Due date: Thursday, November 14, 2024, 2:00 pm. Please create a folder called `assignment9` **in your local working copy of the repository and place all files and folders necessary for the assignment in this folder. Once done with the assignment, add the files and folders to the repo with** `svn add files,folders` **and then commit with** `svn ci -m "SOME USEFUL MESSAGE" files,folders`.

Exercise 9.1 [20 points]
Read chapter "Probabilistic Reasoning" of the textbook.

1. There is an alarm in your local nuclear power station, that senses when a temperature gauge exceeds a given threshold. The gauge measures the core temperature. Consider the Boolean variables A (alarm sounds), F_A (alarm is faulty), and F_G (gauge is faulty), and the multi-valued nodes G (gauge reading) and T (actual core temperature).

   (a) Draw a Bayesian network for this domain, given that the gauge is more likely to fail when the core temperature gets too high.

   (b) Is your network a polytree?

   (c) Suppose there are just two possible actual and measured temperatures, Normal and High; the probability that the gauge gives the correct temperature is x when it is working, but y when it is faulty. Give the conditional probability table associated with G.

   (d) Suppose the alarm works correctly unless it is faulty, in which case it never sounds. Give the conditional probability table associated with A.

   [10 points]

2. This exercise is concerned with the variable elimination algorithm given in Figure 14.11 below.

   (a) Section 13.4/14.4 (3rd/4th edition) in the textbook applies variable elimination to the query

   $\mathbf{P}(Burglary|JohnCalls = true, maryCalls = true)$.

   Perform the calculations indicated and check that the answer is correct.

   (b) Count the number of arithmetic operations performed and compare this with the number performed by the enumeration algorithm.

   (c) Suppose a network has the form of a *chain* – a sequence of Boolean variables $X_1, \ldots, X_n$ where $Parents(X_i) = X_{i-1}$ for $i = 2, \ldots, n$. What is the complexity of computing $\mathbf{P}(X_1|X_n = true)$ using enumeration? Using variable elimination?

   (d) Prove that the complexity of running variable elimination on a polytree network is linear in the size of the tree for any variable ordering consistent with the network structure.

[10 points]

---

function ELIMINATION-ASK(X, **e**, bn) **returns** a distribution over X
   inputs: X, the query variable
          e, observed values for variables **E**
          bn, a Bayesian network specifying joint distribution $\mathbf{P}(X_1, \ldots, X_n)$

   $factors \leftarrow [\,]$
   for each var **in** ORDER(bn.VARS) **do**
      $factors \leftarrow [\text{MAKE-FACTOR}(var, \mathbf{e})|factors]$
      if var is a hidden variable **then** $factors \leftarrow$ SUM-OUT($var, factors$)
   return NORMALIZE(POINTWISE-PRODUCT($factors$))

Figure 14.11   The variable elimination algorithm for inference in Bayesian networks.