# HW 8

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## 1 Bayesian Belief Networks

a. $P(B = T, E = T) =$

$$\sum_{a \epsilon T,F} \sum_{d \epsilon T,F,X} \sum_{c \epsilon T,F} \sum_{f \epsilon T,F} P(A = a)P(B = T)P(C = c)P(D = d|A = a, B = T, C = c)P(E = T|C = c)P(F = f|D = d)$$

There are 4 binary variables and 1 tertiary variable, so the number of parameters for the full joint is $2^4(3^1) = 48$. There are 23 addends and 120 multiplicands for this calculation.
b. We can group together the variables that depend on each other.

$$\sum_{f \epsilon T,F} P(F = f|D = d) \sum_{d \epsilon T,F,X} P(D = d|A = a, B = T, C = c)P(B = T)$$

$$[\sum_{a \epsilon T,F} P(A = a)]P(E = T|C = c)[\sum_{c \epsilon T,F} P(C = c)]$$

This leaves us with 25 addends and 8 multiplicands, which is more efficient for addition but less efficient for multiplication.

## 2 Pneumonia Diagnosis

a.

- pneumonia = unknown
  - P(fever) = 0.606
  - P(paleness) = 0.504
  - P(cough) = 0.116
  - P(highWBcount) = 0.506
  - P(pneumonia) = 0.02
- pneumonia = true
  - P(fever) = 0.9
  - P(paleness) = 0.7
  - P(cough) = 0.9
  - P(highWBcount) = 0.8
- pneumonia = false
  - P(fever) = 0.6
  - P(paleness) = 0.5
  - P(cough) = 0.1
  - P(highWBcount) = 0.5

b.

$$\frac{P(fever = T|pneu = T)P(paleness = F|pneu = T)P(cough = T|pneu = T)P(highWBcount = F|pneu = T)P(pneu}{P(fever = T)P(paleness = F)P(cough = T)P(highWBcount = F)}$$

$$\frac{0.9(0.3)(0.9)(0.2)(0.02)}{0.606(0.496)(0.116)(0.494)} = 0.0564$$

Therefore, there is a 5.64% chance the patient has pneumonia.

c.

$$\frac{P(fever = T|pneu = T)P(cough = T|pneu = T)P(pneu = t)}{P(fever = T)P(cough = T)}$$

$$\frac{0.9(0.9)(0.02)}{(0.606)(0.116)} = 0.2304$$

Therefore, there is a 23.04% chance the patient has pneumonia.