JAGS Model

Tom Park

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Basic Model: Ambulance + Overdose

Ambulance Call-outs Model

n_A: sample size
x_A: the total number who confirmed they did call an ambulance
p_A: probability of a person call an ambulance

$$x_A \sim Bin(n_A, p_A)$$

We assume $n_A = 1000, p_A = 0.8$.
Suppose the prior of p_A is noninformative.

$$p(p_A) \sim Beta(1, 1)$$

Overdose Model

Now we plug in this values into the overdose model and obtain possible O_t values **assuming we have U_t values.**

Also, we have priors.

$$z_t \sim N(\mu, \sigma^2)$$
$$\lambda_t^{OD} = \exp(z_t)$$
$$O_t \sim Poi(\lambda_t^{OD} N)$$
$$U_t \sim Bin(O_t, p_A)$$

For simplicity we set N =10000 for now. We need to generate reasonable U_t values first. Note that U_t comes from μ, σ following all the way through the overdose model.
$\mu = \log 0.05, \sigma = 1, N = 10000$.
We suppose survey data exists: (n_A, x_A) known.

We set for our prior parameters:

$$\mu \sim U(-10, 0)$$
$$\sigma \sim U(0, 5)$$

```r
# install packages
if (!require(rjags)) install.packages("rjags", dependencies = TRUE)
if (!require(coda)) install.packages("coda", dependencies = TRUE)
if (!require(tidyverse)) install.packages("tidyverse", dependencies = TRUE)
if (!require(tinytex)) install.packages("tinytex", dependencies = TRUE)

library('rjags')
library('coda')
library('tidyverse')
library('tinytex')
```

The data is the same data from pymc3 with Python.
Todo: build a pipeline to connect the python (pymc3) and R (JAGS)

```
df <- read.csv('./basic_data.csv')
df$X <- NULL
head(df)
```

```
##    o_t  u_t x_a
## 1 2475 1969 799
## 2  262  217 798
## 3  318  253 795
## 4  149  119 816
## 5 1151  934 805
## 6   39   34 794
```

Now we set the model which defines the relations of overdose model and ambulance call model.

The model defined as follows.

```
cat("model{
## define the priors
p_a ~ dbeta(alpha, beta)
mu ~ dunif(mu_a, mu_b)
sigma ~ dunif(sigma_a, sigma_b)

## the latent variables
z ~ dnorm(mu, 1/(sigma^2))
lambda <- exp(z)

for (i in 1:n) {
  ## ambulance model
  x_a[i] ~ dbin(p_a, n_a) # each survey result for month
}
for (i in 1:n) {
  ## overdose model
  o_t[i] ~ dpois(lambda*N) # total overdoses per month
}
for (i in 1:n) {
  u_t[i] ~ dbin(p_a, o_t[i]) # ambulanced overdoses per month
}

}", file='basic_model.txt')
```

Pre-set variables.

```
n <-  length(df$o_t) # we have 12 samples
n_a <- 1000
N <- 10000
u_t <- df$u_t
x_a <- df$x_a
```

Define the list providing the values of the variables and the parameters for the priors of the model.

```
dat <- list(
            # priors for ambulance model
            'alpha' = 1,
            'beta' =  1,
```

```
            # priors for overdose model
            'mu_a'=(-10),
            'mu_b'=0,
            'sigma_a'=0,
            'sigma_b'=5,

            # likelihood
            'u_t'=u_t,
            'x_a'=x_a,
            'N'=N, # the population
            'n'= n, # total months
            'n_a'=n_a

            )
```

Note: for the list object usually named 'data' or 'dat' in JAGS context, do not use arrow but use equal sign to define elements of the list.

```
interations = 1000
burnin= floor(interations/2)
chains=2
# inits = list()
simple.model <- jags.model(file='basic_model.txt',
                           data=dat,
                           n.chains = chains)
```

```
## Compiling model graph
##    Resolving undeclared variables
##    Allocating nodes
## Graph information:
##    Observed stochastic nodes: 24
##    Unobserved stochastic nodes: 16
##    Total graph size: 55
##
## Initializing model
```

```
simple.model
```

```
## JAGS model:
##
## model{
## ## define the priors
## p_a ~ dbeta(alpha, beta)
## mu ~ dunif(mu_a, mu_b)
## sigma ~ dunif(sigma_a, sigma_b)
##
## ## the latent variables
## z ~ dnorm(mu, 1/(sigma^2))
## lambda <- exp(z)
##
## for (i in 1:n) {
##   ## ambulance model
##   x_a[i] ~ dbin(p_a, n_a) # each survey result for month
## }
## for (i in 1:n) {
##   ## overdose model
```

```
##   o_t[i] ~ dpois(lambda*N) # total overdoses per month
## }
## for (i in 1:n) {
##   u_t[i] ~ dbin(p_a, o_t[i]) # ambulanced overdoses per month
## }
##
## }
## Fully observed variables:
##  N alpha beta mu_a mu_b n n_a sigma_a sigma_b u_t x_a
```

O_t

```r
params= c('o_t')
samples <- coda.samples(simple.model, params, n.iter = 1000)
```

Q1: is init necessary? and it's a characteristic of Gibbs sampling?

```r
summary(window(samples), start=burnin)
```

```
##
## Iterations = 1001:2000
## Thinning interval = 1
## Number of chains = 2
## Sample size per chain = 1000
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##           Mean    SD Naive SE Time-series SE
## o_t[1]  2156.5 14.40   0.3221         0.3919
## o_t[2]   405.0 14.69   0.3286         0.3795
## o_t[3]   440.8 14.28   0.3193         0.4250
## o_t[4]   306.8 14.56   0.3255         0.3619
## o_t[5]  1121.3 14.95   0.3343         0.4341
## o_t[6]   221.5 14.84   0.3318         0.3799
## o_t[7]  2579.4 14.66   0.3279         0.3851
## o_t[8]   382.9 14.55   0.3254         0.4014
## o_t[9]   755.9 13.95   0.3120         0.3741
## o_t[10]  495.4 14.62   0.3269         0.3565
## o_t[11] 1842.9 14.24   0.3183         0.3744
## o_t[12]  242.5 14.14   0.3162         0.3382
##
## 2. Quantiles for each variable:
##
##         2.5%  25%  50%  75% 97.5%
## o_t[1]  2129 2147 2156 2166  2185
## o_t[2]   377  394  405  415   434
## o_t[3]   413  431  441  450   469
## o_t[4]   279  297  306  316   336
## o_t[5]  1092 1111 1121 1131  1151
## o_t[6]   194  211  221  232   252
## o_t[7]  2551 2570 2579 2589  2608
## o_t[8]   354  373  383  393   412
```

```
## o_t[9]    730  746  756  765   784
## o_t[10]   468  485  495  505   525
## o_t[11]  1814 1833 1842 1852  1871
## o_t[12]   215  233  242  252   271
```

Boxplots of O__t

q2: I see two elements from the samples list. Which one I should use it or should I use both?

```r
temp = as.matrix(samples)
colnames(temp) <- seq(1,12)
head(temp)
```

```
##         1   2   3   4    5   6    7   8   9  10   11  12
## [1,] 2162 406 445 330 1114 222 2575 379 769 486 1805 254
## [2,] 2159 427 443 293 1108 210 2588 395 739 485 1859 257
## [3,] 2165 384 439 288 1133 228 2560 384 762 496 1859 248
## [4,] 2158 415 437 319 1141 227 2579 399 748 491 1831 227
## [5,] 2147 433 414 311 1120 228 2606 397 759 498 1845 246
## [6,] 2151 409 426 300 1135 189 2587 378 731 479 1821 252
```

```r
df_o_t <- as.data.frame(temp)
head(df_o_t)
```

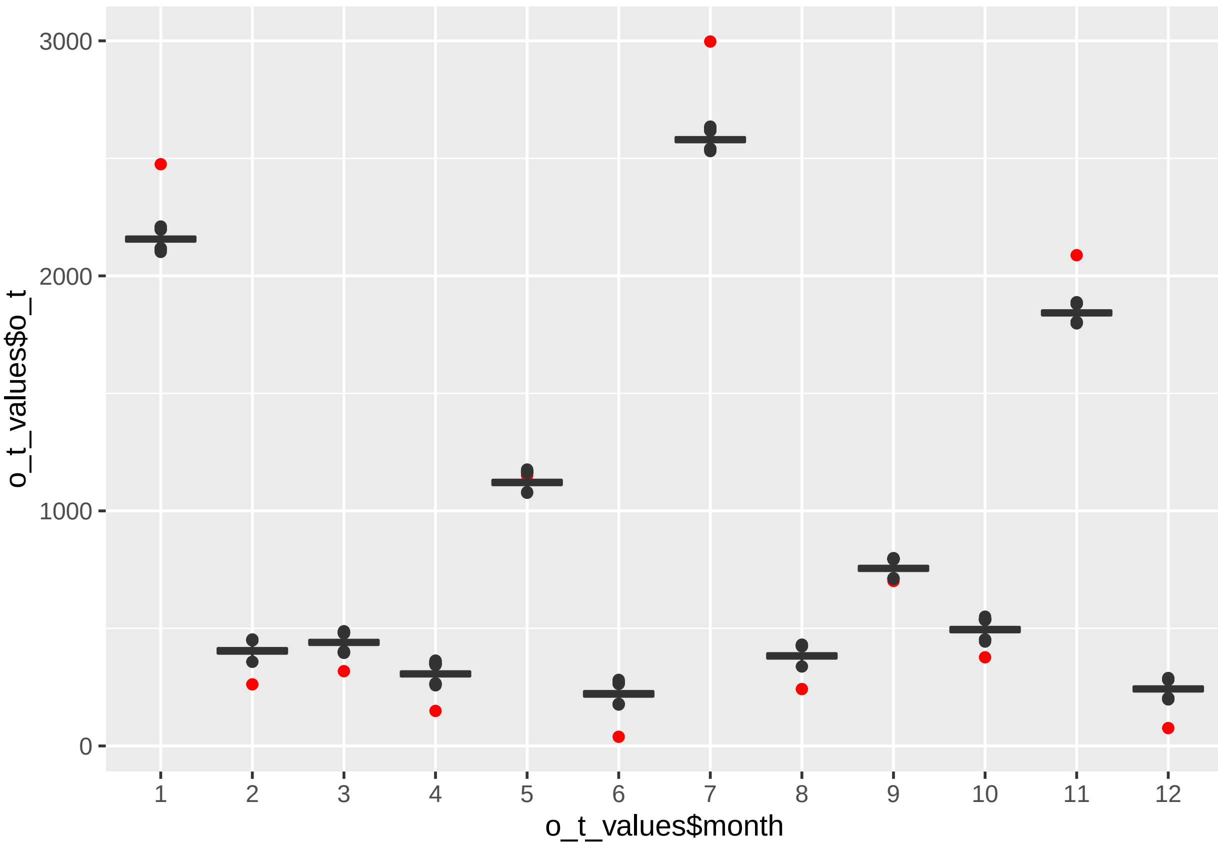
```
##      1   2   3   4    5   6    7   8   9  10   11  12
## 1 2162 406 445 330 1114 222 2575 379 769 486 1805 254
## 2 2159 427 443 293 1108 210 2588 395 739 485 1859 257
## 3 2165 384 439 288 1133 228 2560 384 762 496 1859 248
## 4 2158 415 437 319 1141 227 2579 399 748 491 1831 227
## 5 2147 433 414 311 1120 228 2606 397 759 498 1845 246
## 6 2151 409 426 300 1135 189 2587 378 731 479 1821 252
```

```r
df_o_t <- gather(df_o_t, key = 'month',value = 'o_t')
df_o_t$month <- factor(df_o_t$month,levels = seq(1,12))
str(df_o_t)
```

```
## 'data.frame':    24000 obs. of  2 variables:
##  $ month: Factor w/ 12 levels "1","2","3","4",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ o_t  : num  2162 2159 2165 2158 2147 ...
```

```r
o_t_values=data.frame('month'=seq(1,12),'o_t'=df$o_t)
o_t_values$month <- factor(o_t_values$month,levels = seq(1,12))

ggplot()+geom_point(aes(x=o_t_values$month, y=o_t_values$o_t),color='red')+geom_boxplot(aes(x=month,y=o_
```




```r
params= c('u_t','x_a')
ppc <- coda.samples(simple.model, params, n.iter = 1000)
```

```r
summary(window(ppc),start=burnin)
```

```
##
## Iterations = 2001:3000
## Thinning interval = 1
## Number of chains = 2
## Sample size per chain = 1000
##
## 1. Empirical mean and standard deviation for each variable,
##    plus standard error of the mean:
##
##          Mean SD Naive SE Time-series SE
## u_t[1]   1969  0        0              0
## u_t[2]    217  0        0              0
## u_t[3]    253  0        0              0
## u_t[4]    119  0        0              0
## u_t[5]    934  0        0              0
## u_t[6]     34  0        0              0
## u_t[7]   2392  0        0              0
## u_t[8]    196  0        0              0
## u_t[9]    569  0        0              0
## u_t[10]   308  0        0              0
## u_t[11]  1655  0        0              0
## u_t[12]    55  0        0              0
```

```
## x_a[1]   799  0        0              0
## x_a[2]   798  0        0              0
## x_a[3]   795  0        0              0
## x_a[4]   816  0        0              0
## x_a[5]   805  0        0              0
## x_a[6]   794  0        0              0
## x_a[7]   793  0        0              0
## x_a[8]   780  0        0              0
## x_a[9]   773  0        0              0
## x_a[10]  779  0        0              0
## x_a[11]  788  0        0              0
## x_a[12]  813  0        0              0
##
## 2. Quantiles for each variable:
##
##          2.5%  25%  50%  75% 97.5%
## u_t[1]   1969 1969 1969 1969  1969
## u_t[2]    217  217  217  217   217
## u_t[3]    253  253  253  253   253
## u_t[4]    119  119  119  119   119
## u_t[5]    934  934  934  934   934
## u_t[6]     34   34   34   34    34
## u_t[7]   2392 2392 2392 2392  2392
## u_t[8]    196  196  196  196   196
## u_t[9]    569  569  569  569   569
## u_t[10]   308  308  308  308   308
## u_t[11]  1655 1655 1655 1655  1655
## u_t[12]    55   55   55   55    55
## x_a[1]    799  799  799  799   799
## x_a[2]    798  798  798  798   798
## x_a[3]    795  795  795  795   795
## x_a[4]    816  816  816  816   816
## x_a[5]    805  805  805  805   805
## x_a[6]    794  794  794  794   794
## x_a[7]    793  793  793  793   793
## x_a[8]    780  780  780  780   780
## x_a[9]    773  773  773  773   773
## x_a[10]   779  779  779  779   779
## x_a[11]   788  788  788  788   788
## x_a[12]   813  813  813  813   813
```

```r
temp = as.matrix(ppc)

df_u_t=temp[,1:12]
df_x_a=temp[,13:24]


test <- as.matrix(df_u_t)
colnames(test) <- seq(1,12)
head(test)
```

```
##         1   2   3   4   5  6    7   8   9  10   11 12
## [1,] 1969 217 253 119 934 34 2392 196 569 308 1655 55
## [2,] 1969 217 253 119 934 34 2392 196 569 308 1655 55
## [3,] 1969 217 253 119 934 34 2392 196 569 308 1655 55
```

```
## [4,] 1969 217 253 119 934 34 2392 196 569 308 1655 55
## [5,] 1969 217 253 119 934 34 2392 196 569 308 1655 55
## [6,] 1969 217 253 119 934 34 2392 196 569 308 1655 55
```

```
mtx_u_t <- as.data.frame(test)
head(mtx_u_t)
```

```
##      1   2   3   4   5  6    7   8   9  10   11 12
## 1 1969 217 253 119 934 34 2392 196 569 308 1655 55
## 2 1969 217 253 119 934 34 2392 196 569 308 1655 55
## 3 1969 217 253 119 934 34 2392 196 569 308 1655 55
## 4 1969 217 253 119 934 34 2392 196 569 308 1655 55
## 5 1969 217 253 119 934 34 2392 196 569 308 1655 55
## 6 1969 217 253 119 934 34 2392 196 569 308 1655 55
```

```
df_u_t <- gather(mtx_u_t, key = 'month',value = 'u_t')
head(df_u_t)
```

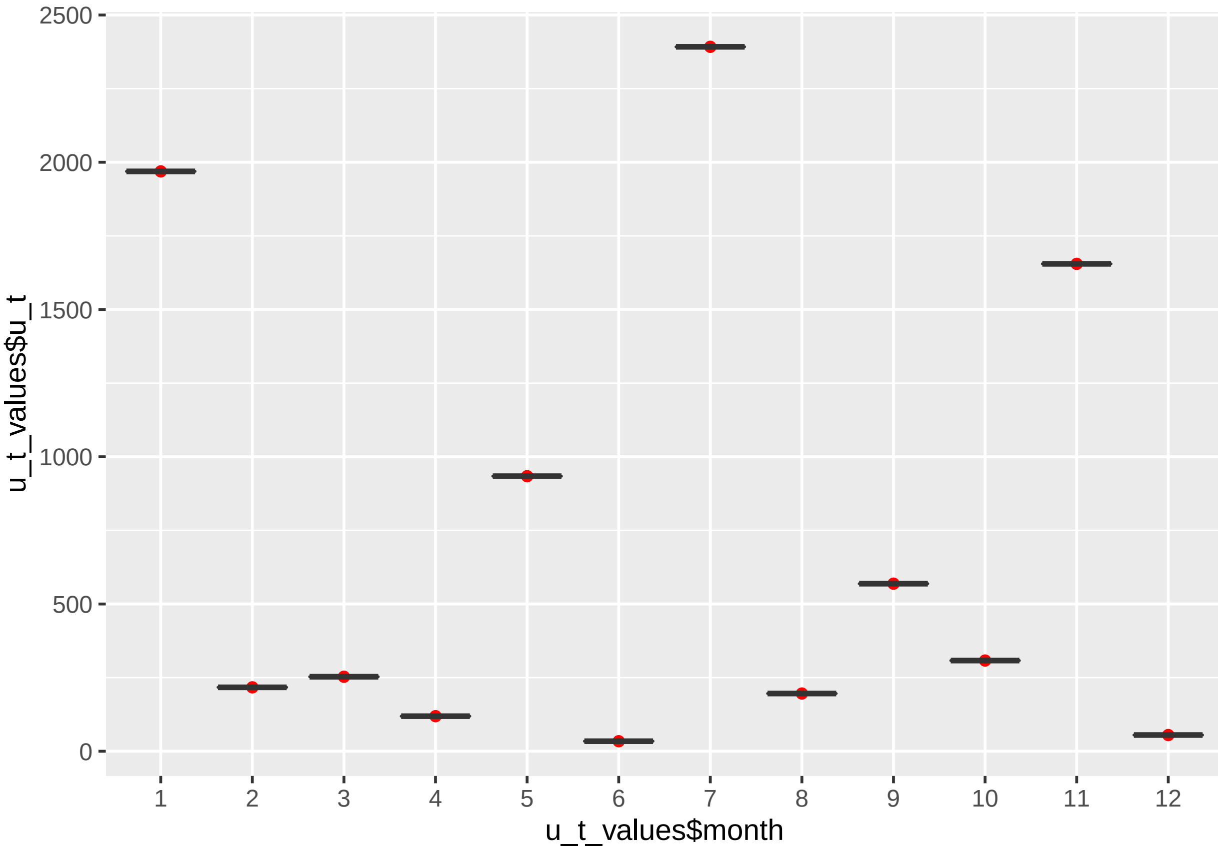
```
##   month  u_t
## 1     1 1969
## 2     1 1969
## 3     1 1969
## 4     1 1969
## 5     1 1969
## 6     1 1969
```

```
df_u_t$month <- factor(df_u_t$month,levels = seq(1,12))
str(df_u_t)
```

```
## 'data.frame':    24000 obs. of  2 variables:
##  $ month: Factor w/ 12 levels "1","2","3","4",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ u_t  : num  1969 1969 1969 1969 1969 ...
```

```
u_t_values=data.frame('month'=seq(1,12),'u_t'=df$u_t)
u_t_values$month <- factor(u_t_values$month,levels = seq(1,12))

ggplot()+geom_point(aes(x=u_t_values$month, y=u_t_values$u_t),color='red')+geom_boxplot(aes(x=month,y=u
```




```r
temp = as.matrix(ppc)
df_x_a=temp[,13:24]


test <- as.matrix(df_x_a)
colnames(test) <- seq(1,12)
head(test)
```

```
##        1   2   3   4   5   6   7   8   9  10  11  12
## [1,] 799 798 795 816 805 794 793 780 773 779 788 813
## [2,] 799 798 795 816 805 794 793 780 773 779 788 813
## [3,] 799 798 795 816 805 794 793 780 773 779 788 813
## [4,] 799 798 795 816 805 794 793 780 773 779 788 813
## [5,] 799 798 795 816 805 794 793 780 773 779 788 813
## [6,] 799 798 795 816 805 794 793 780 773 779 788 813
```

```r
mtx_x_a <- as.data.frame(test)
head(mtx_x_a)
```

```
##     1   2   3   4   5   6   7   8   9  10  11  12
## 1 799 798 795 816 805 794 793 780 773 779 788 813
## 2 799 798 795 816 805 794 793 780 773 779 788 813
## 3 799 798 795 816 805 794 793 780 773 779 788 813
## 4 799 798 795 816 805 794 793 780 773 779 788 813
## 5 799 798 795 816 805 794 793 780 773 779 788 813
## 6 799 798 795 816 805 794 793 780 773 779 788 813
```

```r
df_x_a <- gather(mtx_x_a, key = 'month',value = 'x_a')
head(df_x_a)
```

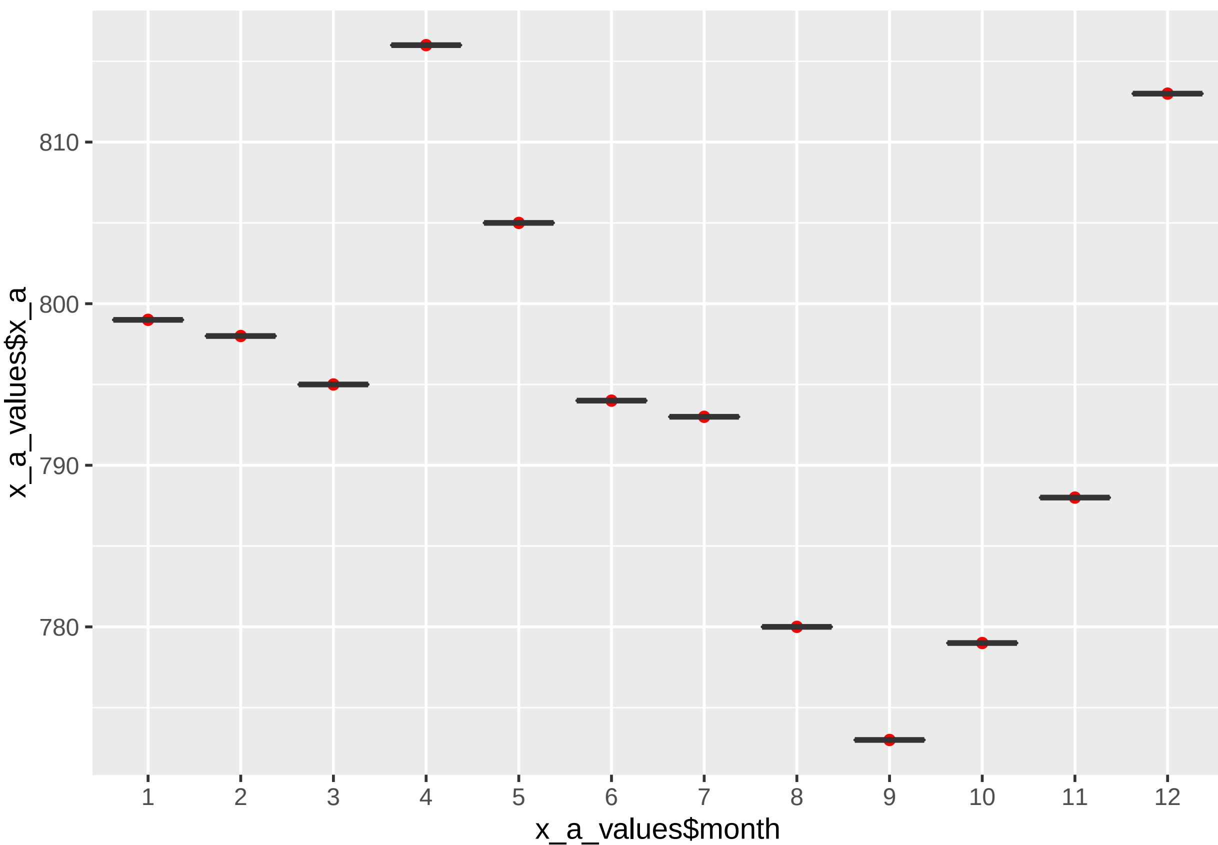
```
##   month x_a
## 1     1 799
## 2     1 799
## 3     1 799
## 4     1 799
## 5     1 799
## 6     1 799
```

```r
df_x_a$month <- factor(df_x_a$month,levels = seq(1,12))
str(df_x_a)
```

```
## 'data.frame':    24000 obs. of  2 variables:
##  $ month: Factor w/ 12 levels "1","2","3","4",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ x_a  : num  799 799 799 799 799 799 799 799 799 799 ...
```

```r
x_a_values=data.frame('month'=seq(1,12),'x_a'=df$x_a)
x_a_values$month <- factor(x_a_values$month,levels = seq(1,12))

ggplot()+geom_point(aes(x=x_a_values$month, y=x_a_values$x_a),color='red')+geom_boxplot(aes(x=month,y=x_
```



Reference

first tutorial
second tutorial
JAGS manual

error handling guide