# Intelligent Autonomous Agents and Cognitive Robotics
Exercise Sheet 4

1. What are the basic components of a Bayesian network and what are the gains of using a BN?

2. Suppose in a hospital an agent monitoring system keeps track of the blood sugar concentration of patients and alarms the staff if the blood sugar gets too low. The blood sugar gauge measures the blood sugar concentration of a patient.
   a. Derive and draw a Bayesian network for the problem described above and integrate failure model for devices that may fail.

   b. Suppose there are just two possible actual and measured blood sugar concentrations, low and normal. The probability that the gauge gives the correct blood sugar concentration is 0.89 when it is working, but 0.05 when it is faulty. Give the conditional probability table associated with the gauge.

   c. Suppose the alarm and blood sugar gauge are working and the alarm sounds. Derive an expression for the probability that the blood sugar is too high, in terms of the various conditional probabilities in the network.

3. Assume a noisy Or gate model for p(A|E,B). Calculate the probability table by assuming p($\neg$A|E, $\neg$B) = 0.2 and p ($\neg$A|$\neg$E,B)=0.9.
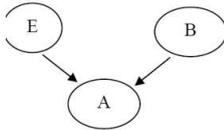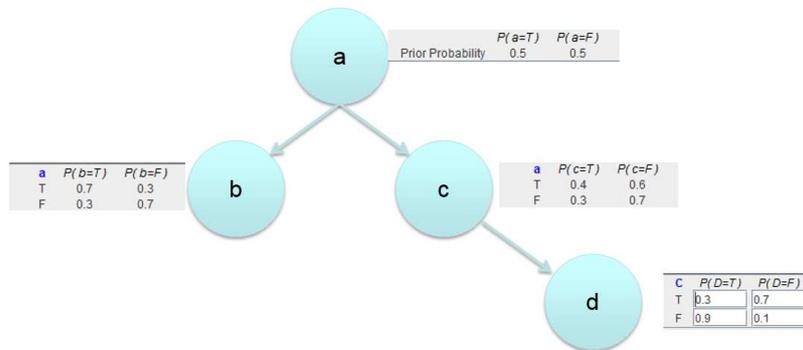

4. In the lecture, we defined the Markov blanket of a node: Parents + children + children's parents. Now, prove that a variable is independent of all other variables in the network given its Markov blanket.

5. Let H_x be a random variable denoting the handedness of an individual x, with possible values l or r. A common hypothesis is that left- or right-handedness is inherited by a simple mechanism; that is, perhaps there is a gene G_x, also with values l or r, and perhaps actual handedness turns out to be the same as the gene an individual possesses. Furthermore, perhaps the gene itself is equally likely to be inherited from either of an individual's parents, with a small nonzero probability rn, of a random mutation flipping the handedness.

   a. Which of the three networks in the following figure claim that
      $$P(G_{father}, G_{mother}, G_{child}) = P(G_{father})P(G_{mother})P(G_{child})?$$
   b. Which of the three networks make independence claims that are consistent with the hypothesis about the inheritance of handedness?
   c. Which of the three networks is the best description of the hypothesis?
   d. Write down the CPT for the G_{child} node in network (a).
   e. Suppose that $P(G_{father} = l) = P(G_{mother}=l) = q$. In network (a), derive an expression for $P(G_{child} = l)$ in terms of m and q only, by conditioning on its parent nodes.

   (a)   (b)   (c)
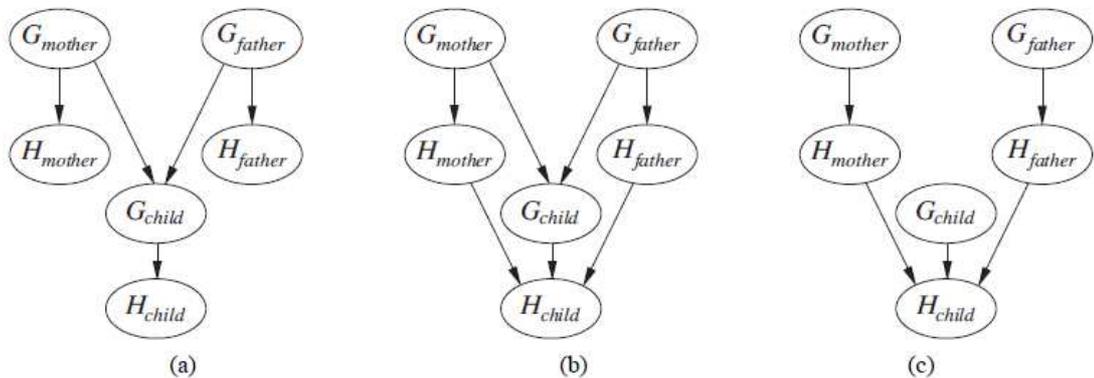
6. Name and explain criteria for simplifying BNs before evaluating a query.

7. Suppose you are given four Boolean random variables a, b, c and d and the following Bayesian Network.

		P(a=T)	P(a=F)
a	Prior Probability	0.5	0.5

a	P(b=T)	P(b=F)
T	0.7	0.3
F	0.3	0.7

a	P(c=T)	P(c=F)
T	0.4	0.6
F	0.3	0.7

c	P(D=T)	P(D=F)
T	0.3	0.7
F	0.9	0.1

a. Write down an expression for computing the distribution of c, nothing given. Also, explain which variables can be eliminated.

b. Write down an expression for computing the probability distribution of b, given a=true and d=true. Also, explain which variables can be eliminated.

c. Write down an expression for computing the probability distribution of b given d=true. Also, explain which variables can be eliminated.