CMPT 310
Artificial Intelligence Survey

Simon Fraser University
Summer 2011

Instructor: Oliver Schulte

Assignment 4: Chapters 14, 15, 18. Probabilistic Reasoning, Learning.

Total Marks: 155.
Due Date: August 5, 10:20 am.

Instructions: Check the instructions in the syllabus. The university policy on academic dishonesty and plagiarism (cheating) will be taken very seriously in this course. *Everything submitted should be your own writing or coding.* You must not let other students copy your work. Discussion of the assignment is okay, for example to understand the concepts involved. If you work in a group, put down the name of all members of your group. On your assignment, put down your **name**, the number of the assignment and the number of the course. Spelling and grammar count.

Handing in the Assignment. Please post your assignment on our course management server https://courses.cs.sfu.ca/1114-cmpt-310-d100/ . Please include text answers and diagrams in a single pdf file. For code, XML files and such, provide a separate archive file. The whole package can be submitted as a .zip file. *The time when you upload your assignment is the official time stamp.*

We also need a printout. Please hand in the printout to the assignment box in CSIL (Computing Science Instructional Lab). *You need an access card for CSIL*. You should put the printout in the assignment box on the due date, but it doesn't have to be by 10:20 am.

Chapter 13, 14. Probabilities and Bayes nets.

1. (10 total) You are a witness of a night-time hit-and run accident involving a taxi in Athens. All taxis in Athens are blue or green. You swear, under oath, that the taxi was blue. Extensive testing shows that under the dim lighting conditions, discrimination between blue and green is 75% reliable. That is, the probability of detecting the right color is 75%.

   I. (5) Is it possible to calculate the most likely color for the taxi? (Hint: distinguish carefully between the proposition that the taxi is blue and the proposition that it appears blue.)

   II. (5) What if you know that 1 out of 10 Athenian taxis is blue?

2. (60 points total) Go to www.aispace.org and start the “belief and decision network” tool. Load the sample file “Simple Diagnostic Problem”. We will use this to test some of the basic probability laws.

   I. (25) Joint Probabilities. Compute the following joint probabilities *up to 6 significant digits.*

   i. Use the product formula of Bayes nets and the conditional probability parameters specified by UBC to compute the probability that: all nodes are true. Don’t do this directly using the tool.
   ii. Use the product formula of Bayes nets and the conditional probability parameters specified by UBC to compute the probability that: all nodes are true except for Sore Throat, and that Sore Throat is false.
   iii. Show how can you use these two joint probabilities to compute the probability that: all nodes other than Sore Throat are true. (Where the value of Sore Throat is unspecified.)
   iv. Verify the product formula:
   P(all nodes are true) =
   P(Sore Throat = true| all other nodes are true) x P(all other nodes are true).
   You can get the first conditional probability by executing a query with the tool.
   v. Compute the probability that Sore Throat is true and that Fever is true. You can use the tool to check your answer, but you should do this using the probability calculus.

   You can enter the computed probabilities in the table below.

Probability to be Computed	Your Result
P(all nodes true)	
P(Sore Throat = False, all other nodes true)	
P(all nodes other than Sore Throat true)	
P(all nodes are true) = P(Sore Throat = true| all other nodes are true) x P(all other nodes are true).	
P(Sore Throat = true, Fever = True)	

   II. Bayes’ Theorem.

   i. (5) Use the tool to compute P(Influenza = True|Wheezing = True).
   ii. (10) Show how you can compute the answer using Bayes’ theorem. You may use the tool to the probabilities that are required for applying Bayes’ theorem. Verify that your calculation and the tool give the the same answer up to round-off.

III. Conditional Independence. If no evidence is observed, Influenza and Smoking are independent.

i. (10) Prove this from the numerical semantics, i.e. show that the values of Influenza and Smokes are independent for all possibilities. You may use queries in the tool to do this.
ii. (10) Prove this from the topological semantics, i.e. using the fact that given values for its parents, a variable is independent of all its nondescendants.

3. (60 pts total) Consider again the 3x3 Wumpus world with pits and breezes from the previous assignment, as discussed in 13.6.

   I. (30) Using the AIspace tool, draw a Bayes net that represents the information about wumpus and stenches. As in Assignment 3, the agent smells a stench on a square if and only if there is wumpus on an adjacent square. Draw a Bayes net that represents this information. This will require 18 Boolean variables. Make the contents of squares the parents of percepts (stenches). So arrows should go in the causal diretion from "there is/is not a wumpus in square[1,2]" to "there is a stench in square[1,3]". The prior probability of a wumpus on any square other than [1,1] is 0.2, and it is 0 on square [1,1]. The conditional probabilities represent that wumpus deterministically imply stenches. Remember the option of editing your Bayes net in a text editor to facilitate copying of similar CP-table entries.

   II. (10) Verify the soundness of your Bayes net by validating the inference "if there is a Wumpus on square [1,3], then there is a stench on square [1,2]". This can be done by executing a query about the probability of there being a stench on square [1,2] given the presence of a Wumpus on square [1,3].

   III. Let us check the difficult inference from the previous assignment in the Bayes net.

   i. (10) Given that the agent perceives a stench at square [1,2], use the query tool to compute the probability p1 = that there is a wumpus in square [1,3]. Intuitively, should p1 be higher or lower than the unconditional probability 0.2? Should this probability be 1, i.e., p1 = 1? Briefly explain your answer.

   ii. (10) Given that the agent perceives a stench at square [1,2], and no stench at square [2,1] use the query tool to compute the probability p2 = that there is a wumpus in square [1,3]. Intuitively, should this be higher or lower than the previous probability, i.e. should p2 > p1? Should this probability be 1, i.e., p2 = 1? Briefly explain your answer.

   What to Submit for this question. Everything specified in the problem, including answers and brief explanations. In addition: A loadable .xml or .bif file for your Bayes net in part 1. A screenshot of your Bayes net and of one of your CP-tables. Also screenshots of your queries.

4. **Learning, Chapter 18. 15 points total.** For definitions and notation see the text. Construct by hand a neural network that computes the XOR function of two inputs. Make sure to specify what sort of units you are using, and which activation functions.

Final Exam Question. 10 points total.

I. Design a question for the final exam.

The purpose is to start you thinking about the course material for the final exam. I will put the best question on the final. This will basically be graded on a pass/fail basis, with some higher points for special creativity, and lower points for lack of effort.