Time Series Project

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```
library(R.matlab)
```

```
## R.matlab v3.7.0 (2022-08-25 21:52:34 UTC) successfully loaded. See ?R.matlab for help.

##
## Attaching package: 'R.matlab'

## The following objects are masked from 'package:base':
##
##     getOption, isOpen
```

```
library(depmixS4)
```

```
## Loading required package: nnet

## Loading required package: MASS

## Loading required package: Rsolnp

## Loading required package: nlme
```

```
data <- readMat("Mouse28-140313_BS0150_HMMready.mat")
angdata <- as.vector(data$resampledAwakeHeadAngleData)
# Transpose thet data so that there are 71 columns, one column for each cell, and 15243 rows, one for e
celldata <- t(data$celldata)
```

```
# Exclude cells that are active less than 100 times overall
col_idx = which(colSums(celldata)<100)
celldata = celldata[,-col_idx]
```

```
# Reduced to 59 cells
dim(celldata)
```

```
## [1] 15243    59
```

```r
cell_data <- data.frame(celldata)

# Response and list must be on list-form

# Response has to be in a list
res <- list()

# List of families. One for each cell
families <- list()

# Number of columns(cells)
n_cells <- ncol(cell_data)

for (i in 1:n_cells) {
  form <- as.formula(paste(colnames(cell_data)[i], "~ 1",sep=""))
  res[[i]] = form
  families[[i]] = poisson()
}
```

```r
# Model with 5 states
model5 <- depmix(response = res, nstates = 5, data= cell_data, family = families)
fit5 <- fit(model5)
```

```
## converged at iteration 34 with logLik: -948315.1
```

```r
summary(fit5)
```

```
## Initial state probabilities model
## pr1 pr2 pr3 pr4 pr5
##   0   0   0   1   0
##
## Transition matrix
##         toS1  toS2  toS3  toS4  toS5
## fromS1 0.915 0.001 0.052 0.032 0.000
## fromS2 0.001 0.902 0.001 0.042 0.055
## fromS3 0.030 0.000 0.913 0.000 0.056
## fromS4 0.036 0.075 0.000 0.889 0.000
## fromS5 0.000 0.045 0.046 0.000 0.909
##
## Response parameters
## Resp 1 : poisson
## Resp 2 : poisson
## Resp 3 : poisson
## Resp 4 : poisson
## Resp 5 : poisson
## Resp 6 : poisson
## Resp 7 : poisson
## Resp 8 : poisson
## Resp 9 : poisson
## Resp 10 : poisson
## Resp 11 : poisson
## Resp 12 : poisson
```

```
## Resp 13 : poisson
## Resp 14 : poisson
## Resp 15 : poisson
## Resp 16 : poisson
## Resp 17 : poisson
## Resp 18 : poisson
## Resp 19 : poisson
## Resp 20 : poisson
## Resp 21 : poisson
## Resp 22 : poisson
## Resp 23 : poisson
## Resp 24 : poisson
## Resp 25 : poisson
## Resp 26 : poisson
## Resp 27 : poisson
## Resp 28 : poisson
## Resp 29 : poisson
## Resp 30 : poisson
## Resp 31 : poisson
## Resp 32 : poisson
## Resp 33 : poisson
## Resp 34 : poisson
## Resp 35 : poisson
## Resp 36 : poisson
## Resp 37 : poisson
## Resp 38 : poisson
## Resp 39 : poisson
## Resp 40 : poisson
## Resp 41 : poisson
## Resp 42 : poisson
## Resp 43 : poisson
## Resp 44 : poisson
## Resp 45 : poisson
## Resp 46 : poisson
## Resp 47 : poisson
## Resp 48 : poisson
## Resp 49 : poisson
## Resp 50 : poisson
## Resp 51 : poisson
## Resp 52 : poisson
## Resp 53 : poisson
## Resp 54 : poisson
## Resp 55 : poisson
## Resp 56 : poisson
## Resp 57 : poisson
## Resp 58 : poisson
## Resp 59 : poisson
##     Re1.(Intercept) Re2.(Intercept) Re3.(Intercept) Re4.(Intercept)
## St1           0.036           0.224          -2.696          -2.602
## St2          -0.014           0.181          -3.555          -2.131
## St3          -0.078           0.103          -0.845          -2.347
## St4          -0.144           0.362          -1.382          -2.315
## St5           0.100           0.039          -2.590          -1.997
##     Re5.(Intercept) Re6.(Intercept) Re7.(Intercept) Re8.(Intercept)
```

```
## St1          -2.802          -2.100          -5.844          -4.197
## St2          -4.307          -1.763          -6.881          -0.707
## St3          -2.494          -1.738          -0.344          -0.950
## St4          -2.244          -2.906          -6.871          -3.780
## St5          -0.609          -3.568          -2.304          -5.337
##     Re9.(Intercept) Re10.(Intercept) Re11.(Intercept) Re12.(Intercept)
## St1           1.798            2.082            1.694           -2.042
## St2           1.217            1.942            1.562           -1.962
## St3           1.355            2.022            1.666           -2.458
## St4           1.810            2.013            1.574           -1.479
## St5           1.279            1.931            1.348           -3.651
##     Re13.(Intercept) Re14.(Intercept) Re15.(Intercept) Re16.(Intercept)
## St1            0.041            0.009           -3.250            0.536
## St2           -1.309           -0.507           -2.334            0.325
## St3           -0.953           -0.598           -0.156            0.647
## St4           -0.923            0.845           -3.339            0.518
## St5           -1.541           -0.271           -3.213            0.358
##     Re17.(Intercept) Re18.(Intercept) Re19.(Intercept) Re20.(Intercept)
## St1           -3.659           -2.487           -3.521           -1.211
## St2           -1.360           -3.962           -5.513           -3.065
## St3           -3.845           -2.909           -0.879           -1.598
## St4           -3.456           -3.438           -6.177           -2.930
## St5           -3.764           -3.592           -2.264           -2.719
##     Re21.(Intercept) Re22.(Intercept) Re23.(Intercept) Re24.(Intercept)
## St1            0.308            1.737           -3.213           -1.288
## St2           -0.240            1.788            0.427            1.152
## St3           -0.588            1.828           -3.260           -0.943
## St4            1.098            1.626           -2.425           -0.897
## St5           -0.412            1.512           -2.877            0.274
##     Re25.(Intercept) Re26.(Intercept) Re27.(Intercept) Re28.(Intercept)
## St1            1.693           -2.364           -2.063            1.910
## St2            1.511           -1.194           -2.039            1.775
## St3            1.878           -2.594           -2.192            1.886
## St4            1.722           -2.614           -2.148            2.035
## St5            1.684           -2.579           -2.180            1.817
##     Re29.(Intercept) Re30.(Intercept) Re31.(Intercept) Re32.(Intercept)
## St1            1.915            1.315            0.814           -1.757
## St2            1.471            1.288            0.717           -1.772
## St3            1.750            1.301            0.865           -1.512
## St4            1.771            1.282            0.716           -1.513
## St5            1.467            1.241            0.907           -1.602
##     Re33.(Intercept) Re34.(Intercept) Re35.(Intercept) Re36.(Intercept)
## St1           -0.483           -1.224            0.519           -0.863
## St2           -2.525           -1.382            0.579           -1.379
## St3           -1.367           -1.128            0.605           -1.295
## St4           -3.971           -1.163            0.479           -1.139
## St5           -2.736           -1.346            0.425           -1.909
##     Re37.(Intercept) Re38.(Intercept) Re39.(Intercept) Re40.(Intercept)
## St1            1.972           -1.139           -2.890           -4.467
## St2            1.976           -0.819           -2.935            0.134
## St3            1.910           -1.993           -2.314           -3.944
## St4            1.975           -0.314           -0.433           -2.204
## St5            1.801           -1.364           -2.596           -3.421
##     Re41.(Intercept) Re42.(Intercept) Re43.(Intercept) Re44.(Intercept)
```

```
## St1           -2.363            0.575           -0.883           -2.177
## St2            0.822           -2.894           -1.254           -4.293
## St3           -2.958           -0.212           -2.344            2.486
## St4           -3.017            2.079           -1.991           -6.465
## St5            1.076           -2.459           -1.571           -1.227
##     Re45.(Intercept) Re46.(Intercept) Re47.(Intercept) Re48.(Intercept)
## St1           -1.741           -0.143           -3.596           -5.587
## St2           -1.554            0.863           -4.587           -4.315
## St3           -3.439           -0.091            0.781            0.039
## St4           -0.724           -0.263           -3.400           -3.196
## St5           -1.425            0.953            0.753            0.310
##     Re49.(Intercept) Re50.(Intercept) Re51.(Intercept) Re52.(Intercept)
## St1           -5.133           -1.326            1.414           -3.076
## St2           -0.019           -4.326           -5.116            0.801
## St3           -5.766           -2.955           -4.579           -1.085
## St4           -0.859           -1.429           -1.607            1.985
## St5           -2.296           -2.805           -3.589           -0.427
##     Re53.(Intercept) Re54.(Intercept) Re55.(Intercept) Re56.(Intercept)
## St1           -0.887           -1.425           -2.845           -5.230
## St2           -5.455           -2.267           -4.010           -0.757
## St3           -4.273           -2.148           -4.006           -0.042
## St4           -1.375           -2.500           -2.511           -0.784
## St5           -3.904           -0.400           -2.910            2.277
##     Re57.(Intercept) Re58.(Intercept) Re59.(Intercept)
## St1           -1.030            0.052           -0.648
## St2           -4.318           -3.324           -0.401
## St3            2.774           -4.277           -0.822
## St4           -6.465           -2.409           -0.461
## St5           -0.841           -4.503           -0.652
```

```
AIC(model5)
```

```
## [1] 4579341
```

Fit models with more than 5 states

```
# Dette tar tid!
# Model with 10 states
#mod10 <- depmix(response = res, nstates = 10, data = cell_data, family = families)
#fit10 <- fit(mod10)
# Model with 15 states
#mod15 <- depmix(response = res, nstates = 15, data = cell_data, family = families)
#fit15 <- fit(mod15)
```

```
#summary(fit10)
```

Model selection based on AIC

```r
# Model selection based on AIC

AIC(fit5)
```

```
## [1] 1897268
```

```r
# AIC(fit10)

# AIC(fit15)

# AIC(fit20)
```

Indices of each state

```r
# States for all time intervals
states = posterior(fit5)$state
```

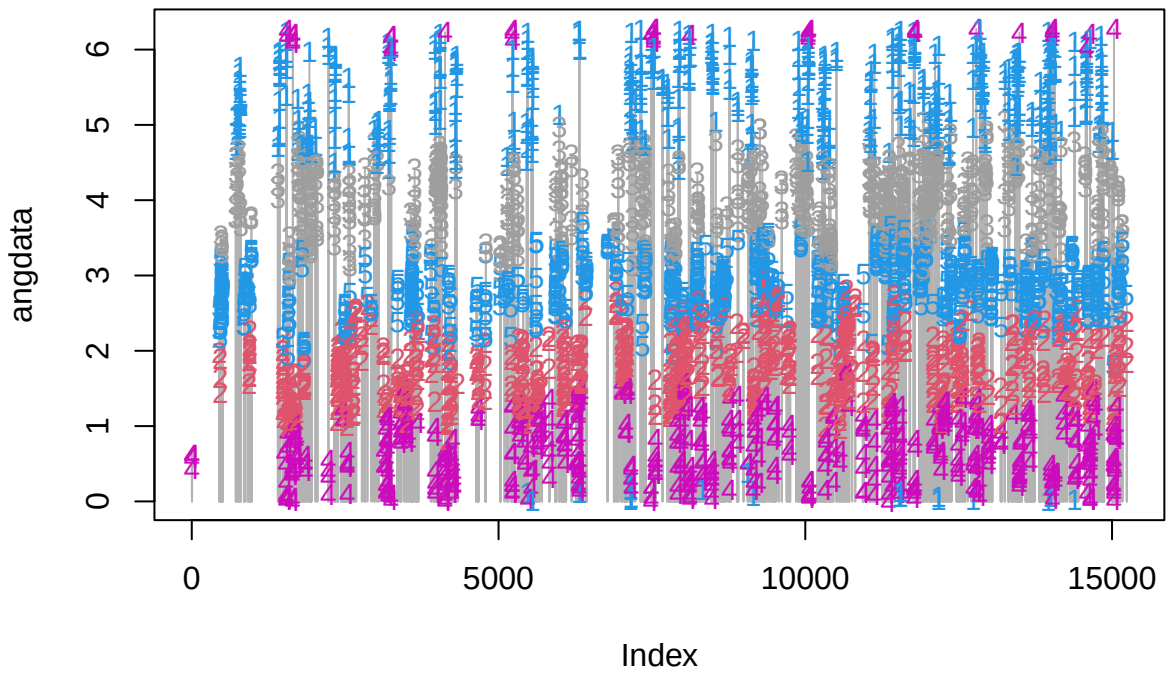
```
## Warning in .local(object, ...): Argument 'type' not specified and will default
## to 'viterbi'. This default may change in future releases of depmixS4. Please
## see ?posterior for alternative options.
```

```r
# Indices for which state is 1
idx_state1 <- which(states == 1)
idx_state2 <- which(states == 2)
idx_state3 <- which(states == 3)
idx_state4 <- which(states == 4)
idx_state5 <- which(states == 5)
```

```r
#Avrege for of
avg_state1 <- mean(angdata[idx_state1], na.rm = TRUE)
avg_state2 <- mean(angdata[idx_state2], na.rm = TRUE)
avg_state3 <- mean(angdata[idx_state3], na.rm = TRUE)
avg_state4 <- mean(angdata[idx_state4], na.rm = TRUE)
avg_state5 <- mean(angdata[idx_state5], na.rm = TRUE)
avg <- c(avg_state1, avg_state2, avg_state3, avg_state4, avg_state5)
```

Histogram over head direction for each state

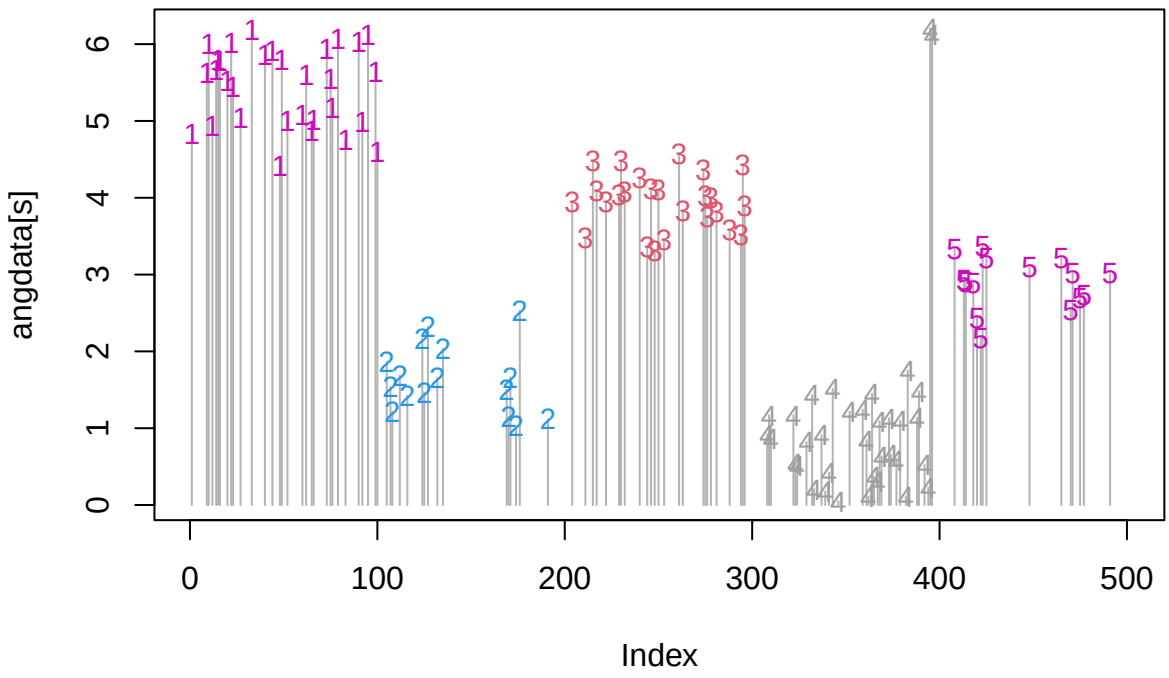
```r
plot(angdata, main="", type="h", col = gray(.7))
text(angdata, col=6*states-2, labels=states, cex=.9)
```



Difficult to see. Take a random sample of the angle data

```
#  Don´t plot all head angles. Take a random sample. Easier to visualize
s_1 = sample(idx_state1, 100)
s_2 = sample(idx_state2, 100)
s_3 = sample(idx_state3, 100)
s_4 = sample(idx_state4, 100)
s_5 = sample(idx_state5, 100)
s=c(s_1, s_2, s_3, s_4, s_5)
```

```
plot(angdata[s], type = "h", col=gray(.7))
text(angdata[s], col = 6*states[s], labels = states[s], cex=.9)
```

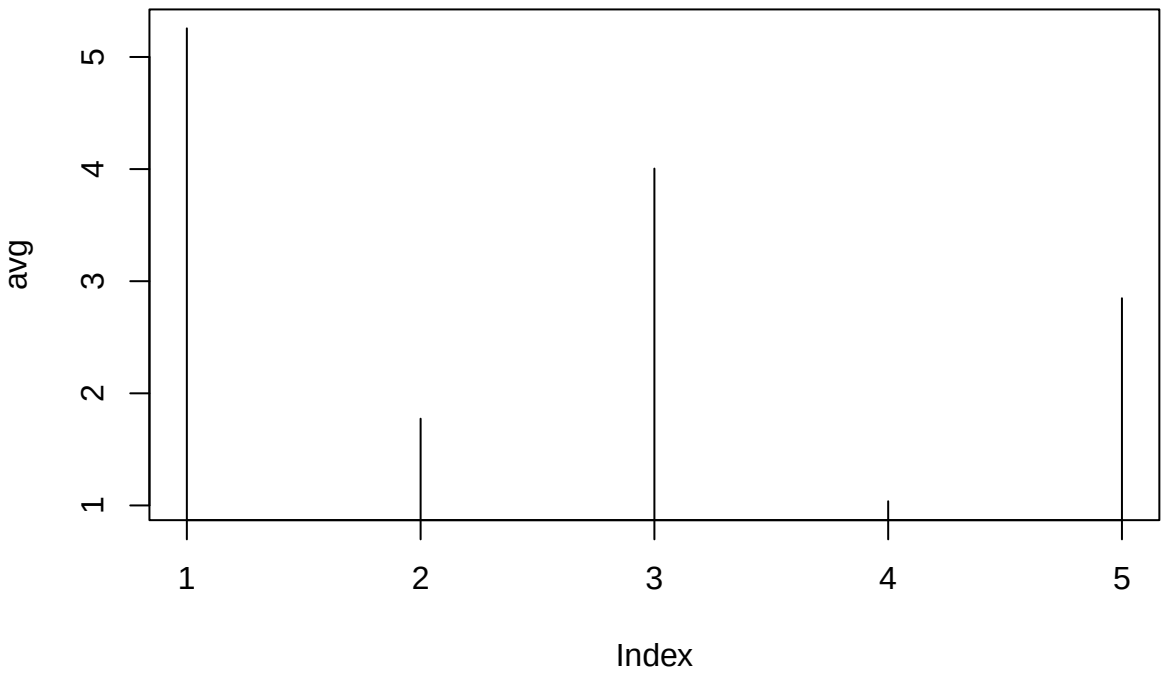


Plotting the average head direction of each state

```
## Plot of mean head
avg
```

```
## [1] 5.255357 1.773650 4.004686 1.037438 2.848121
```

```
plot(avg, type="h")
```


avg
1
2
3
4
5
Index
1
2
3
4
5