CSE 150 Programming Assignment #4

Due: June 3, 2016 11:59PM

1 Overview

In this project, you will be implementing inference algorithms for Bayesian networks. The Bayesian networks we use are the "alarm" network shown in **Figure 14.2** (Page 512) of the textbook, and the "guilty" network shown in **Figure 14.23** (Page 563) of the textbook . For the alarm network, you have to perform the exact inference algorithm by hand. For both networks, you have to solve the inference problem using the code you write for three approximate inference algorithms: rejection sampling, likelihood weighting, and Gibbs sampling.

2 Provided Code

We have provided code to construct a Bayesian network. Some basic elements in a Bayesian network, such as `CPT` (conditional probability table), `RandomVariable`, `Sample`, `Edge`, and `Node` classes are provided in `Assignment4.py`. The `BayesianNetwork` class in `BayesianNetwork.py` provides an interface to construct a Bayesian network. All the approximate inference algorithms should also be implemented in this class. The `TestNetwork.py` file shows how to create the alarm network.

You may change the provided code, as long as you do not change the public interface used for testing (in `BayesianNetwork.py`).

3 Requirements

You must implement rejection sampling, weighted sampling, and Gibbs sampling algorithms. The public interfaces of these methods are marked in `BayesianNetwork.py` with "TODO". You must also submit a report, as described below.

1. For the alarm network, manually compute the probability $P(J = 1|B = 0, E = 1)$, show the result and steps you used in the report.
2. For the alarm network, manually compute the probability $P(B = 1|J = 1)$, show the result and steps you used in the report.
3. For the two above queries in the alarm network, perform rejection sampling, likelihood weighting, and Gibbs sampling. Report the following:
   (a) Describe the three sampling algorithms and how you implement them.
   (b) For each algorithm and each query, perform test with at least 5 different reasonably large values for the number of trials parameter, and graph how the estimated probabilities converge to the correct probability.
   (c) How many trials do you need for each method to give an estimate that was reasonably close to the actual probability? How do these methods compare to each other? Discuss your findings.
   (d) Plot the probability of each query vs the number of iterations for all the three algorithms.
4. For the guilty network, compute the query of $P(J = 1|B = 1, M = 0)$ and $P(M = 1|J = 1)$, using the three sampling methods. Repeat 3(b) and 3(c).
5. For the Gibbs sampling algorithm, you must compute $P(Z_i|mb(Z_i))$, where $mb(Z_i)$ denotes the values of the variables in Z_i's Markov blanket. Perform the following:

(a) From the textbook, we learned that in a Bayesian network, a variable is independent of all other variables in the network, given its Markov blanket. Prove this statement and show steps in your report. (Hint: you may use the equation in part (b)).

(b) Explain how do you compute $P(Z_i|mb(Z_i))$ in your report. Prove that:

$$P(Z_i|mb(Z_i)) = \alpha P(Z_i|parents(Z_i)) \times \prod_{Y_{j \in Children(Z_i)}} P(y_j|parents(Y_j))$$

. Show steps in your report.

6. A paragraph from each author stating what their contribution was and what they learned.