# Programming Assignment 3

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## Abstract

In this programming assignment, we implemented a Bayesian Network and Rejection Sampling, Weighted Sampling, and Gibbs Sampling with a Markov Blanket.

## 1 Contribution

We worked collaboratively on the project at the same time. We split up typing up the data for this report, while the other person wrote up the calculations. We figured out the calculations by hand together as well as working together to code the sampling algorithms.

## 2 Probability Calculations

### 2.1 Test Case 1 – P(J=1 | B=0, E=1)

P(J = 1 | B = 0, E = 1) = P(J and ~B and E)/P(~B and E) =

(P(J|~B,E,M,A) + P(J|~B,E,M,~A) + P(J|~B,E,~M,A) + P(J|~B,E,~M,~A)) /(P(~B)*P(E)) =

(P(J|A) * P(M|A)*P(A|~B,E) * P(~B) * P(E) + P(J|~A) *P (M|~A) * P(~A|~B,E) * P(~B) * P(E) + P(J|A) * P(~M|A) * P(A|~B,E) * P(~B) * P(E) + P(J|~A) * P(~M|~A) * P(~A|~B, E) * P(~B) * P(E)) / (P(~B) * P(E)) =

((0.9)*(0.7)*(0.29)*(0.999)*(0.002)+(0.05)*(0.01)*(0.71)*(0.999)*(0.002)+(0.9)*(0.3)*(0.29)*(0.999)*(0.002)+(0.05)*(0.99)*(0.71)*(0.999)*(0.002))/((0.999)*(0.002)) = 0.2965

### 2.2 Test Case 2 – P(B=1 | J=1)

P(B = 1 | J = 1) = P(B and J) / P(J) =

(P(B|~E,~A,J,~M) + P(B|~E,~A,J,M) + P(B|~E,A,J,~M) + P(B|~E,A,J,M) + P(B|E,~A,J,~M) + P(B|E,~A,J,M) + P(B|E,A,J,~M) + P(B|E, A, J, M)) / (P(J)) =

(P(J|~A) * P(~M|~A) * P(~A|B,~E) * P(B) * P(~E) + P(J|~A) * P(M|~A) * P(~A|B,~E) * P(B) * P(~E)+P(J|A) * P(~M|A) * P(A|B,~E) * P(B) * P(~E)+P(J|A) * P(M|A) * P(A|B,~E) * P(B) * P(~E) + P(J|~A) * P(~M|~A) * P(~A|B,E) * P(B) * P(E) + P(J|~A) * P(M|~A) * P(~A|B,E) * P(B) * P(E) + P(J|A) * P(~M|A) * P(A|B,E) * P(B) * P(E) + P(J|A) * P(M|A) * P(A|B, E) * P(B) * P(E)) / (P(J)) =

((0.05)*(0.99)*(0.06)*(0.001)*(0.998)+(0.05)*(0.1)*(0.06)*(0.001)*(0.998)+(0.9)*(0.3)*(0.94)*(0.001)*(0.998)+(0.9)*(0.7)*(0.94)*(0.001)*(0.998)+(0.05)*(0.99)*(0.05)*(0.001)*(0.002)+(0.05)*(0.01)*(0.05)*(0.001)*(0.002)+(0.9)*(0.3)*(0.95)*(0.001)*(0.002)+(0.9)*(0.7)*(0.95)*(0.001)*(0.002))/(0.0521) = 0.01630108368

# 3 Sampling Results

## 3.1 Test Case 1 – P(J=1 | B=0, E=1)

For each case, it took about 1,000 trials to get a sample close to the actual result.

### 3.1.1 Sampling

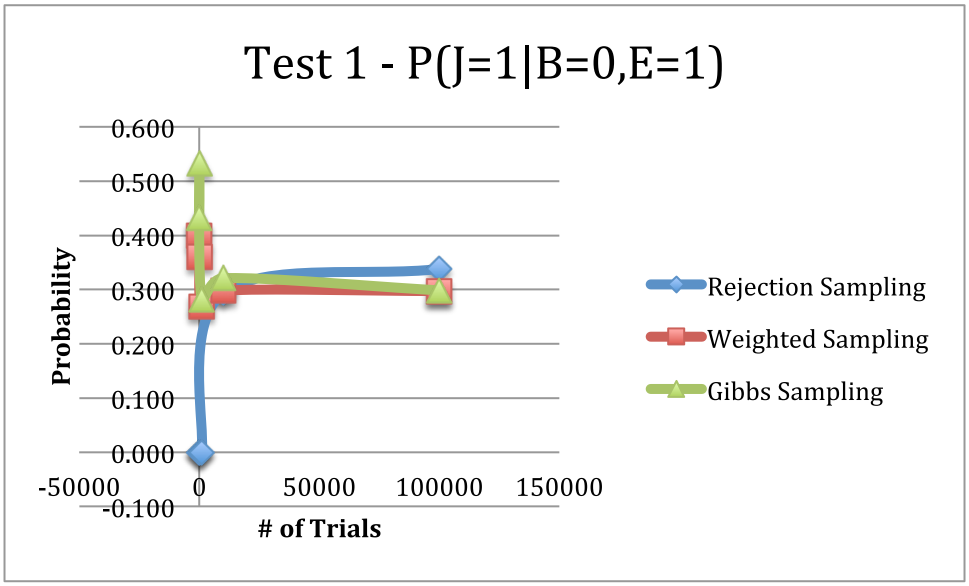


Figure 1: Test 1

## 3.2 Test Case 2 – P(B=1 | J=1)

For each case, it took about 10,000 trials to get a sample close to the actual result.

### 3.2.1 Sampling

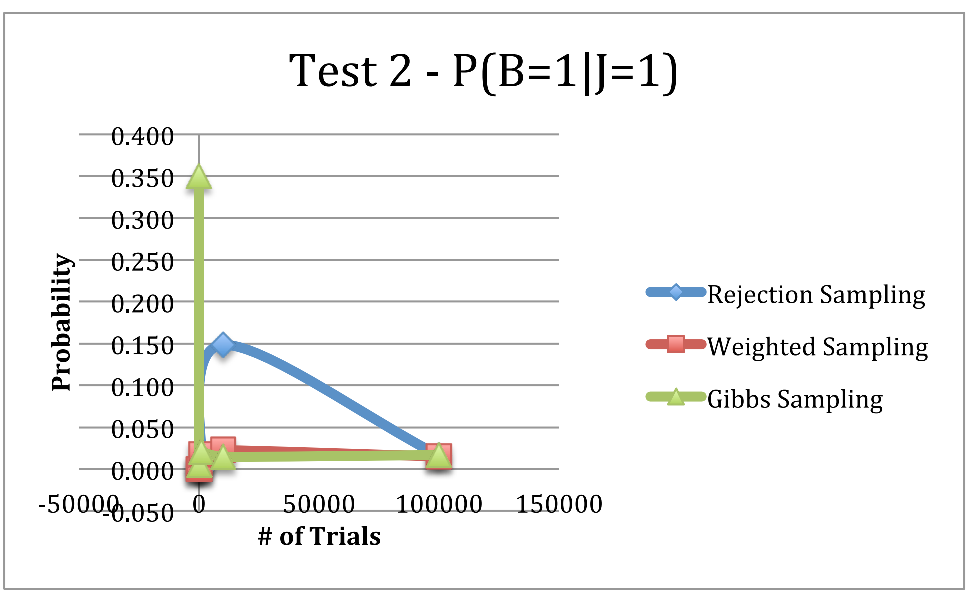

Figure 2: Test 2

### 3.3 Test Case 3 – P(E=1 | M=1)

For each case, it took about 1,000 trials to get a sample close to the actual result.

#### 3.3.1 Sampling

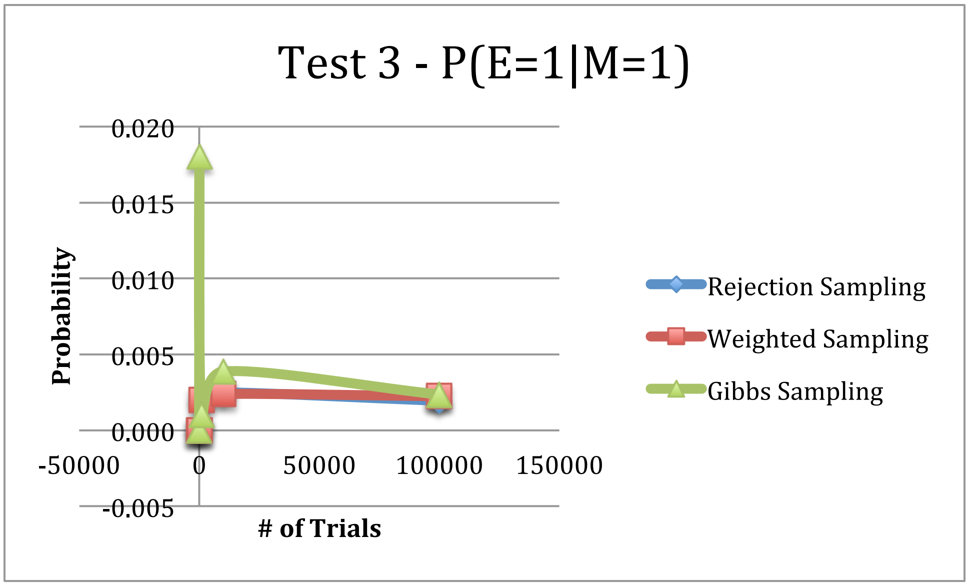


Figure 3: Test 3

## 4 Gibbs Sampling

- evidence variables E is set to given values
- non-evidence variables Z, all variables not in E, non-evidence variables are initialized to random values
- query variables Z

Algorithm:

```
for 1 to N
  for each zi in Z
    assign zi based on P(zi | mb(zi)) = P(zi | every other node)
    look at value of q
    if(Q = q){
      numTimesq++
    }
    numStateChanges = N * |Z|

return numTimesq/numStateChanges
```

### 4.1 Markov Blanket

Markov Blanket (mb) of X includes:
1) parents(X)
2) children(X)
3) parents(children(X))