Fall 2008

CMPT 310: Introduction to Artificial Intelligence — Instructor: Greg Mori

Assignment 4: Probability
Due Nov. 13 at 12:30pm, 32 total marks, worth 5%

This assignment is to be done individually.

Important Note: The univeristy policy on academic dishonesty (cheating) will be taken very seriously in this course. You may not discuss the specific questions in this assignment, nor their solutions with any other student. You may not provide or use any solution, in whole or in part, to or by another student.
You are encouraged to discuss the general concepts involved in the questions in the context of completely different problems. If you are in doubt as to what constitutes acceptable discussion, please ask! Further, please take advantage of office hours offered by the instructor and the TA if you are having difficulties with this assignment.

Question 1

Consider a robot that has only one sensor that can accurately determine whether or not it is currently raining. This robot would like to determine its location using this sensor. Let R denote the boolean random variable that is true if it is raining. Let L (location) denote the discrete random variable that takes values from $< Vancouver, Kyoto, Quillagua >$. Given the following probability distributions:

L	$P(r\|L)$
Vancouver	0.7
Kyoto	0.4
Quillagua	0.1

$P(L = Vancouver)$	0.2
$P(L = Kyoto)$	0.4
$P(L = Quillagua)$	0.4

(a) **2 marks**. State precisely in English what is meant by the formula $P(L = Kyoto) = 0.3$?

(b) **4 marks**. Compute $\mathbf{P}(L|r)$ by using Bayes' Rule with "α normalization", and solving for α.

Question 2

Consider the problem of determining whether a person will attend SFU or not. Define a boolean random variable A (true if the person will attend SFU), discrete random variables P (parents' education level: can take values h for high school or p for post-secondary) and G (current provincial government: can take values g for Green Party, l for Liberal Party, n for NDP), and continuous valued random variables E (current provincial economy size) and T (SFU tuition level).

(a) **4 marks**. Draw a simple Bayesian network for this domain.

(b) **8 marks**. Supply all necessary conditional distributions. Explain your choices of class of distribution.

(c) **2 marks**. Write the factored representation for the joint distribution $\mathbf{P}(A, P, G, E, T)$ that is described by your Bayesian network.

Question 3

Let us extend the model of the robot in Question 1 to include a temporal aspect. In particular, let L_t denote the robot's location at time t and R_t whether the robot senses rain at time t. Define the "transition probabilities", which are the probabilities of the robot being at a particular location at time t given its location at time $t-1$, and the inital state probabilities, as below. Use the same sensor model ($\mathbf{P}(R|L)$) as question 1, repeated below.
We shall make the standard assumptions: L_t is first-order Markov, the measurement of R_t is sensor Markov, and that the process is stationary. i.e. we have an HMM.

$P(L_t\|L_{t-1})$	$L_{t-1} = V$	$L_{t-1} = K$	$L_{t-1} = Q$
$L_t = Vancouver$	0.4	0.3	0.1
$L_t = Kyoto$	0.3	0.6	0.1
$L_t = Quillagua$	0.3	0.1	0.8

L_t	$P(R_t = true\|L_t)$
Vancouver	0.7
Kyoto	0.4
Quillagua	0.1

$P(L_0 = Vancouver)$	0.2
$P(L_0 = Kyoto)$	0.4
$P(L_0 = Quillagua)$	0.4

(a) **6 marks**. Use the Viterbi algorithm to give the most probable path through this HMM (most probable sequence of locations L_0, L_1, L_2) given the evidence $[R_1 = true, R_2 = false]$.

(b) **6 marks**. Compute $\mathbf{P}(L_2|R_1 = true, R_2 = false)$ using the filtering algorithm.

Submitting Your Assignment

This assignment is a written one, and is to be handed in at the beginning of lecture on November 13. Please write legibly or typeset your document using your favourite word processor.