Machine Learning

Simon Fraser University
Fall 2012

Instructor: Oliver Schulte

Assignment 1: Bayes Nets and Probability Laws.

Total Marks: 120. **This assignment will not be graded. I would still like you to hand it in so I can see how the class is doing.**
Due Date: Oct 4, 3 pm.

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/2012fa-cmpt-726-g1/. 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.*

1. (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.

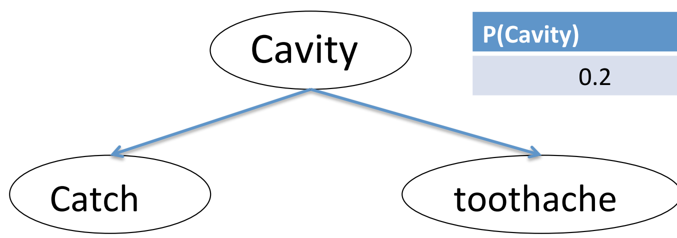
IV. Theory (50)

i. (10) Recall the definition of conditional probability, $P(A|B) = P(A,B)/P(B)$. Prove that conditional probabilities are normalized. That is, if we define $P_B(\bullet) = P(\bullet|B)$, then P_B is a proper probability measure.

ii. (20) Exercise 8.1. in Bishop: Show that the product formula for Bayes nets defines a distribution over joint assignment that satisfies the probability axioms. In particular, the distribution is normalized. Hint: Use induction on the number of nodes in the Bayes net.

iii. (20) Consider the Bayes net shown in the Figure. Find an alternative Bayes net graph with parameters that encodes the **same** distribution as that in the Figure.

Assignment 1 Problem



P(Cavity)
0.2

Cavity	P(Catch|Cavity)
true	0.54
false	0.5

Cavity	P(toothache|Cavity)
true	0.6
false	0.1

Figure 1

III. Programming Prep. (10 marks)

In the *next* assignment you will implement linear basis function regression with polynomial and Gaussian bases. These steps are meant to prepare you for using Matlab so that you can concentrate on the actual problem rather than on the Matlab interface and language.

Start by downloading the code and dataset from the website. The dataset is the AutoMPG dataset from the UCI repository. The task is to predict fuel efficiency (miles per gallon) from 7 features describing a car.

Functions are provided for loading the data1, and normalizing the features and targets to have 0 mean and unit variance.

```
[t,X] = loadData();
X_n = normalizeData(X);
t = normalizeData(t);
```

Make sure you can load the data and call the functions. Observe the transformations. I may ask you to provide printouts of the transformed data.