Bayesian Learning

Lab 4

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Question 1

```
bid <- read.table("../data/eBayNumberOfBidderData.dat",header = TRUE)
```

a)

```
poiglm <- glm(nBids ~ . - 1, data = bid, family = poisson(link = "log"))
summary(poiglm)
```

```
##
## Call:
## glm(formula = nBids ~ . - 1, family = poisson(link = "log"),
##     data = bid)
##
## Deviance Residuals:
##    Min      1Q  Median      3Q     Max
## -3.580  -0.722  -0.044   0.527   2.461
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## Const         1.0724     0.0308   34.85  < 2e-16 ***
## PowerSeller  -0.0205     0.0368   -0.56    0.577
## VerifyID     -0.3945     0.0924   -4.27  2.0e-05 ***
## Sealed        0.4438     0.0506    8.78  < 2e-16 ***
## Minblem      -0.0522     0.0602   -0.87    0.386
## MajBlem      -0.2209     0.0914   -2.42    0.016 *
## LargNeg       0.0707     0.0563    1.25    0.210
## LogBook      -0.1207     0.0290   -4.17  3.1e-05 ***
## MinBidShare  -1.8941     0.0712  -26.59  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##     Null deviance: 6264.01  on 1000  degrees of freedom
## Residual deviance:  867.47  on  991  degrees of freedom
## AIC: 3610
##
## Number of Fisher Scoring iterations: 5
```

b)

```
library(mvtnorm)

logprior <- function(beta, mean, sigma){
    dmvnorm(beta, mean = mean, sigma = sigma, log = TRUE)
}


logfac <- function(i){
  sum(log(1:i))
}

# loglikelihood <- function(beta, X, Y){
#
#   linear_prediction <- t(X) %*% beta
#
#   lf <- sum(sapply(Y, FUN = logfac))
#
#   probabilities <- lf + sum(Y) * linear_prediction -
#     nrow(X) * exp(linear_prediction)
#
#   loglike <- sum(probabilities)
#
#     ## if (abs(loglike) == Inf)
#     ##     loglike = -20000
#
#     loglike
# }

loglikelihood <- function(beta,X,Y){
  linear_prediction <- t(X) %*% beta
  probs <- dpois(Y , lambda = exp(linear_prediction), log = TRUE)
  sum(probs)
}


logposterior <- function(beta, X, Y, mean, sigma){
   loglikelihood(beta, X, Y) + logprior(beta, mean, sigma)
}

X <- as.matrix(bid[,-1])
Y <- as.matrix(bid[,1])

mu <- rep(0, ncol(X))
sigma <- 100 * solve(t(X) %*% X)

optpost <- optim(par = matrix(rep(0,ncol(X)), ncol = 1),
                 fn = logposterior, method = "BFGS", hessian = TRUE,
                 X = t(X), Y = Y,
                 mean = mu, sigma = sigma,
                 control=list(fnscale=-1))
```

```
hessian <- optpost$hessian
```

```
optpost$par
```

```
##          [,1]
##  [1,]  1.0698
##  [2,] -0.0205
##  [3,] -0.3930
##  [4,]  0.4436
##  [5,] -0.0525
##  [6,] -0.2212
##  [7,]  0.0707
##  [8,] -0.1202
##  [9,] -1.8920
```

```
t(coef(poiglm))
```

```
##      Const PowerSeller VerifyID Sealed Minblem MajBlem LargNeg LogBook
## [1,]  1.07     -0.0205   -0.395  0.444 -0.0522  -0.221  0.0707  -0.121
##      MinBidShare
## [1,]       -1.89
```

c)

```
targetdensity <- function(theta, priormu, priorsigma, X, Y, ...) {
    likelihood <- dpois(Y, lambda = exp(t(X) %*% t(theta)), log = TRUE)
    prior <- dmvnorm(theta, mean = priormu, sigma = priorsigma, log=TRUE)
    sum(likelihood) + prior
}

proposaldensity <- function(x, mu, propsigma, ...){
    dmvnorm(x, mean = mu, sigma = propsigma, log=TRUE)
}

proposalsample <- function(mu, propsigma, ...){
    matrix(rmvnorm(1, mean = mu, sigma = propsigma), nrow = 1)
}

metropolis_hastings <- function(proposalsample, proposaldensity, targetdensity, X0, iters, ...){
    x <- X0
    values <- matrix(0, ncol = length(X0), nrow = iters + 1)
    values[1,] <- X0

    alpha <- function(x, y, proposaldensity, targetdensity, ...) {
        numerator <- targetdensity(y,...) + proposaldensity(x, y,...)
        denominator <- targetdensity(x,...) + proposaldensity(y, x,...)
        exp(numerator - denominator)
    }

    for (i in 1:iters) {
        y <- proposalsample(x,...)
        u <- runif(1)
```

```
        if (u < alpha(x, y, proposaldensity, targetdensity, ...)) {
            x <- y
        }

        values[i+1,] <- x
    }

    values
}

iters <- 5000
X0 <- rep(0, times = ncol(X))

l <- list(
    proposalsample = proposalsample,
    proposaldensity = proposaldensity,
    targetdensity = targetdensity,
    X0 = matrix(rep(0, times = ncol(X)), nrow = 1),
    iters = iters,
    X = t(X),
    Y = Y,
    priormu = rep(0, times = ncol(X)),
    priorsigma = 100 * solve(t(X) %*% X),
    propsigma = 0.6 * -solve(hessian)
)

res <- do.call(metropolis_hastings, l)

colMeans(res)
```

```
## [1]  1.0324 -0.0235 -0.3702  0.4467 -0.0513 -0.1914  0.0462 -0.1207 -1.8417
```

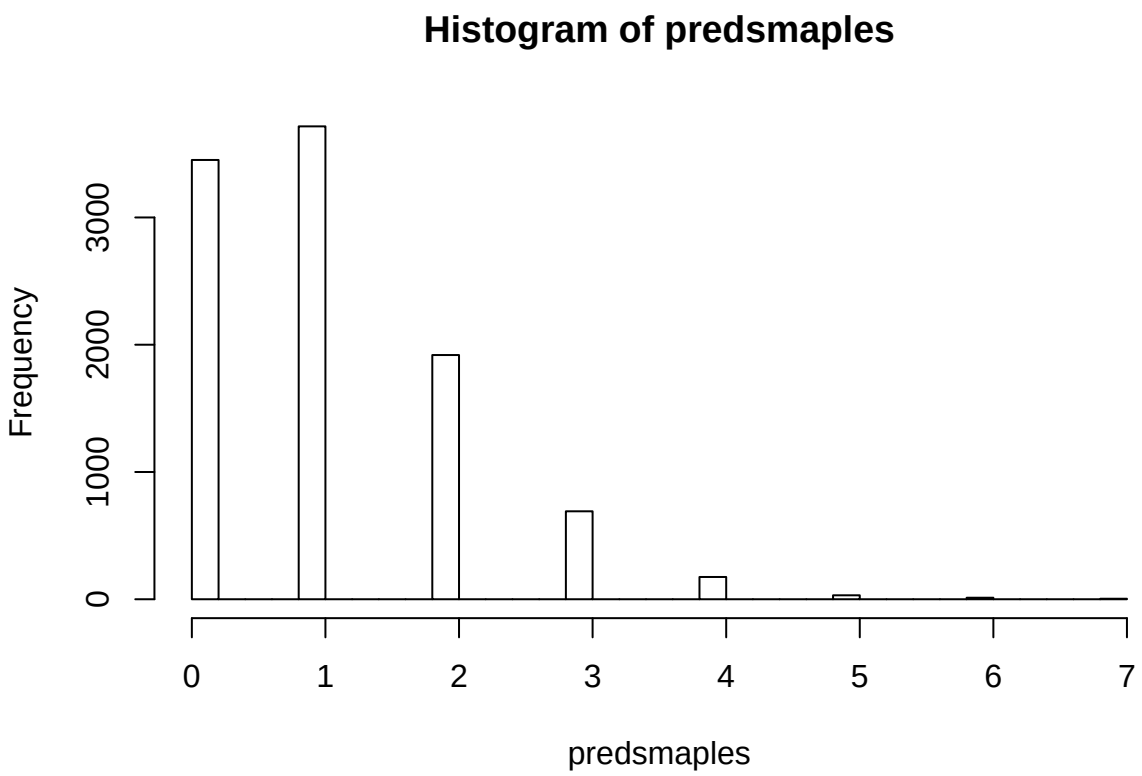
d

```
Xpred <- matrix(c(1, 1, 1, 1, 0, 0, 0, 1, 0.5), nrow = 1)
predsmaples <- rpois(10000, lambda = exp(Xpred %*% t(res)))

mean(predsmaples == 0)
```

```
## [1] 0.345
```

```
hist(predsmaples, breaks = 50)
```


Histogram of predsmaples
Frequency
0
1000
2000
3000
0
1
2
3
4
5
6
7
predsmaples