Reproducibility\_RealData\_Regression\_for\_Directional\_Response

# Loading the R Package

library(RBVNF)

##   
## Attaching package: 'RBVNF'

## The following object is masked from 'package:base':  
##   
## norm

load\_packages()

## Loading required package: numDeriv

## Loading required package: MASS

## Loading required package: Rcpp

## Loading required package: RcppZiggurat

## Loading required package: RcppParallel

##   
## Attaching package: 'RcppParallel'

## The following object is masked from 'package:Rcpp':  
##   
## LdFlags

##   
## Rfast: 2.1.0

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## Loading required package: cowplot

##   
## Attaching package: 'mvtnorm'

## The following objects are masked from 'package:Rfast':  
##   
## Crossprod, dmvnorm, dmvt, rmvnorm, rmvt, Tcrossprod

## Loading required package: Matrix

## Loaded glmnet 4.1-8

load\_additional\_packages()

##   
## Attaching package: 'plotly'

## The following object is masked from 'package:ggplot2':  
##   
## last\_plot

## The following object is masked from 'package:MASS':  
##   
## select

## The following object is masked from 'package:stats':  
##   
## filter

## The following object is masked from 'package:graphics':  
##   
## layout

## Loading required package: dplyr

##   
## Attaching package: 'dplyr'

## The following object is masked from 'package:gridExtra':  
##   
## combine

## The following object is masked from 'package:Rfast':  
##   
## nth

## The following object is masked from 'package:MASS':  
##   
## select

## The following objects are masked from 'package:stats':  
##   
## filter, lag

## The following objects are masked from 'package:base':  
##   
## intersect, setdiff, setequal, union

## ── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──  
## ✔ forcats 1.0.0 ✔ stringr 1.5.0  
## ✔ lubridate 1.9.3 ✔ tibble 3.2.1  
## ✔ purrr 1.0.2 ✔ tidyr 1.3.0  
## ✔ readr 2.1.4   
## ── Conflicts ────────────────────────────────────────── tidyverse\_conflicts() ──  
## ✖ dplyr::combine() masks gridExtra::combine()  
## ✖ tidyr::expand() masks Matrix::expand()  
## ✖ dplyr::filter() masks plotly::filter(), stats::filter()  
## ✖ purrr::is\_integer() masks Rfast::is\_integer()  
## ✖ dplyr::lag() masks stats::lag()  
## ✖ dplyr::nth() masks Rfast::nth()  
## ✖ tidyr::pack() masks Matrix::pack()  
## ✖ dplyr::select() masks plotly::select(), MASS::select()  
## ✖ lubridate::stamp() masks cowplot::stamp()  
## ✖ purrr::transpose() masks Rfast::transpose()  
## ✖ tidyr::unpack() masks Matrix::unpack()  
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors

library(glmnet)

#Real Data Analysis (Vector Cardiogram Data):

MCMC\_Posterior\_Sample\_Size=1000  
 ########################################################  
 ######## Example 2######################################  
 #########################################################  
 file="/Users/subhadippal/Dropbox/projects/Old projects/ClusteringDTIonStiefel/DensitySVD\_sep1\_16/vcg\_data/vcg.csv"  
 vcg\_data = read.csv(file)  
  
  
 X1 = vcg\_data[,3:5]  
 X2 = vcg\_data[,6:8]  
  
 X1\_M = vcg\_data[,12:14]  
 X2\_M = vcg\_data[,15:17]  
  
 ##### Entire data  
 #output\_file = "./vcg\_data/vcg\_output.RData"  
  
 N = 98  
 YY = array(c(0,0,0,0,0,0), c(3, 2, N))  
 YY\_M = YY  
  
 for (i in 1:N){  
 YY[,1,i] = t(X1[i,])  
 YY[,2,i] = t(X2[i,])  
  
 YY\_M[,1,i] = t(X1\_M[i,])  
 YY\_M[,2,i] = t(X2\_M[i,])  
 }  
  
 data = YY;data\_M = YY\_M  
  
  
 XX<-as.data.frame(model.matrix( ~ as.factor(AgeSex)-1, data=vcg\_data ))  
  
 Gender= XX[, 3]+XX[,4] # Female =1  
 Age= XX[, 1]+XX[,3] # Age between 2 to 10 =1  
  
 Y=t(YY[,1,] )  
 X=as.matrix(cbind(Intercept = replicate(length(Age), 1), Gender=Gender, Age=Age, Gender\_Age\_Int=Gender\*Age ))  
 #X= cbind(replicate(dim(Y)[1], 1),as.integer(Maps$Maze)-1, as.integer(Maps$Trial.type)-1, Maps$L.c)  
  
  
  
 n=dim(Y)[1] # NUmber of the samples  
 p=dim(X)[2] # NUmber of the regression covariates  
 d=dim(Y)[2] # Number of direcions in the direcional data  
 #### bbeta is a matrix of dimension p\times d  
 #bbeta=matrix( rnorm(p\*d), nrow=p, ncol=d)  
 sigma\_square=1  
 tau\_square=1000  
  
 beta\_EM=EM\_Dir\_regression\_optimizer\_V1(Y=Y, X=X, prior=NULL, beta\_init = NULL, EM\_tolerence = .00001)

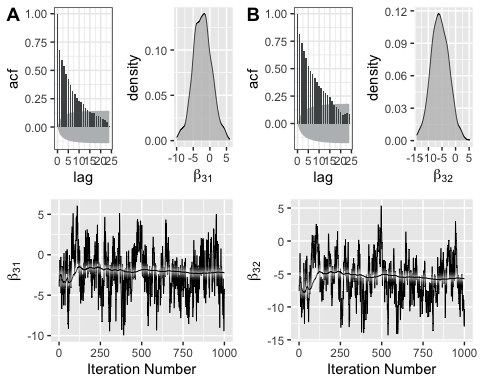
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beta\_init=beta\_EM  
 lst=MCMC\_Dir\_regression\_sampler\_V1(Y=Y, X=X, prior=NULL, beta\_init = NULL, MCSamplerSize =MCMC\_Posterior\_Sample\_Size)

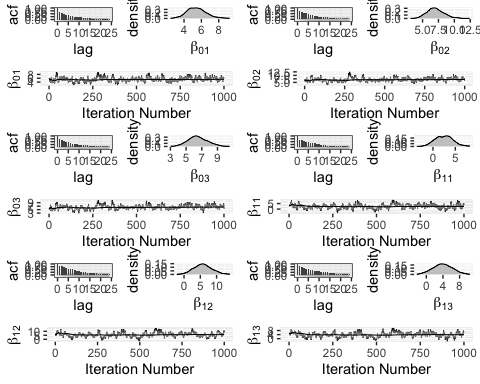
## [1] "Default Procedure using EM is being used to obtain initial value of the regression coefficients that will be used to start the MCMC Data Augmentation Algorithm. Iteration number of EM algorithm is being printed untill convergence."  
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## [1] " Initial value and prior information obtained successfully. The MCMC samples are being generated. This step may take significnt amount of time depending on the MCMC sample size to be Generated. "  
## [1] "MC\_Iter=100completed"  
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### Outputs from MCMC

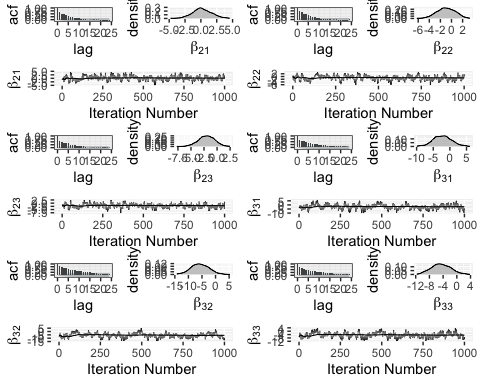
i=4;j= 1  
 p1=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
 i=4;j= 2  
 p2=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
  
 library(cowplot)  
  
  
  
  
#pdf(file="/Users/subhadippal/Dropbox/projects/Regression of Directional data/DirReg\_WriteUpShared/fig/Plot\_VCG\_beta31\_beta32\_TripletPlot1.pdf", width = 10, height= 5)  
 plot\_grid(p1, p2, labels = c('A', 'B'))



#dev.off()  
  
  
  
 ### All plots for appendix  
 #Set1  
  
 i=1;j= 1  
 p1=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
 j=2  
 p2=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
 j= 3  
 p3=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
 i=2;j=1  
 p4=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
 j=2  
 p5=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
 j= 3  
 p6=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
  
  
  
 #pdf(file="/Users/subhadippal/Dropbox/projects/Regression of Directional data/DirReg\_WriteUpShared/fig/Plot\_VCG\_Set1\_TripletPlot1.pdf", width = 10, height= 15)  
 plot\_grid(p1, p2,p3,p4,p5,p6, ncol = 2)



#dev.off()  
  
  
  
 #Set2  
 i=3;j= 1  
 p1=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
 j=2  
 p2=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
 j= 3  
 p3=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
 i=4;j=1  
 p4=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
 j=2  
 p5=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
 j= 3  
 p6=Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i-1)][.(j)]))  
  
  
  
 #pdf(file="/Users/subhadippal/Dropbox/projects/Regression of Directional data/DirReg\_WriteUpShared/fig/Plot\_VCG\_Set2\_TripletPlot1.pdf", width = 10, height= 15)  
 plot\_grid(p1, p2,p3,p4,p5,p6, ncol = 2)



# dev.off()  
  
  
  
  
  
 Beta\_est<-apply(lst$MC$Mc\_Beta, MARGIN = c(2,3), FUN = mean)  
  
 Beta\_sd<-apply(lst$MC$Mc\_Beta, MARGIN = c(2,3), FUN = sd)  
 Beta\_est<- matrix(paste0(round(c(Beta\_est),2),"(", round(c(Beta\_sd),2),")"), nrow=4)  
 #write.csv(Beta\_est, file="/Users/subhadippal/Dropbox/projects/Regression of Directional data/VCG\_Beta\_est.csv")  
  
  
 i=4; j=1  
 xx<-(lst$MC$Mc\_Beta[1:MCMC\_Posterior\_Sample\_Size, i, j])  
 round(c(quantile(xx, .025), quantile(xx, .975)),2)

## 2.5% 97.5%   
## -7.69 3.49

# Real Data Example: German Political Preference Data

MCMC\_Posterior\_Sample\_Size=1000  
#############################  
 ##### Example 1  
 #########################  
  
 library(foreign)  
 #library(Cairo)  
 germany <- read.dta("/Users/subhadippal/Dropbox/projects/Regression of Directional data/dataverse\_files/germandata.dta")  
 #attach(germany)  
 summary(germany)

## year outofwed outofwed2 reunification   
## Min. :1949 Min. : 9.00 Min. : 4.50 Min. :0.0000   
## 1st Qu.:1968 1st Qu.:15.90 1st Qu.: 7.00 1st Qu.:0.0000   
## Median :1983 Median :29.50 Median : 9.50 Median :0.0000   
## Mean :1981 Mean :26.48 Mean :11.21 Mean :0.4167   
## 3rd Qu.:1995 3rd Qu.:32.38 3rd Qu.:13.75 3rd Qu.:1.0000   
## Max. :2005 Max. :45.80 Max. :23.00 Max. :1.0000   
## unemp unemplag unempdiff divorce   
## Min. : 0.700 Min. : 0.700 Min. :-4.7000 Min. :0.1078   
## 1st Qu.: 3.775 1st Qu.: 3.775 1st Qu.:-1.4952 1st Qu.:0.1788   
## Median : 8.900 Median : 8.650 Median : 0.0000 Median :0.2999   
## Mean : 7.448 Mean : 7.123 Mean : 0.3245 Mean :0.3102   
## 3rd Qu.:10.823 3rd Qu.:10.823 3rd Qu.: 2.2112 3rd Qu.:0.3981   
## Max. :13.034 Max. :12.318 Max. : 5.3000 Max. :0.5210   
## divorcelag divorcediff direction cducsu   
## Min. :0.1078 Min. :-0.044800 Min. : 29.2 Min. :0.0000   
## 1st Qu.:0.1788 1st Qu.:-0.002283 1st Qu.:113.2 1st Qu.:0.0000   
## Median :0.2997 Median : 0.029529 Median :148.3 Median :0.0000   
## Mean :0.2863 Mean : 0.023826 Mean :165.9 Mean :0.2667   
## 3rd Qu.:0.3531 3rd Qu.: 0.061101 3rd Qu.:193.8 3rd Qu.:1.0000   
## Max. :0.5210 Max. : 0.083783 Max. :358.6 Max. :1.0000   
## spd fdp green pds   
## Min. :0.0000 Min. :0.0000 Min. :0.0000 Min. :0.00000   
## 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.00000   
## Median :0.0000 Median :0.0000 Median :0.0000 Median :0.00000   
## Mean :0.2667 Mean :0.2667 Mean :0.1167 Mean :0.08333   
## 3rd Qu.:1.0000 3rd Qu.:1.0000 3rd Qu.:0.0000 3rd Qu.:0.00000   
## Max. :1.0000 Max. :1.0000 Max. :1.0000 Max. :1.00000

# convert counterclockwise angles  
 germany$direction.rad <- (360-germany$direction) / 360 \* 2\* pi  
 #germany$direction.rad <- as.circular(germany$direction.rad, units = "radians",  
  
  
  
  
 #Constructing Response and Design Matrix  
 Y= cbind(cos(germany$direction.rad), sin(germany$direction.rad))  
 X\_numerical= cbind(unemp=germany$unemp,  
 outofwed=germany$outofwed,  
 year=germany$year,  
 yearSQ=(germany$year)^2/100)  
  
 X\_categorical=cbind( Intercept=replicate(n = length(germany$direction.rad),1 ),  
 CduCsu=germany$cducsu,  
 Spd=germany$spd,  
 Green=germany$green,  
 Pds=germany$pds,  
 Reunification=germany$reunification)  
 X\_numerical =scale(X\_numerical, scale = FALSE)  
X=cbind(X\_categorical, X\_numerical)  
  
  
 n=dim(Y)[1] # NUmber of the samples  
 p=dim(X)[2] # NUmber of the regression covariates  
 d=dim(Y)[2] # Number of direcions in the direcional data  
 #### bbeta is a matrix of dimension p\times d  
 #bbeta=matrix( rnorm(p\*d), nrow=p, ncol=d)  
 sigma\_square=1  
 tau\_square=1000  
  
 beta\_EM=EM\_Dir\_regression\_optimizer\_V1(Y=Y, X=X, prior=NULL, beta\_init = NULL, EM\_tolerence = .00001)

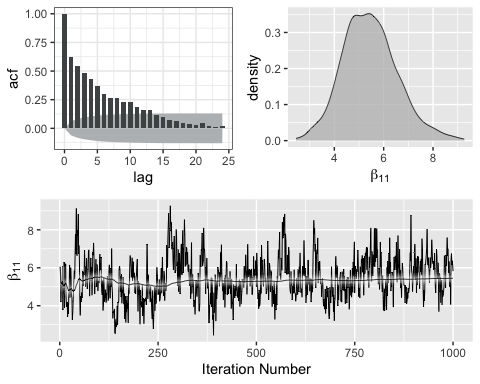
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beta\_init=beta\_EM  
 lst\_germany=MCMC\_Dir\_regression\_sampler\_V1(Y=Y, X=X, prior=NULL, beta\_init = NULL, MCSamplerSize=MCMC\_Posterior\_Sample\_Size)

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## [1] " Initial value and prior information obtained successfully. The MCMC samples are being generated. This step may take significnt amount of time depending on the MCMC sample size to be Generated. "  
## [1] "MC\_Iter=100completed"  
## [1] "MC\_Iter=200completed"  
## [1] "MC\_Iter=300completed"  
## [1] "MC\_Iter=400completed"  
## [1] "MC\_Iter=500completed"  
## [1] "MC\_Iter=600completed"  
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## [1] "MC\_Iter=800completed"  
## [1] "MC\_Iter=900completed"  
## [1] "MC\_Iter=1000completed"

# save(lst\_germany, file="/Users/subhadippal/Dropbox/projects/Regression of Directional data/workspaces/Germany\_RUN\_Example1\_11000.rdata")

i=1;j= 1  
 Plot\_MCMC\_Diag\_Triplet(lst$MC$Mc\_Beta[,i,j],y\_lab\_text = bquote(beta[.(i)][.(j)]))



Beta\_est=apply(lst$MC$Mc\_Beta, MARGIN = c(2,3), FUN = mean)  
 Beta\_sd=apply(lst$MC$Mc\_Beta, MARGIN = c(2,3), FUN = sd)  
 cbind(Estimate=c(Beta\_est), SD=c(Beta\_sd))

## Estimate SD  
## [1,] 5.4481165 1.105848  
## [2,] 2.4718260 1.964510  
## [3,] 0.1882103 1.512888  
## [4,] -2.2288490 2.725511  
## [5,] 7.0495046 1.339140  
## [6,] 5.7849210 2.780718  
## [7,] -0.9934751 1.638886  
## [8,] -5.7265096 3.255936  
## [9,] 6.4825360 1.224975  
## [10,] 3.9336418 2.304710  
## [11,] -2.0031958 1.523062  
## [12,] -4.6081840 2.788098

Beta\_est\_CI\_L=apply(lst$MC$Mc\_Beta, MARGIN = c(2,3), FUN = function(x){quantile(x, .025)})  
 Beta\_est\_CI\_R=apply(lst$MC$Mc\_Beta, MARGIN = c(2,3), FUN = function(x){quantile(x, 1-.025)})  
 CI\_beta<- matrix(paste0("[",round(Beta\_est\_CI\_L, 2)," , ", round(Beta\_est\_CI\_R,2), "]"), ncol=10)

## Warning in matrix(paste0("[", round(Beta\_est\_CI\_L, 2), " , ",  
## round(Beta\_est\_CI\_R, : data length [12] is not a sub-multiple or multiple of  
## the number of columns [10]

CI\_beta

## [,1] [,2] [,3] [,4]   
## [1,] "[3.37 , 7.95]" "[-2.71 , 3.22]" "[4.73 , 10.03]" "[-4.29 , 2]"   
## [2,] "[-1.15 , 6.55]" "[-7.69 , 3.49]" "[0.49 , 11.43]" "[-11.99 , 0.87]"  
## [,5] [,6] [,7] [,8]   
## [1,] "[4.16 , 9.03]" "[-5.08 , 0.87]" "[3.37 , 7.95]" "[-2.71 , 3.22]"  
## [2,] "[-0.57 , 8.53]" "[-9.79 , 0.88]" "[-1.15 , 6.55]" "[-7.69 , 3.49]"  
## [,9] [,10]   
## [1,] "[4.73 , 10.03]" "[-4.29 , 2]"   
## [2,] "[0.49 , 11.43]" "[-11.99 , 0.87]"