P(R)_{-r} * P(M\|I,R)$
$-i$	$+r$	$+m$	0.056	
$-i$	$+r$	$-m$	$=(.2)(.4)(.3) = .024$	$= P(I)_{-i} * P(R)_{+r} * P(M\|I,R)$
$-i$	$-r$	$+m$	0.024	
$-i$	$-r$	$-m$	$=(.2)(.6)(.8) = .096$	$= P(I)_{-i} * P(R)_{-r} * P(M\|I,R)$

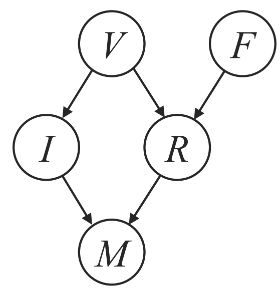
(b) (5 points) What is the marginal probability $P(+m)$ that you have the mumps?

$$P(+m) = P(+i, +r, +m) + P(+i, -r, +m) + P(-i, +r, +m) + P(-i, -r, +m)$$
$$= \varnothing + \varnothing + (.056) + (.024) = \boxed{.08}$$

(c) (5 points) Assuming you do have the mumps, you're concerned that your roommate may have the disease as well. What is the probability $P(+r \mid +m)$ that your roommate has the mumps given that you have the mumps? Note that you still don't know whether or not you have immunity.

$$P(+r \mid +m) = \frac{P(+r \text{ AND } +m)}{P(+m)}$$
$$= \frac{P(-i, +r, +m) + P(+i, +r, +m)}{P(+m)} = \frac{.056 + 0}{.08} = \boxed{.7}$$

You're still not sure if you have enough information about your chances of having the mumps, so you decide to include two new variables in the Bayes net. Your roommate went to a frat party over the weekend, and there's some chance another person at the party had the mumps ($+f$). Furthermore, both you and your roommate were vaccinated at a clinic that reported a vaccine mix-up. Whether or not you got the right vaccine ($+v$ or $-v$) has ramifications for both your immunity (I) and the probability that your roommate has since contracted the disease (R). Accounting for these, you draw the modified Bayes net shown on the right.



(d) (11 points) Indicate, *True / False*, for all the following statements based on the Bayes net shown above: Note there is 1 point for answer and one point for explanation (i.e. where path is blocked /open)

(i) $V \perp M \mid I,\ R$

(ii) $V \perp M \mid R$

(iii) $M \perp F \mid R$

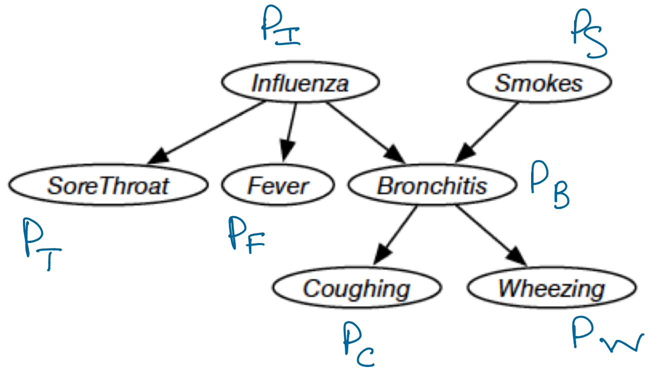
$\boxed{\text{(iv) } V \perp F}$ Because R is given V and F seperately

(v) $V \perp F \mid M$

$\boxed{\text{(vi) } V \perp F \mid I}$

Question 3: Simple Diagnostic Network

[15 pts] Consider the belief network for a “Simple diagnostic system given below. Use the network to answer the following questions.



(a) (2 points) The posterior probabilities of which variables change when Smokes is observed to be true? That is, give the variables X such that $P(X|Smoke = true) \neq P(X)$.

Bronchitis is given Smokes (dependent)
Coughing and Wheezing are given Bronchitis (dependent)
⇒ So, when Smokes is True, then Bronchitis, Coughing and Wheezing will change.

(b) (2 points) Starting from the original network, the posterior probabilities of which variables change when Fever is observed to be true? That is, specify the X where $P(X|Fever = true) \neq P(X)$.

when Fever is True, it causes Influenza change → SoreThroat and Bronchitis change → Coughing and wheezing change.
Smoke has no change.

(c) (2 points) Does the probability of Fever change when Wheezing is observed to be true? That is, is $P(Fever|Wheezing = true) \neq P(Fever)$?

Yes, Wheezing is given Bronchitis which is given Influenza. This causes a changing on Fever.

(d) (2 points) Suppose Wheezing is observed to be true. Does the observing Fever change the probability of Smokes? That is, is $P(Smokes|Wheezing) \neq P(Smokes|Wheezing, Fever)$?

Yes, when Wheezing is True, $P_{Bronchitis}$ is changed.
If Fever (given Influenza) is changed, then Influenza changes → causes Smokes changes because Bronchitis is given Influenza and Smokes.

(e) (2 points) What could be observed so that subsequently observing Wheezing does not change the probability of SoreThroat. That is, specify a variable or variables X such that $P(SoreThroat|X) = P(SoreThroat|X, Wheezing)$, or state that there are none. Explain why.

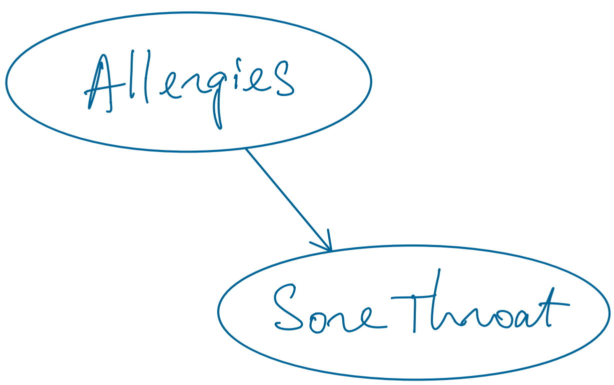
In case of wheezing does not change the $P_{sorethroat}$, means wheezing doesnot change Bronchitis and Influenza.

$P(SoreThroat \mid X) \Rightarrow X = $ Fluenza

(f) (5 points) Suppose Allergies could be another explanation of Sore Throat. Change the network (i.e. Draw the network) so that Allergies also affects Sore Throat but is independent of the other variables in the network . Give reasonable probabilities that shall be added.

Allergies could be another explanation of Sore Throat.

Hence, the graph could be



$P(SoreThroat \mid Allergies) = P(SoreThroat \mid Influenza, Wheezing)$